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of the

5th International Conference
on Integrated Fruit Production

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Preface

The activities of IOBC/WPRS in the field of integrated fruit production (IFP) have a long lasting history and meetings of the former working group integrated plant protection in orchards have been important focal points in the development of science as well as agricultural practices in IFP.

Small specialised workshops are important to strengthen scientific co-operation and progress in the different working groups and subgroups of IOBC/WPRS, but they will always focus more on details. It needs big symposia like this one to present the state of art of IFP, to force the co-operation between the different specialised disciplines and to get an integration of scientific results.

This 5th Conference on Integrated Fruit Production in Orchards took place in the city of Lleida, located in Catalonia in the north of Spain in October 2000. Local organisers were the Universitat de Lleida (UdL) and the Institut de Recerca i Tecnologia Agroalimentàries (IRTA, Institut for Food and Agricultural Research and Technology). Jesus Avilla was the chairman of the organising committee.

More than 140 participants from 26 countries attended the symposium. All important fruit producing regions of the world were represented by scientists or advisors. This way the conference had an real international level. An efficient organisation, a nice meeting place, the campus of the UdL, excellent oral and poster presentations and fruitful discussions, which went on till late in the evenings worked together and made the conference to an successful happening, we like to remember back.

This volume presents the proceedings of the conference to give everyone, participants as well as interested scientists and advisors the chance to read or reread the important oral and poster presentations held in the frame of the meeting.

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Table of Contents

Preface........................................................................................................................................ i
List of participants..................................................................................................................... iii

OPENING LECTURE

Functional Biodiversity and Agro-Ecosystems Management:
1. Identified Information Gaps
   Boller, E.F. ........................................................................................................................ 1

Functional Biodiversity and Agro-Ecosystems Management:
2. Role in Integrated Fruit Production.
   Brown, M.W. ..................................................................................................................... 5

GENERAL ASPECTS OF IFP

Integrated Fruit Production in France: A new challenge for horticultural research.
P.-E. Lauri, Y. Lespinasse, M. Navarrete, D. Plenet, J. Pluvinage, C. de Sainte-Marie,
B. Sauphanor, S. Simon, J.-F. Toubon & J. Sterns....................................................... 13

Farming system comparison in integrated apple growing
Gildemacher, P., F.v. Alebeek & B. Heijne ................................................................. 21

Status of integrated production in French apple orchards
Toubon, J.-F., B. Sauphanor, Chr. de Sainte-Marie, D. Plenet & R. Habib ............... 27

Ten years of IFP in Poland – theory and practice
Niemczyk, E. ...................................................................................................................... 33

Development of Integrated Fruit Production Programmes in the New Zealand horticultural industry

Integrated Production in Chile: peaches, nectarines and plums, two years of research and development
Cooper, T., L. Sazo & K. Sagredo ................................................................................. 45

Use of industry agrochemical use data in the development of Integrated Fruit Production Programmes in the New Zealand Horticultural industry
Manktelow, D., J. Walker, A. Hodson & M. Suckling................................................. 51

Integrated Fruit Production in Brazil
Valdebenito-Sanhueza, R.M. & J.F. da Silva Protas ...................................................... 57

Certification of Integrated Fruit Production in Argentina and Uruguay
Magdalena, J., S. Nuñez, S. Dimasi, I. Scatoni & D. Fernández.............................. 63
Development of integrated fruit production at the Research Station for Fruit Tree Growing Baneasa, Bucharest, Romania
Balan, V., A. Ivascu, S. Drosu, C. Chireceanu, M. Oprea, V. Tudor, M. Roman & P. Gherghe ................................................................. 67

ARTHROPOD PESTS

The possibilities of IPM in the Hungarian sour-cherry orchards
Jenser, G., K. Balázs & V. Markó ........................................................................ 73

Valuations about mating disruption method application in Cydia molesta (Busck) control on nearly 400 hectares of peach tree in the Plane of Sibari (Calabria, South Italy)
Cravedi, P., F. Guarino & A. Tocci .................................................................. 79

Protecting peach orchards by Cydia molesta and Anarsia lineatella using sex pheromones through the method of “disorientation”
Molinari, F., P. Cravedi, F. Rama, F. Reggiori, M. Dal Pane, T. Galassi .............. 85

Infestation of roots of stone-fruit rootstocks by larvae of two Capnodis species (Buprestidae) and its relation to level of cyanogenic compounds
Ben Yehuda, S., F. Assael & Z. Mendel ............................................................ 91

The stone fruit bud weevil Anthonomus bituberculatus Puzyr – sometimes an important pest on plums and apricots in Austria
Polesny, Fritz .................................................................................................. 97

Comparison between Conventional and Integrated Peach Pest Management in Emilia-Romagna (Italy)
Cravedi, P., D. Giovannini, F. Molinari & I. Ponti ........................................... 99

Integrated fruit production of peach tree in the Plane of Sibari (Calabria, South Italy). Analysis of organisation
Guarino, F. & A. Tocci .................................................................................... 105

Fatty acid control trials on some peach and almond arthropods
Moleas, T. & M. Pizza .................................................................................... 109

Integrated pest management strategies for Frankliniella occidentalis on peach tree in the Plane of Sibari (Calabria, South Italy)
Guarino, F. & A. Tocci .................................................................................... 113

The control of Cydia molesta in pome fruit orchards using sex pheromones through the method of “disorientation”
Rama, F., F. Reggiori, M. Dal Pane, F. Molinari, P. Cravedi & M. Boselli .......... 117

Coccinellidae in peach orchards in connection with agricultural practices
Baviera, C. & Molinari, F. ............................................................................... 123

Improving the prediction of adult codling moth (Cydia pomonella L.) emergence in a natural environment
Graf, B., H. Höpli & H. Höhn ........................................................................ 127

Cydia molesta and Cydia pomonella: comparison of adult behaviour
Dorn, S., J. Hughes, F. Molinari & P. Cravedi ............................................... 133
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Attract and kill”. A new IPM method in apple orchards against Cydia pomonella (L.)</td>
<td>Alma, A., A. Arzone, A. Galliano &amp; F. Vittone</td>
<td>139</td>
</tr>
<tr>
<td>Population numbers, harmfulness and control of pear psylla (Cacopsylla pyri L.) in Serbia</td>
<td>Stamenkovic, S., S. Milenkovic &amp; M. Injac</td>
<td>145</td>
</tr>
<tr>
<td>Monitoring resistance of pear psylla Cacopsylla pyri to amitraz</td>
<td>Schaub, L., B. Bloesch, U. Aeschlimann &amp; G. Garnier</td>
<td>151</td>
</tr>
<tr>
<td>Ground dwelling predatory carabid beetles as biocontrol agents of pests in fruit production in UK</td>
<td>Fitzgerald, J. &amp; M. Solomon</td>
<td>155</td>
</tr>
<tr>
<td>Exploiting the parasitoids Lathrolestes ensator and Platygaster demades for control of apple sawfly and apple leaf midge in IPM in apple orchards</td>
<td>Cross, J. &amp; Ch. Jay</td>
<td>161</td>
</tr>
<tr>
<td>Mass trapping of Synanthedon myopaeformis (Borkhausen) in Lleida (Spain) with pheromone traps</td>
<td>Bosch, D., M. J. Sarasúa &amp; J. Avilla</td>
<td>167</td>
</tr>
<tr>
<td>Control of leopard moth, Zeuzera pyrina L., in apple orchards in NE Spain: mating disruption technique</td>
<td>Sarto i Monteys, V.</td>
<td>173</td>
</tr>
<tr>
<td>Selective insecticides in control of fruit moths and leaf rollers</td>
<td>Olszak, R.W. &amp; Z. Pluciennik</td>
<td>179</td>
</tr>
<tr>
<td>The use of geostatistics to study the spatial distribution of Cydia pomonella and Pandemis heparana in Lleida (Spain)</td>
<td>Ribes-Dasi, M., R. Albajes, M.J. Sarasúa &amp; J. Avilla</td>
<td>185</td>
</tr>
<tr>
<td>Fish-liver oil as repellent in IPM</td>
<td>Ciglar, I. &amp; B. Baric</td>
<td>189</td>
</tr>
<tr>
<td>Phenology of San José Scale, Quadraspidiotus perniciosus (Comstock) on apple in Guarda region (central eastern Portugal)</td>
<td>Rodrigues, A.N. &amp; L.M. Torres</td>
<td>195</td>
</tr>
<tr>
<td>Overwintering of the San José Scale on stone fruit in Northern Italy</td>
<td>Mazzoni, E.</td>
<td>201</td>
</tr>
<tr>
<td>Effects of several pesticides on the predacious mite Agistemus fleschneri (Summers) (Acari: Stigmaeidae) in Quebec apple orchards</td>
<td>Bostanian, N.J. &amp; N. Larocque</td>
<td>213</td>
</tr>
<tr>
<td>Ground dwelling Coleoptera fauna of commercial apple orchards</td>
<td>Kutasi, Cs., A. Balog &amp; V. Markó</td>
<td>215</td>
</tr>
<tr>
<td>Pear tree responses to psyllid infestation: intercultivar variation in emission of volatiles</td>
<td>Scutareanu, P., J. Bruin, B. Drukker, M.A. Posthumus &amp; M.W. Sabelis</td>
<td>221</td>
</tr>
</tbody>
</table>
Systemic and non-systemic responses induced by herbivory: variation among pear cultivars

P. Scutareanu, M.W. Sabelis & J.J. Boon ................................................................. 227

Efficiency and timing of some active ingredients to control Hoplocampa brevis Klug in Emilia-Romagna (Italy)

Vergnani, S., M. Ardizzoni, G. Ferioli & E. Pasqualini ........................................ 235

Predators of the rosy apple aphid, Dysaphis plantaginea (Pass.), in Asturian (NW Spain) apple orchards

Miñarro, M. & E. Dapena ....................................................................................... 241

Evaluation of the tolerance to the rosy apple aphid, Dysaphis plantaginea (Pass.), in descendants of the crossing ‘Raxao’ x ‘Florina’

Dapena, E. & M. Miñarro ....................................................................................... 247

Monitoring and control of currant clearwing moth (Synanthedon tipuliformis Cl.) and black currant stem midge (Resseliella ribis Marik.) on black currant plantations

Labanowska, B.H. ................................................................................................. 253

Current pest management status in IFP in Uruguay

Nunez, S. & I. Scatoni .............................................................................................. 259

PLANT PATHOGENS

Alternatives to fumigation for control of Apple Replant Disease in Washington State orchards

Granatstein, D. & M. Mazzola ............................................................................... 265

Reducing losses due to fungal rots in cider apple orchards

Berrie, A. & L. Copas .............................................................................................. 273

Evaluation of the Adem Apple Scab Prediction system on Bramley’s Seedling Apple, Malus silvestris x Malus pumila Mill in Northern Ireland

Mac An Tsaoir, S. ................................................................................................. 279

Accuracy of a model simulating the dynamic of apple scab primary inoculum in the orchard

Rossi, V., S. Giosuè, I. Ponti & R. Bugiani ........................................................... 283

Effects of treatments with strong electrolysed water and fruit size on mould in storage mandarins

Schörner, A. ........................................................................................................... 289

Insect problems in a scab resistant/tolerant apple orchard in Hungary

Voigt, E. ................................................................................................................ 293

Study of relationships established within the apple-tree biocenosis genetically resistant to apple scab and powdery mildew, aiming to setting management of Integrated Fruit Production

Balan, V., A. Ivascu, S. Drosu, C. Chireceanu & M. Oprea ................................ 299

Prediction model of bitter pit risk incidence at post-harvest in Golden apples

Sió, J., J. Usall, I. Viñas & J. Boixadera ................................................................. 305
Biological control of *Monilinia laxa* on stone fruits
*Larena, I., A. De Cal & P. Melgarejo* ................................................................. 313

Use of a model simulating *Taphrina deformans* infection on peaches for optimal disease control
*Spada, G., G. Carli, I. Ponti, S. Giosuè & V. Rossi* ........................................... 319

Role of wood destroying fungi in orchards in Austria
*Kovacs, G.* ........................................................................................................... 325

Fungal endophytes of European Elder (*Sambucus nigra*) and their role in the occurrence of corymb wilt symptoms
*Steffek, R.* ........................................................................................................... 331

Usage of UV-C light to protect Fuji apples from *Penicillium expansum* infection
*Valdebenito-Sanhueza, R.M. & L. Raseira Maia* .................................................... 335

Severity of apple scab in monoculture and mixture of apple cultivar's orchards
*Masny, S. & A. Bielenin* ........................................................................................ 339

The suppression of ascospore production of *Venturia inaequalis* and changes in the microbial population of apple leaves after autumn urea treatment
*Meszka, B. & A. Bielenin* ..................................................................................... 345

**OTHER ASPECTS OF IFP**

Incidence des haies sur les peuplements d'arthropodes prédateurs en verger de poiriers
*Debras, J.F. & R. Rieux* ......................................................................................... 349

Effects of vineyard soil management and fertilization on grape diseases and wine quality
*Marangoni, B. Marangoni, M. Toselli, A. Venturi, M. Fontana, D. Scudellari* ........ 353

Fruit development, yield and quality in response to irrigation and nitrogen application on *Golden delicious* apples

Timing irrigation by measurement of seasonal fruit growth of apple
*Lakatos, T., T. Bubán & O. Krammer* ................................................................. 367

Herbicide use and the sustainability of soil quality
*Bromilow, R.H.* .................................................................................................... 373

Flowering ground cover plants for pest management in peach and apple orchards
*Brown, M.W.* ....................................................................................................... 379

Soil management and weed control in French orchards: towards new approaches governed by the principles of integrated farming
*Bernard, J.-L.* ....................................................................................................... 383

Towards insecticide free apple orchards in Quebec
*Bostanian, N.J., H. Goulet & L. Masner* .............................................................. 389

Horticultural performance, soil quality, and orchard profitability of integrated, organic, and conventional apple production systems
*Andrews, P.K., J.D. Glover & J.P. Reganold* ....................................................... 393
Effects of treatments with strong electrolysed water and an organic extract with minerals on fruit quality of mandarins – a field trial
Schörner, A. .................................................................................................................. 401

Volume rate adjustment in apple trellising in the Upper Valley of Río Negro, Argentina
Magdalena, J. & S. Bemher .................................................................................................. 403

Label concept for untreated fruits
Schaub, L. ..................................................................................................................... 409
Functional Biodiversity and Agro-Ecosystems Management:
1. Identified Information Gaps

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Introduction

Biological pest control has been a central preoccupation of IOBC ever since its foundation in 1956. Important additional elements and tools of plant protection became available especially in the late 1970s and 1980s and were incorporated in the 1993 IOBC concept of Integrated Production (IP) and Integrated Plant Protection (IPP) such as indirect plant protection measures, agro-ecosystems, ecological infrastructures and habitat-management (see Boller et al. 1999 and full texts on internet).

Modern regional IP-guidelines established according to IOBC standards address three important items that are of special relevance to the aspect of functional biodiversity and are referring to the three trophic levels of a modern cropping system: 1) the list of key pests, diseases and weeds; 2) the identification of at least two key antagonists and their protection and enhancement; and 3) the identification and management of at least 5% of the farm surface as ecological compensation areas (infrastructures). An additional 4th element of relevance in this context consists of the green and yellow lists of pesticides permitted without or with clearly defined restrictions in IP-programs. These 4 items are part of the Technical Guidelines II and hence mandatory aspects to be addressed in all guidelines and in all crops.

Observations of the Commission during the endorsement procedure of relatively well advanced IP-programs indicate that in most cases the key pests and diseases are well defined, that a list of antagonists is established and that the 5% ecological surface rule is fulfilled. Great progress has been made in the proper selection of pesticides exhibiting no or only minor negative side-effects on important beneficials.

Identified Problems

Whereas most formal requirements are apparently fulfilled the quality of these features raise questions.

We can observe that the lists of antagonists are usually very large and rather general. The few lists found that focussed on a few “key antagonists” often identified the key organisms by intuition and serendipity rather than by judgement based on hard experimental facts. The situation becomes even more difficult if we consider the first trophic level, i.e. the botanical characteristics of the cover plants within our crops or of ecological infrastructures situated outside our cropping systems.

What are the characteristics of a good ecological infrastructure necessary to supply, maintain and enhance the key antagonists? In most situations we simply lack competent answers.

In order to achieve progress in the plant protection tools of a sustainable agriculture there is need to generate and to compile more information about the importance of individual key
antagonists, to gather more information about the food sources and host spectra of our most important predators and parasitoids; and especially to get sounder information about the plant species where our beneficial organisms find these resources.

Finally, we should be able to establish recommendations, however crude and simple at the beginning, on how to establish, maintain and enrich these botanical habitats both outside and inside our crops. All these aspects are somehow covered by the modern term of Functional Biodiversity appearing more and more frequently in the relevant literature. Functional biodiversity does address explicitly the question we are interested in: Which part of the popular and often eroded term of biodiversity is relevant for our agricultural purposes and for the active habitat management at the farm level?

We are grateful to the IOBC/WPRS Council for having identified the need for deeper investigations in the field of functional biodiversity and for encouraging its working groups to address this important matter during their meetings. The Commission on IP-Guidelines strongly supports the Council’s recommendation and extends its thanks and appreciation to the organisers of this meeting for putting this topic on the agenda. Should even a project – however modest – emerge from this meeting the objective of our introductory presentation would be more than fulfilled.

Before Mark Brown will cover the specific aspects of functional biodiversity in fruit production I would like to close my first introductory part with a few practical examples taken from my own experience in Swiss viticulture.

**Practical examples from viticulture**

Orchards and vineyards are both perennial systems that show certain interesting potentials not available to annual crops. One such aspect is the possibility to plan the establishment and maintenance of ecological infrastructures over a longer period of time. Despite these similarities we are fully aware of the fact that the situation in viticulture and in fruit orchards are quite different.

After many years of investigations on the floristic and faunistic aspects of the vineyards in Northern Switzerland we can confirm the expectation that the situation is quite complex. However, we arrived at the conclusion that even a complicated situation could possibly be reduced with respect to arthropod pests to a few robust facts and recommendations that can immediately be applied at the farm level:

**(Potential) key pests:** From the list of potentially damaging arthropod species we declared spider mites (*Panonychus ulmi, Tetranychus urticae*) and the 2 grape moth species (*Eupoecilia ambiguella, Lobesia botrana*) as key pests. Pests of secondary importance and problematic only under certain conditions are eriophyid mites (*Calepitrimerus vitis*) and the grape leafhopper (*Empoasca vitis*).

**Two key antagonists:** Out of the list of potential antagonists we selected *Typhlodromus pyri* as key antagonist no. 1 and a parasitoid complex represented by *Trichogramma* spp.(parasitoids of grape moths) as a second group of key antagonists. Recent investigations confirmed that the choice of parasitoids as a large and general biodicator group was still valid, but that Mymarids (parasitoids of the green grape leafhoper *Empoasca vitis*) were of higher economic importance than *Trichogramma* spp.

**Ecological compensation areas:** *In close vicinity to vineyards* we recommend the protection of existing hedges and border areas containing a certain amount of black
berries/brambles (*Rubus fruticosus*) as important source of phytoseiid mites (Boller, Remund & Candolfi, 1988), and wild roses (*Rosa canina*) as a major source of host insects for the leafhopper parasitoid *Anagrus atomus* (Remund & Boller, 1996; Baur et al. 1998). The burning nettle (*Urtica dioica*) should be tolerated to the largest possible extent as important food plant for indifferent lepidoptera (and aphid species) and hence important for the build-up of their parasitoid complex.

*Inside vineyards* we can (under certain conditions such as sufficient precipitation, application of pesticides harmless for honey-bees) establish and maintain a species rich plant community with predominantly perennial broad leaf herbs. Furthermore, we can provide by an alternating mowing regime a permanent flower supply, hence increasing dramatically the faunistic diversity. In the present (and still very limited) Swiss list of ecologically interesting plants in vineyards (Boller, Gut and Remund, 1997) we find among others the common nettle (*Urtica dioica*), the wild carrot (*Daucus carota*) and the ground elder (*Aegopodium podagraria*).

These few recommendations to the grape growers will possibly provide the basis for ecologically more interesting compensation areas inside and outside the vineyards.

Monitoring the development of the faunistic diversity in vineyards is still in development. The existing wisdom suggests that we do not want to utilise the presence of phytoseiid mites as only ecological yardstick. We are trying to develop additional robust tools (e.g. yellow sticky traps as “ecometers” exposed for 1 week) for catching e.g. Mymarid parasitoids as more reliable bioindicator species.

**References**


Functional Biodiversity and Agro-Ecosystems Management:
2. Role in Integrated Fruit Production

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Abstract: The orchard ecosystem needs to be redesigned, with consideration of all management activities, to allow us to make use of the biodiversity that exists. The use of selective control alternatives will help preserve the biodiversity, but system level management changes are needed to fully take advantage of biodiversity to help manage pest populations. Examples of current activities to enhance the functional biodiversity of orchards are reviewed, and recommendations for future research are given.

Key Words: biological control, agroecosystem management, bioindicators

Introduction

The main problem with maintaining biodiversity in orchards is horticulturists. Not to disparage the profession of Horticulture, but orchards have been designed by horticulturists to maximize both total productivity and the quality of the fruit yield. To maximize harvests, orchards are grown as monocultures with very little genetic diversity. When other plants are grown in orchards, it is to aid in horticultural management, such as single species of grasses to reduce soil erosion and compaction and to allow tractor traffic in the orchard to perform management operations. Use of pesticides, synthetic fertilizers, mowing, and tillage also tend to reduce the orchard's biodiversity. In the spirit of Integrated Fruit Production (IFP) we must seek to redesign orchards to incorporate all aspects of orchard management, not to maximize production but to optimize all inputs into orchard production. Greater integration of pest management into overall orchard management is needed to ensure more ecological approaches to fruit production (Prokopy 1994, Boller et al 1998). It is necessary to redesign the way orchards are established and managed to make greater advances toward true biological management of orchard pests (Hill et al. 1999). We must begin to think of pest problems as an indication of an unhealthy ecosystem rather than a normal aspect of agriculture.

Enhancing arthropod functional biodiversity

The composition of the arthropod community on apple has been well documented (e.g., Oatman et al. 1964, Mészáros 1984). However, there has been little analysis of the multitude of interactions found among the various insects and mites beyond specific predator/prey interactions. General comments on the orchard ecosystem have been made (Croft and Hull 1983, Liss et al. 1986), but without more specific knowledge of how the ecosystem functions and responds to external inputs, success in our attempts at managing orchard ecology are dependent upon good luck. Progress in understanding the ecology of arthropods in orchards is being made. Szentkirályi and Kozár (1991) have shown that the regional extra-orchard
landscape is important to the biodiversity of apple orchards. I have shown that the arthropod community on apple can be highly resilient to disturbance in the form of pyrethroid application (Brown 1993). The effects of insecticides on the arthropod community have been well documented (e.g., Pickett & Patterson 1953, Massee 1958), but horticultural practices can also influence arthropod ecology by providing more vigorous and nutritious food for herbivores (Brown & Welker 1992).

Selective insect control alternatives such as mating disruption (Howell et al. 1992), attract and kill (Charmillot et al. 1996), and more selective insecticidal activity (e.g., de Reede et al. 1985) have been shown to control specific pests without disrupting the entire community of arthropods. These pest control alternatives are valuable tools for us to enhance functional biodiversity. For the remainder of this discussion, however, I will focus on studies that use a systems approach to pest management, where the primary approach is to manage the orchard habitat to be more attractive to natural control. Some of the alternative control methods mentioned will be used with habitat manipulation to develop a management system that will be acceptable to farmers and society.

Paoletti (1999) has reviewed the various farming systems that can be used to increase functional biodiversity in agricultural ecosystems. Most recent research on enhancing biodiversity in orchards has focused on increasing plant diversity within the orchard system. Planting flowering plants to provide nectar, pollen, alternate hosts and refugia for beneficial arthropods has been researched in many regions. Predatory mite abundance has been enhanced by increasing the diversity of broadleaf plants in apple and pear orchards (Coli et al. 1994, Tuovinen 1994), but at least one study has found no such increase in response to plant diversity (Nyrop et al. 1994). Abundance and diversity of predators and parasitoids have also been increased with the use of flowering plants in New Zealand (Stephens et al. 1998), Hungary (Jenser et al. 1999), England (Solomon et al. 1999), North America (Brown & Glenn 1999), Switzerland (Wyss 1996), and China (Yan et al. 1997). However, not all studies with flowering plants have resulted in a subsequent increase in biological control (Gruys 1981, Vogt & Weigel 1999). Fewer studies have examined fruit crop yield and quality, which must be done before this technology can be transferred to farmers. Altieri & Schmidt (1985) did show lower codling moth damage in an orchard with flowering plants compared with an orchard with bare ground, both with organic pest control methods. Brown & Glenn (1999) found fruit quality in an orchard with ground covers and reduced insecticides equivalent to that in a conventionally managed control orchard, but total yield was reduced in the orchard with ground covers.

Hedgerows and windbreaks can also increase orchard functional biodiversity (Solomon 1981, Rieux et al. 1999). Both of these studies have shown that selection of the tree species in the hedgerow is important in providing predators and parasitoids that are adapted for foraging in orchards and in preventing increased pest pressure (both insect and disease) on the fruit trees. Hedgerows also influence dispersal patterns of both beneficial and pest insects (M. E. Whalon, Michigan State University, pers. comm.). I have also been investigating the effect of interplanting several fruit tree species in an orchard on pest dynamics (Brown 2000). More work needs to be done to address landscape scale ecosystem diversity beyond the orchard ecosystem.

Another opportunity for enhancing functional biodiversity in orchards is through the use of organic mulches. Organic mulches are extremely good for soil quality and fertility (Glover et al. 2000). Organic mulches have also been shown to increase arthropod abundance and diversity, including several major predator groups (Mathews 1999).
Enhancing microorganism functional biodiversity

Less study of the diversity of microorganisms on fruit trees has been done as compared with arthropods. The micro-fauna on apple fruits has been documented (e.g., Bizeau et al. 1990), but the ecological relationships among microorganisms remain largely unexamined. The use of conventional fungicides does severely reduce the functional biodiversity of microorganisms in orchards (Andrews and Kenerley 1978). Increasing microorganism biodiversity as antagonists to control pathogens on fruit has had varying degrees of success with post-harvest diseases (Wilson et al. 1993), apple scab (Kalenich and Padalko 1996, Carisse et al. 1997), and fire blight (Zeller and Wolf 1996). Wilson (1998) has reviewed aspects of conservation biological control with microorganisms in fruit. Several methods of plant disease management that would lead to conserving the functional biodiversity of microorganisms were addressed at the Working Group on Integrated Control of Pome Fruit Diseases meeting in Croydon, UK, in 1996. Mixing several cultivars of apple, including scab resistant cultivars, has reduced scab severity, even in the susceptible cultivars (Bousset et al. 1997). Application of urea in the fall to accelerate the decomposition of overwintering scab (Cimanowski et al. 1997) and breeding resistance to diseases (Kellerhals et al. 1997) were also discussed. Any control method based on sanitation of disease inoculum could also enhance functional biodiversity.

Recommendations for Future Research

1. A critical need before implementing orchard management to enhance functional biodiversity is the identification of one or more bioindicator guilds. Bioindicators are species or assemblages of species that are particularly well matched to specific features of the ecosystem and/or react to impacts and changes within the ecosystem (Paoletti and Bressan 1996). Through the use of such bioindicators, managers can easily determine the health of their ecosystem without surveying the entire biodiversity. The use of a guild, rather than one species, would give better and more useful information on ecosystem health because some species in a guild could be very sensitive to environmental impacts, whereas others could be more resistant, thus giving a range of conditions that could be monitored. A useful bioindicator must be taxonomically well-known, ecologically understood, readily surveyed, broadly distributed in higher taxa, specialized and sensitive to habitat changes in lower taxa, reflective of biodiversity patterns in other unrelated taxa, and important to some aspect of ecosystem function (Pearson 1994). Appropriate bioindicator guilds for fruit production need to be identified, and basic ecological information must be gathered to establish sampling protocols and characteristic guild structures for various states of ecosystem health.

2. More studies identifying the microorganism biodiversity in orchards are needed if we are to be able to rely upon increased functional biodiversity to provide more natural control of plant diseases. We must know what species are present before we can try to manage them.

3. More information on the ecological interactions, both among arthropods and among microorganism communities, is needed. Successful management relies on being able to predict ecosystem responses to specific management inputs. If we do not understand how species, species groups, and trophic levels interact, we cannot accurately predict the outcomes of our management efforts.
Table 1. Specific research projects to further knowledge of functional biodiversity and to effectively manage functional biodiversity in orchards.

<table>
<thead>
<tr>
<th>1. Bioindicators: select appropriate guilds (such as phytoseiid mites or coccinellids); identify the guild composition and individual species niche requirements worldwide.</th>
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<tr>
<td>3. Ecological interactions: elaborate interactions among species and trophic levels under different management regimes.</td>
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<tr>
<td>4. Pest control alternatives: continue development of alternatives for all pest groups including resistance breeding, selective chemicals, management options.</td>
</tr>
<tr>
<td>5. Landscape scale management: compile data on fruit/pest/antagonist interactions, including extra-orchard influences; identify information gaps; develop simple models building up to more complex ecosystem models.</td>
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</tbody>
</table>

4. More options for selective, non-disruptive pest control of arthropods and pathogens are needed to allow us to manage individual pests without destroying ecosystem health as a whole.

5. Management of the functional biodiversity of orchards must be approached at a landscape scale. Beyond redesign of orchards, this will require higher levels of integration of fruit production to include entire agricultural landscapes. The 5% ecological compensation in IFP may not be enough, and consideration of the influences made by species pools in parkland and residential areas must be included for management of beneficial and pest species.

Specific research projects that will further our knowledge of functional biodiversity and help us begin to effectively manage this biodiversity are given in Table 1. To facilitate the landscape scale approach to fruit production and support the research efforts to address these needs, more integration and coordination of the research effort is needed. Through the auspices of this IFP Working Group, such coordination is possible. Regional or even global effort is needed to identify appropriate bioindicators and to identify the more critical ecological information that must be collected before we can implement more ecologically based management systems to take advantage of the functional biodiversity that exists in orchards.

References


Integrated Fruit Production in France: a new challenge for horticultural research


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Abstract: The paper presents the framework which a large group of INRA researchers have used to design a cooperative research project on integrated fruit production (IFP). Within this framework, special attention was given to multidisciplinary issues. These entail several interfaces: between the technical and economic fields, within the technical fields between crop production (including quality) and crop protection and, last, between research and development. To address these issues, the project was divided into several tasks which contribute to the multidisciplinary approach: the economic analysis of IFP as a new production standard, strategies of producer organisations, decision rules at the orchard level, and the biotechnical modelling of the fruit crop. The paper also provides a broad outline of expected results, among which one of the most important is the building of a dynamic collaboration between research, extension and stakeholders.

Key words: multidisciplinary approach, orchard management itinerary, fruit quality, pest, modelling

Introduction

Integrated Fruit Production is likely to become the new standard for fruit production in Europe (Sansavini, 1997), though the operationalisation of its definition (OILB/SROP, 1993) is constantly evolving and subject to interpretation. This flexibility maintains the dynamic and innovative features of integrated production and lends itself to a multi-criteria conceptualisation of sustainability (Landais, 1998). In this way, integrated fruit production calls for an adaptation of agricultural practices that influence the biological processes related to the development of fruit quality and the environmental impacts of fruit production.

Despite the fact that the adoption of certain aspects of integrated fruit production (IFP) has met with resistance in France as a result of both local socio-cultural practices and technical deadlocks (Toubon, 1999), we feel that a sustainable technical and organisational change is progressing in the field of IFP in France. This change challenges researchers not only with regard to their capacity to produce scientific data necessary to accompany this change but also to anticipate the focus and direction of this change.
In order to meet these expectations, we have developed a research project which takes the evolution of IFP into account. The design of the scientific project involved a major coordination effort between researchers from many different fields (about 25 INRA researchers participated, to varying degrees, in discussions and drafting of working tools and concepts). We hope that this coordination will result in a wealth of interdisciplinary knowledge which will correspond to the type of questions asked.

We will briefly present the challenges, objectives and expected results for this original research program whose purpose is to promote the development of IFP.

**Interface challenges**

We identify three major challenges which correspond to multidisciplinary relationships between scientific fields and to relationships to be established between researchers and their partners.

- To provide an interface between economic and socio-economic fields, on the one hand, and the technical fields, on the other hand, by clearly defining (i) the operating practices involved in integrated fruit production for farms and producer organisations (PO’s) as well as (ii) the economic environment of the producers in general.

  Our aim is to link the forms of production implemented by different operators and the biotechnical models developed by agronomists within the framework of IFP. Indeed, we approach it as a social construction in that IFP is not an established standard. Two positions exist in France: (i) those who are for a minimum technical standard (“acceptable practice code”) which would guarantee food product safety for the consumer but would validate overall production practices as it were; (ii) those who are for a more rigid standard that would make it possible to create a new market segment (product certification, label). Each position has qualitatively different socio-economic impacts, which this project will identify.

  To contribute to an IFP standard implies that the relationships between practices implemented by fruit farmers and the development of technical specifications must be clearly specified. These practices then have the status of variables to be explained (Biarnes and Milleville, 1998).

- To provide an interface between agronomists in the field of fruit production and plant protection specialists since it is absolutely necessary to take both production and protection into account if we are to meet the expectations of producers within the framework of IFP.

  Modelling the effect of cultivation techniques on harvest quality is a crucial concern at this time in relation to IFP (Sansavini, 1997; Gary et al., 1998). This modelling will be the bases for management itineraries that would make it possible to successfully meet a production objective. It also seems necessary to study the interactions between orchards and parasites in greater depth, with emphasis on the environmental effects of management itineraries and pest control strategies in particular. Models of parasite development and production must not only be linked together (Habib and Lescourret, 1999), but defined in relation to management entities used by farmers and the indicators upon which they rely. Such models are the basis for proposing decision-making tools that are truly useful for crop management (Sebillotte and Soler, 1990). The existing forms and diversity of these indicators must be identified through producer surveys. Moreover, on-farm surveys make it possible to not only evaluate the factors that limit yield and quality, but to formalise the farmers’ decision rules (creating the basis of proposed decision-making tools).
• To provide an interface between public research, interprofessional and professional organisations since success of the project will be measured by the scope of its impact. We hope that this interface will motivate the farming sector to concentrate its efforts in view of its capacity to deal with new regulatory requirements and to come up with proposals adapted to changes in regulations and the operationalisation of IFP. It is the specifications related to environmental questions and the quality of products, in particular, which necessitate negotiations between farmers and other social participants (Brossier and Dent, 1998). As a matter of fact, IFP does not propose standard management itineraries to the orchardist but, instead, reasoning modes (indicators to be observed, intervention thresholds, etc.) and an extended range of technical means (e.g. alternatives for pest control without using chemicals). At the same time, agricultural advisors need new reasoning tools which will provide them with the means to evaluate the likely consequences of technical changes on production. On the other hand, some distributors establish agreements linking them to producers, and commit themselves to providing consumers with quality products. This period of soul-searching and questioning seems to be a good time for defining partnerships and for contributing to the building of social demand (Sebillotte, 1999).

Objectives and organisation of the INRA IFP program

Objectives and identification of research tasks
The organisation of the project revolved around four major research objectives:

1. Analysis of the evolution of the IFP concept and its implementation at the different levels of the sector within both national and community institutional and economic settings.
2. Understanding of how fruit farming practices are determined by the way producers are organised within PO’s (in relation to their marketing objectives, for example), as well as inherent limitations (e.g., type of farm, work organisation, physical layout of orchards in relation to the landscape, etc.).
3. Characterization of practices implemented by producers and identification of their activity categories. Association of observed practices with agronomical performances in relation to other factors (examination of deviations from the desired objectives or norms).
4. As appropriate, building tools to help the professionals in modifying the technical specifications as a function of local and/or regional characteristics so that the final results are in keeping with the proposed objectives (by designing management itineraries subjected, to some degree, to biotechnical models).

In order to facilitate the relationships between the different scientific fields, the project was organised into “blocks” which are identified as tasks. These tasks, which are most often pluridisciplinary, were, themselves, broken down into activities which were generally monodisciplinary (and which could be evaluated by peers).

Task descriptions
• Development of socio-economic and socio-technical bases for IFP
We hope to develop knowledge about the economic and institutional environment which supports the systems in which agricultural production activities will be carried out. We consider that the IFP norm\(^1\) defines itself and becomes operational as a result of the

\(^1\) We have adopted a broad definition here of “norm” or “standard” (anglo-saxon term): norms may be imposed or voluntarily adopted; they may exist from a legal point of view within the framework of government regulations or voluntary associations (\(de\ jure\) norm); or, they may only be the result of an individual strategy of a large firm or uncoordinated microdecisions of several firms (\(de\ facto\) norm).
interaction between individuals and institutions (consumers, upstream and downstream partners of producers, the authorities, competitive foreign businesses) and covers, like most of today’s norms, a decisive strategic dimension for the organisation of participants and their respective roles (Reardon et al., 1999). Consequently, it becomes useful and necessary to re-examine the relevance of chosen variables and to think about the problem in more general terms, beyond the farm itself. This point of view is in keeping with an institutional type of economic approach in which it is considered that market mechanisms (prices) are not likely to solve economic coordination problems (quality, traceability, etc.) by themselves. These mechanisms must be backed up by formal or informal rules which may be either voluntary or imposed (technical specifications, labels, official signs of quality, international standards, etc.). Such rules are administered by different types of institutional systems, private or public, that we intend to define.

Moreover, we consider that the supply basin, considered by agronomists as a management entity for product quality (Le Bail, 1997), will evolve into a "coordination level" in the years ahead. It consists of producers who bring their products to an intermediate marketing entity (producer organisation or private shipping agent). This producer/intermediate marketing unit forms an economic coordination unit with identifiable limits and which operates on a continuous basis in order to meet a set of shared objectives (Brousseau, 1995). The integration of an aspect of agronomic study (field, crop management itinerary, etc.) within a coordination level also modifies the ways in which biotechnical entities are conceived.

- Development of biotechnical bases
  Our goal is to design biotechnical models which compensate for certain major shortcomings in existing models when used with crop management and technical decision-making objectives. We therefore intend to:
  - take the entire production cycle and the management itinerary which characterises it into account rather than just certain periods or isolated technical means;
  - consider the individual fresh product and its characteristics and not just the summed up dry matter at the field or tree level (as in Grossman and De Jong, 1994, for peach trees, for example);
  - take the development of the variability of fruit quality into account at the different organisation levels (Lescourret et al., 1999), rather than making the assumption of homogeneous production at the orchard level;
  - clearly explain the effects of the interaction between genetic factors (choice of variety) and environmental and technical factors (crop operations);
  - allow for the fact that a plant may be sick or that an orchard does not always function under optimal conditions and take this into consideration in the development of this new generation of models.

Risk evaluation models whose purpose is to help make decisions concerning treatment(s) (i.e., fungicides, insecticides), resulted in a great deal of research. Doyle (1997) identified 4 major reasons which could limit the scope of application of these models: (1) they do not deal with non-chemical methods of control; (2) environmental risks are often overlooked; (3) they are not mechanistic enough to propose an alternative to classic treatments; (4) they generally only concern one type of parasite.

Agronomic performance and disease and pest control are separate areas of modelling at this time. Thus, the need to quantify the impact of parasitism on the way plants grow and on yield becomes increasingly obvious if we are to better define economic tolerance thresholds
(Riba and Silvy, 1989). If we assume (Blaise et al., 1996) that a treatment strategy can only be optimised if we are capable of quantifying the consequences of a treatment decision, the problem comes down to quantifying the risks of yield loss (quantitative and qualitative) related to a treatment error. Moreover, yield loss is not the only criteria of choice for protection measures. Economic tolerance thresholds will be higher if the adopted methods (by allowing for a reduction in chemical control) lead to increased production and provide for the long-term regulation of parasitism by restoring ecological balances (e.g., the creation of varieties resistant to certain diseases, microbiological control methods). The study of these types of interactions is of major importance in developing sustainable arboriculture, one that is based on the principles of fruit quality, human health and respect for the environment and which is economically viable at the same time. To our knowledge, this direction has not yet been sufficiently explored (e.g., apple trees: Elfing et al., 1993; grapevines: Blaise et al., 1996).

Expected results and project consequences

In comparison with the three challenges described above, we have identified the results and consequences of the project that we feel that we can reasonably hope to obtain. They are summarized in Table 1. We also present the relationships between tasks in the last column of the same table.

Each task brings researchers of different backgrounds together to work with the same objective in mind. Each task is under the direction of one person. This approach encourages interactions between tasks, and even gives rise to complementary associated “tasks” within work groups in order to specifically study certain interfaces that are particularly sensitive (e.g., between socio-economic and technical fields).

In the same way, an economic analysis of the institutional mechanisms which produce the IFP norm and which integrate it into the sector (and not just at the production level), must, in return, make it possible to carry out a critical analysis of the performance variables used in simulation models.

Conclusion

The design of this project, which took place over a long period of time and which generated discussions which were both numerous and productive, has already had a very positive effect on some of us by making us rethink our research programmes and adapting them so that the interfaces between our different specialities can be taken into account. In this way, it seems to us that the means for designing the project and the interactions between researchers that resulted from it are, themselves, the answer to doubts that were sometimes expressed about a set, pre-determined organisation of knowledge. This was done by opting for a progressive definition that included both socio-economic and technical considerations in identifying areas of knowledge which would be useful/urgent to explore. It is obvious that one should not be unduly optimistic but, nevertheless, this was certainly a conscious attempt at a real collective appropriation of the project by a group of partners interested in its advancement.
<table>
<thead>
<tr>
<th>Tasks</th>
<th>Expected results</th>
<th>Consequences of the project</th>
<th>Relationships between tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/ Economic analysis of the institutional environment of IFP</td>
<td>Description of the institutional IFP environment at the national and international levels. Specific description of coordination measures between producers and distributors for the development of IFP. Analysis of consumer perceptions of the production sector.</td>
<td>Evaluation of experiments concerning IFP. Assistance with decision-making for authorities and the profession. Evaluation of coordination mechanisms for the establishment of IFP. Information to make market signals clearer for the consumer.</td>
<td>Relationships between product qualification changes and production means, the operation of “enterprises” (farms, stations), and the coordination methods between the concerned parties (individuals and collectives [Tasks 1/ and 2/]).</td>
</tr>
<tr>
<td>2/ Analysis of the strategies of producer organisations (PO) in relation to IFP</td>
<td>IFP qualification: adaptive strategy or innovative organisation model? Formalisation of a reference frame in view of the development of collective technical norms (technical specifications): relationships between types of farms, production rules and conditions for implementing technical specifications.</td>
<td>Help with revising and negotiating technical specifications. Decision-making assistance for a qualification strategy (differentiation, communicable characteristics, type of certification). Support for the choice of IFP by producers (investments, risk management, organisation of activities on the farm).</td>
<td>Identification of relevant entities for “upward” traceability, making it possible for the fruit farmer to follow the fruits (biotechnical and transaction entities) all the way to their final destination [Tasks 2/ and 3/].</td>
</tr>
<tr>
<td>3/ Analysis of practices and the formulation of models of decision-making rules</td>
<td>Formalisation of decision-making models for farmers: relationships between the codification of arboriculture practices and the contents of the technical specifications. Analysis of the feasibility of combining decision-making models for farmers and biotechnical crop models.</td>
<td>Development of management charts for orchard management. Complementarity between decision-making models and optimisation models subject to constraints.</td>
<td>Tools for collective action: “hybrid” entities (harvest sites, etc.) and disposition measures (supply basins) [Tasks 1/ 2/ and 3/].</td>
</tr>
<tr>
<td>4/ Formalisation of a biotechnical crop model</td>
<td>Relating an orchard model to a parasite(s) model. Orchard management model making it possible to test innovative decision rules, to organise them on the basis of a multicriteria analysis and to limit the range of experiments on sets of decision rules.</td>
<td>Consideration of fruit quality and « environment » in orchard management. Improvement of selection criteria and criteria for the choice of seeds for the improvement of varieties.</td>
<td>Development of knowledge about the technical management of orchards, compatible with the decision models of the fruit farmers [Tasks 3/ and 4/].</td>
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For the project in general:
- Creation of a Research - Development - Stakeholders dynamic.
- Adaptation of the orchard (replacement, quality management, protection of the environment) to new market specifications.
- Development of knowledge to help with negotiations at the national and international level.

Table 1: Expected results and consequences of the project
References


Farming system comparison in integrated apple growing

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Abstract: Apple farming system research on two locations revealed that an integrated and a minimum system were less profitable than a conventional system, mainly because of their extra labour demand. The integrated and minimum system had a much lower impact on the environment. Large reductions were made in the use of insecticides and herbicides. A reduction in the use of fungicides proved more difficult. Omitting fungicides against fruit tree canker proved disastrous and reducing the fungicide dosage against scab impossible. Manual control of powdery mildew in stead of fungicide application was sufficient. Insect problems in the minimum system increased on one location, but not on the other.

Key Words: farming system research, integrated control, pests, diseases, apple, economics

Introduction

Dutch agricultural policy at the end of the eighties aimed at a reduction of dependence on pesticides while maintaining high production levels of good quality. In support of this policy agricultural research and extension was directed towards integrated crop production (Schenk and Wertheim, 1992). A special research program for integrated fruit production was initiated in 1989. Farming system research into integrated apple production formed the major part of the program and started the same year. The aim of the farming system research was the development of an economically sound and environmentally sustainable apple growing system.

Materials and methods

Three farming systems were designed, a conventional system, an integrated system and a system with minimal chemical inputs. Each system covered 0.5 ha on the regional experimental orchards in Numansdorp and Zeewolde. Per system eight cultivars were planted: Jonagold, Elstar, Red Boskoop, Cox’s Orange Pippin, Alkmene, Discovery and the Vf-resistant Ecolette and CPRO 78039-27. Trees were planted in single rows in a 3 m * 1.25 m arrangement in the spring of 1990. In Numansdorp the trees were uprooted after the harvest of 1994. In Zeewolde the experiment was ended after the harvest of 1996.

The conventional farming compelled to the guidelines for environmentally conscious production (MBT). Where possible the dosages of the chemicals were reduced to 75% percent of the advised amount. Predatory mites (Typhlodromus pyri) were introduced for the control of red spider mite (Panonychus ulmi) and rust mite (Aculus schlechtendali). For scab (Venturia inaequalis) and powdery mildew (Podosphaera leucotricha) initially regulated control after van der Scheer (1992) was applied. From 1995 RIMpro was used as a warning and decision making model for scab.

The integrated farming system compelled to the international and Dutch Integrated Fruit Production (IFP) standards. Pesticides forbidden in ground water protection areas were not used and broad spectrum pesticides avoided. Management was aimed at a low environmental
impact while maintaining the conventional production level. Where possible the dosages of pesticides were reduced to 50% of the advised amount. Predatory mites were introduced and mating disruption with pheromones controlled leaf rollers. Different methods to reduce herbicide use were tested. No carbaryl was used for thinning.

In the minimum system more risks regarding the production were taken compared to the integrated system. For all pest and disease problems it was tried to find biological control measures. It was attempted to reduce all remaining pesticide applications to 25% of the advised dosages. Fruit tree canker (*Nectria galligena*) was controlled solely by removing infected shoots and cutting out cankers. Powdery mildew was controlled by cutting infected twigs. Different biological weed control methods were tested. No spraying scheme against storage diseases was implemented. Except GA$_{4+7}$ no growth regulators were employed, thinning was done by hand.

Of fifteen sample trees per cultivar per system growth, production and damage due to insects, diseases and other causes were monitored. Pest and disease incidence in the trees and herb coverage of the weed-free zone were recorded. The capital investments and the amount of labour used per system were registered. The three systems were evaluated agronomically, economically and environmentally continuously and adaptations in their management were made regularly. New insights were incorporated in the systems and banned chemicals were abandoned. As a result the used methods and chemicals changed over the years.

**Results and discussion**

**Economic results**

The cumulative economic results are presented in figure 1. No costs for buildings, machinery and land are incorporated. It was assumed that all management and 10% of picking and sorting was done by regular labour, costing €14.5 per hour, and 90% of picking and sorting by casual labour, costing €7.7 per hour.

![Figure 1: Cumulative economic result of the conventional, integrated and minimum system in and Zeewolde (1990-1996) Numansdorp (1990-1994).](image)

Figure 1 shows the highest economic return for the conventional system in both Zeewolde and Numansdorp, the minimum system had the lowest economic result while the integrated system had intermediate results. The figures for Numansdorp should be considered with caution, as the systems were productive for only four years.

The differences in economic result were caused by a combination of factors. Figure 2 shows the percentage of loss compared to the result of the conventional system caused by different parameters.
Higher labour demand for the alternative weed control in the integrated and minimum system was the most important factor in reducing the economic result. Production loss in 1992 as a result of weed competition and rust mite damage in 1991 reduced the result in the minimum system in Zeewolde. Production loss in the integrated system in Numansdorp developed gradually. Quality loss due to insect pests was an important factor in Zeewolde, not in Numansdorp. The costs of anti-weed cloth raised input costs in the minimum system in Numansdorp.

**Environmental impact assessment**

The environmental impact of the three systems as a result of pesticide use was assessed using the CLM ‘environmental yardstick for pesticides’. The environmental yardstick values sprayings according to their impact on soil life, water organisms and ground water. Table 1 gives the average yearly scores of the three systems in Numansdorp and Zeewolde.

Table 1 shows that fungicides and insecticides gave the highest environmental hazards in the conventional system. The minimum and integrated systems in both Zeewolde and Numansdorp successfully diminished the environmental hazard due to insecticides and herbicides. Reducing the environmental burden due to fungicides proved much more difficult.

Table 1: Average yearly scores of the conventional, integrated and minimum system on the environmental yardstick for pesticides in Numansdorp (1992-1994) and Zeewolde (1992-1996).

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Integrated</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zeewolde</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td>4639</td>
<td>455</td>
<td>1977</td>
</tr>
<tr>
<td>Insecticides</td>
<td>2767</td>
<td>504</td>
<td>6802</td>
</tr>
<tr>
<td>Herbicides</td>
<td>667</td>
<td>116</td>
<td>259</td>
</tr>
<tr>
<td>Total</td>
<td>32463</td>
<td>1076</td>
<td>9038</td>
</tr>
<tr>
<td><strong>Numansdorp</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td>7924</td>
<td>628</td>
<td>2954</td>
</tr>
<tr>
<td>Insecticides</td>
<td>2396</td>
<td>508</td>
<td>6668</td>
</tr>
<tr>
<td>Herbicides</td>
<td>501</td>
<td>78</td>
<td>203</td>
</tr>
<tr>
<td>Total</td>
<td>10821</td>
<td>1213</td>
<td>9826</td>
</tr>
</tbody>
</table>

The score on the environmental yardstick depended largely on the use of a few insecticides and fungicides. The fungicide thiram and the insecticide propoxur accounted for the bulk of the points in the conventional system in Numansdorp. One application of the insecticide fosalan was responsible for the three times higher yearly burden on water life in the conventional system in Zeewolde compared to Numansdorp. By not using these pesticides the score in the minimum systems was low. In both Numansdorp and Zeewolde, propoxur was used in the integrated system, which increased the risk of groundwater pollution dramatically.
**Pest & Disease management**

After reduction of the fungicide dosage to 50% and 25% of the advised dosage in the integrated and minimum system respectively, scab could not be kept under control. It was decided to treat all systems with a standard captan scheme. The scab resistant cultivars were never sprayed. The other cultivars were sprayed according to a decision scheme for regulated control (Van der Scheer, 1992). From 1995 the RImpro decision making model made reductions in the number of fungicide applications in Zeewolde possible. Since all the systems were subject to the same control scheme no differences in scab infestation were found.

Powdery mildew control measures were implemented according to the guided control decision scheme for powdery mildew after Van der Scheer (1992). Although powdery mildew infection in the minimum system was higher than in the conventional and integrated system, it was never problematic.

Cutting shoots and cutting out cankers did not sufficiently control fruit tree canker in the minimum system. The infection exploded in Zeewolde in 1995 after a wet autumn and winter season, more than 8000 infected shoots were cut in the minimum system (see table 2). High disease pressure due to the high infestation in the minimum system caused the integrated and conventional system to suffer from high canker infection. The conventional and integrated system were sprayed twice with 1.87 and 1.25 kilos of Captan respectively.

| Table 2: Number of shoots infected with canker per system per year in Zeewolde. |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| Conventional                    | 8     | 2     | 3     | 172   | 872   | 114   |
| Integrated                      | 9     | 2     | 7     | 149   | 1586  | 185   |
| Minimum                         | 12    | 9     | 42    | 258   | 8026  | 1979  |

In Numansdorp no remarkable differences in average insect damage percentages between systems were found. In Zeewolde the minimum and integrated system suffered notably more damage from insect pests than the conventional system. The total percentage of apples with insect damage amounts 6.8% and 3% in the minimum and integrated system respectively (see table 3). This explains the loss due to lesser quality in the minimum system in Zeewolde.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Caterpillars (Lepidoptera) in springa</td>
<td>0.5 %</td>
<td>1.5 %</td>
<td>2.5 %</td>
<td>1.0 %</td>
<td>1.1 %</td>
<td>1.4 %</td>
</tr>
<tr>
<td>Leafrollers (Tortricidae)</td>
<td>0.9 %</td>
<td>0.3 %</td>
<td>1.8 %</td>
<td>0.5 %</td>
<td>0.4 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Rosy apple aphid (Dysaphis plantaginea)</td>
<td>0.1 %</td>
<td>0.5 %</td>
<td>0.7 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td>1.0 %</td>
</tr>
<tr>
<td>Earwigs (Forficula auricularia)</td>
<td>0.2 %</td>
<td>0.3 %</td>
<td>0.9 %</td>
<td>1.0 %</td>
<td>1.8 %</td>
<td>1.1 %</td>
</tr>
<tr>
<td>Green apple capsid (Lygocorus pabulinus)</td>
<td>0.2 %</td>
<td>0.4 %</td>
<td>1.0 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Codling moth (Cydia pomonella)</td>
<td>0.2 %</td>
<td>0.1 %</td>
<td>0.0 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Dock sawfly (Ametastegia glabrata)</td>
<td>0.3 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total harvest</td>
<td>1.8 %</td>
<td>3.0 %</td>
<td>6.8 %</td>
<td>3.5 %</td>
<td>4.0 %</td>
<td>4.1 %</td>
</tr>
</tbody>
</table>

aPest damage below 0.1% is not presented; bSecondary damage, original cause of damage impossible to establish.

The introduction of predatory mites proved to be effective. In the second year after introduction an equilibrium situation with no red spider mites and little rust mites and predatory mites established. Correction with fenbutinoxine proved useful in the first year in Zeewolde, but redundant in Numansdorp.
Savona did not control rosy apple aphid in the minimum systems. It was decided to combat the pest with a single pirimicarp (200 g/ha) treatment against the stem mothers. This proved less efficient than the integrated and conventional treatment. Depending on field observations two pirimicarp applications of 200 and 300 g/ha were given respectively.

Spring caterpillars (*Operophtera brumata* and *Orthosia spp.*) gave a high damage percentage in the minimum system in Zeewolde. The flight of moths was monitored with pheromone traps. Treatment was implemented when the threshold level of 2 or 3 caterpillars per 100 clusters was exceeded. Diflubenzuron and fosalone gave adequate control in the conventional system, but fosalone scored extremely bad on the environmental yardstick. Bacillus thuringiensis preparation did not control spring caterpillars successfully in the integrated system in 1995 and 1996. The temperature was too low, it should be warmer than 15°C for successful control of spring caterpillars (Niemczyk, 1980). No increase in damage over the years was observed in the untreated minimum systems, nevertheless the damage level in the minimum system in Zeewolde was high.

Leaf rollers, including codling moth, were controlled by mating disruption with RAK 3+4, 500 dispensers per hectare. This proved effective against all species except eyespotted bud moth (*Spilonota ocellana*). In Numansdorp damage due to leafrollers was limited, but slightly higher in the conventional system without mating disruption. In Zeewolde damage was inexplicably high in the minimum system in 1995, probably due to *Spilonota ocellana*.

The use of environmentally harmful pesticides against green capsid bug in the conventional and integrated system proved unneeded in Numansdorp as the damage pattern in the untreated minimum system showed the same low damage pattern. In Zeewolde the damage due to green capsid bug was highest in the minimum system due to a damage of 2.6% in 1996. Propoxur gave adequate control in the integrated and conventional system at the cost of high environmental hazard.

Different weed management strategies were tested. Brushing with contact herbicides and burning gave no adequate control and were too labour intensive due to the low working speed. Woven polypropylene cloth required too much investments and labour and was not fool proof as weeds grew on the sides and at the tree stems. Narrowing the width of the weed free strip to 50 cm in combination with contact herbicides spraying worked effectively in Zeewolde. Besides this active herb control was ended at the onset of summer. This reduced the environmental burden due to herbicides compared to the conventional system.

**Conclusions**

The farming systems research made clear that integrated apple production could reduce the environmental hazard. The economic result of the integrated and minimum systems lacked behind the conventional systems, mainly due to extra labour demand and to a lesser extend due to quality and production loss. Further research into integrated farming system development should focus on these factors.

Reducing the use of harmful insecticides and herbicides proved easier than reducing the amount of fungicides. Chemical canker control was indispensable and reducing the scab fungicide dosage failed. Chemical mildew control could be substituted by cutting infected branches.

**References**


Status of Integrated Production in French apple orchards

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Abstract: Over the last ten years, numerous strategies have been implemented by French growers in order to valorise fruit production. Widespread support for the French initiative known as “Agriculture Raisonnée” or “Integrated Farming” of the EIF (European Initiative for Integrated Farming), was observed in the 90s, targeted mainly towards consumers with emphasis on the preservation of the environment. The diversity of private steps towards certification or quality assurance is detrimental to the expression of their specificity compared with conventional production. Some representative French IFP guidelines were analysed. Their requirements concerning protection practices bear more on the EIF guidelines than those of the IOBC. We found a few references to the foundation of integrated pest management, i.e. the integrity of the agro-ecosystems which could, for example, result from regulated requirements for preservation of the biodiversity or for restrictions on pesticide use. The other agricultural practices are only stated as recommendations by the IOBC. This institutional framework does not fully express the progress of IFP in France, observed through quality initiatives and control procedures. We also expect a convergence of the EIF and IFP as a result of the implementation of alternative pest-control methods and of the withdrawal of the most harmful compounds from the European registry. This analysis also points out the necessity of associating all the participants in the fruit production network and the predominant role of advisors in IFP programs.

Key words: apple orchards, institutional framework, integrated pest management, quality, control

Introduction

Integrated Production was originally a scientific concept, defined in Europe by the IOBC and whose purpose was to obtain quality products while preserving the integrity of agroecosystems (IOBC, 1993). The support of French fruit growers for the IOBC guidelines related to Integrated Fruit Production (IFP) remained marginal for a long time because they were too demanding at the technical level, not competitive enough at the economic level and were at odds with socio-economic curbs as well. At the beginning of the 1990’s, professionals and representatives of industry and distribution created the French Federation of Environment-Friendly Integrated Farming (FARRE), bringing the European Initiative for Integrated Farming (EIF) to France. The concept of integrated farming which calls for a commitment to production quality, respect for the environment and a sustainable agriculture seems to be very similar to IFP, as far as its objectives are concerned. But the different types of farmers and the wide range of regional and national approaches in the fruit industry (IFP or integrated farming, as well as quality approaches), make it difficult to interpret the developments in progress and the real effects on the organisation of production. In order to analyse the institutional framework of IFP in France in this document, we have limited ourselves to one product, the apple, in order to facilitate the presentation, and to the specifications representative of approaches taken in the southeast region, at the local level.
Reference documents analysed

The documents consulted can be divided into three integration levels (Fig. 1):

– **National level.** These documents deal only with general intentions and address themselves, on the whole, to institutions and to farmers as well (for analysis purposes, we will refer to the IFP Charter of the National Apple Section, or determine stringent technical requirements directed towards technical-economic groups (COVAPI).

– **Regional level.** These documents, technical breakdowns of the general level, make up the specifications (reference documents). They must be approved by higher authorities and involve the obligation for external control. This is the case of the Rhône Mediterranean Basin (BRM) guideline, a regional adaptation of the national apple charter, and of the Integrated Production reference document of the GRCETA (Regional Group of Technical Agricultural Research Centres) which ascribes, in particular, to the FARRE guidelines. The integrated production charter of SUD NATURE, as is the case with the BRM and the GRCETA, is recognised by the national apple charter. Its approach is based on technical guides that it approves.

– **Local level.** It is at this level that the specifications are implemented, either by economic interest groups or by the fruit growers themselves who can refer to the practical guides published by these groups.

At all of these levels, differences between the specifications are also determined by the process which may remain private or which may be the subject of official recognition by the French government through the National Commission of Labels and Certification (CNLC). Among the “certified features communicated to the consumer”, we can mention *Integrated Pest Management* (COVAPI) which appeared in 1993, *Integrated Production* (Fruits of the Alps of the Haute Durance) in 1994, *Integrated Production and Respect for the Environment* (GRCETA) in 1997 and other features (including IFP) after 1997. Today, the CNLC refuses to certify a global production concept within the framework of a specific product certification, if the product is not different from a conventional product.

**Orchard management**

While their general principles are based on the IOBC guidelines, the technical guidelines analysed base their communication mainly on respect for the environment and on the health and taste aspects of the production. Only the COVAPI gives priority to the notion of the integrity of the agrosystem, calls for orchard management and refers to actions in favour of the environment and maintains the principle of standards which are stricter than those in the regulations.

On the other hand, traceability, which is implicit in the IOBC guidelines, is a requirement and included in the contracts for all of the French charters or specifications and, as a result, represents a guarantee for the consumer, particularly in the area of food safety.

**Agronomy section**

The recommendations in the technical guidelines, like the IOBC guideline, are not very specific in relation to subjects such as stock, variety, tree management and shape, or load management. The objectives are identical, that is, to satisfy tree requirements to the greatest extent possible and to achieve a vegetative/reproductive balance which would guarantee quality production. The technical guidelines may be more specific on some subjects than the IOBC guideline. This is the case for pollination control and for the counting of floral organs. But none of them explicitly forbid the use of growth regulators for purposes other than chemical thinning, nor do they recommend a preference for manual thinning (unrealistic for most apple varieties). Likewise, there is no mention of a preference for parasite-resistant or tolerant cultivars.

The principles announced by the IOBC and the guidelines are also similar on the subject of fertilisation and irrigation. Decision-making is based on the same indicators: analysis of the soil and leaves, rainfall, evapotranspiration. But in the absence of utilisation instructions, these practices cannot be counted on to reduce pollution risks in one case or another.
It is the biological diversity and landscape management that most clearly differentiates the IOBC guideline from the specifications in the agronomy section. The national apple charters, SUD NATURE and the BRM specifications mention the beneficial role of hedges and ecological compensation areas which are not, however, obligatory. None of the specifications covers the maximum size of fields. If this specification is included, it would have practical implications when hail protection nets, which make it possible to eliminate windbreak hedges, are laid, possibly leading to the creation of continuous apple cultivation units of 40 ha.

**Pest and disease control section**

Concerning pest and disease control, few national or regional guidelines include obligatory preservation of key beneficials. However, the SUD NATURE charter does recommend the preservation of beneficial fauna and of the biodiversity. The GRCETA reference document mentions a beneficial to the apple tree, *Neoseiulus californicus*, plus another for the pear tree, *Anthocoris nemoralis*. The BRM specifications recommend the introduction of phytoseids if they are not present in the crop.

Protection management is based on the scientific monitoring methods described for each species in the technical guides (ACTA, CTIFL), for both risk evaluation and intervention decisions. A specific point exists at this level in the GRCETA reference document which makes it possible to intervene on a range of possible solutions concerning population levels which are lower than the tolerance thresholds.

The COVAPI requires that a positive product list be drawn up as well as a list that can be used with restrictions, recommends residue contents lower than the legal standard and an increase in time allowed before harvesting. The BRM specifications and the Sud Nature charter include the possibility of more restrictive product lists, without obligation. The other technical guidelines authorize without restriction all the registered compounds.

Several groups such as the COVAPI comply with the IOBC guidelines on all of the issues concerning protection. For the majority of the technical guidelines, protection measures strictly comply with the regulations, considered to be a guarantee of food safety. But the obligation to record interventions and to protect farmers, of training and even of the classification of products according to their toxicity, forces fruit growers to be aware of their responsibilities and encourages them to adopt protection methods which correspond to the IFP objectives.

**Control procedure**

According to the IOBC, the farm is the unit that is subject to control. The technical guidelines are technical reference standards which concern the production approach for each product (pomefruits, apples) whereas the recording of practices concerns the production unit (field). The technical guidelines also constitute a contract which is subject to control and for which two systems coexist:

– **internal control**, under the responsibility of technical groups and handled (i) locally by a technician (orchard monitoring) or the person in charge of quality (post-harvest controls), and (ii) regionally or nationally by the higher level (economic committee) which approves local specifications and accredits production structures through the Certification Organisms. This procedure is the result of the national apple charter in particular, which is not approved by the CNLC for the IFP label.

– **external control** in the case of compliance certification of products (CCP) or systems (ISO) and also of private guidelines. The internal control is supervised by an independent certifying agency, itself approved by the CNLC. This is the case for the GRCETA (Integrated Production CCP), and the COVAPI (CCP, IFP). These specifications comply, at this level, with the IOBC Integrated Production guideline of 1999.
Fig. 1: Institutional Framework for IFP in France and some significant Guidelines for Apple Production

**SUPRA-NATIONAL and NATIONAL LEVEL**
- Institutions
- Interprofession
- Farmers

**REGIONAL LEVEL**
- Institutions
- Interprofession
- Advisors

**LOCAL LEVEL**
- Producers Organizations
- Advisors
- Farmers

- **IFP NATIONAL CHARTER FOR APPLE PRODUCTION**
  - S.N.P.
  - FARRE
  - IOBC

- **EIF CHARTER**
  - BRM
  - SUD NATURE ®
  - COVAPI

- **IFP TECHNICAL GUIDELINES III POME FRUITS**
  - Guidelines for IFP
  - Guidelines for IFP

- **REFERENCE DOCUMENT FOR CERTIFICATION**
  - Agreement
  - Agreement

- **REFERENCE DOCUMENT FOR REASONED PRODUCTION**
  - Agreement
  - Agreement

- **TECHNICAL AND ECONOMICAL GROUPEMENTS**
  - FARMS AND FARMERS

**CO**: Process checked by a Certification Organism approved by CNLC
- FARRE: Federation of Environment-Friendly Integrated Farming (E.I.F) – GRCETA: Regional Group of Technical Agricultural Research Center
- S.N.P.: National Apple Section
Discussion and conclusion

At the technical level, the technical guidelines analysed recommend an integration of the agronomic management of the orchard on the same bases as the IOBC whose guideline is too general on the subject to be able to characterise IFP production.

The guideline lays out strict rules only for pest and disease control measures and the preservation of the biodiversity. Therefore, the only way that it would be possible to consider a production in compliance with IFP according to IOBC standards would be to adopt regulations concerning these control measures. On this basis, the IFP label would only apply to a limited part of the French apple production.

But more than 50% of the organised production in France receives the approval of the national charter at this time. On these grounds, it is designated as IFP by the national apple section, on bases which are not as strict as those of the IOBC concerning protection but extremely stringent in relation to traceability. However, the French acceptance of IFP is not detrimental to the level of technicality of the fruit growers, nor of their commitment to new production methods or to a quality approach. It should be mentioned that an INRA-professional network exists for tree management, making it possible to regularise the fructification and restrict the use of chemical thinning, as well as networks that monitor fruit maturity to determine when harvesting will begin, or brands. Technical aspects such as load management, which are more clearly defined in some of the technical guidelines than in the IOBC guideline, also satisfy the quality objective as a result of a better homogeneity of the size and maturity.

In the area of protection, a group such as the GRCETA, which is dedicated to integrated farming, makes sure that its members maintain phytoseids, recommends mating disruption in peach trees to fight against *Cydia molesta* and has experimented this method to fight *Cydia pomonella* for a long time. The registration of mating disruption against *C. pomonella* in the year 2000 provides the opportunity to consider the establishment of Territorial Farming Contracts (similar to agri-environmental subsidies), based on employment incentives to provide the weekly visual controls that are required. These incentives to adopt methods that reduce pollution and the expected withdrawal of the most toxic active compounds from European registrations will encourage the progressive adoption of a more global IFP approach.

And then there is the problem of the commercial development of products resulting from IFP. The practices that they involve are often costly and their present definition does not give fruits the distinctive qualities which would make it possible for the consumer to recognize them. The same is true for the increasing diversity of the intervening parties and the guidelines. But the IFP specifications are increasingly becoming a condition for access to the market and the certifications guarantee the identification of products all the way to the stand.

The multidisciplinary IFP research activities undertaken by INRA should make it possible to eliminate some of the technical and socio-economic obstacles discussed in this study. One must also question the concept of IFP itself, which resulted from an initiative by plant protection specialists and which unperfectly integrate farming practices other than those within the protection framework. These research or development activities should also encourage consideration of the protection-production interaction, the real environmental impact of fertilisation and irrigation methods and the impact of the new official framework on the economic viability of the farms.
Ten years of IFP in Poland – theory and practice

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Abstract: Integrated Fruit Production (IFP) in Poland was commenced 10 years ago (1991) and during first 5 years regarded only apple orchards. In next years also guidelines for strawberries (1995), pears (1997) and sour cherries (1999) were elaborated. During organization of IFP, special attention was paid to activity and initiative of individual IFP groups. In this article the actual situation in practice dealing with integrated production in apple orchards is described. It regards: control of the pests, diseases and weeds, fertilization of the orchards, cooperation of advisory service with fruit growers, activity of IFP groups, estimation of grower performance for IFP certificates and evaluation of IFP by fruit growers.

Key words: IFP (Integrated Fruit Production), apple orchards, Poland

Introduction

Poland is one of the important fruit producers in Europe. We produce 2 - 2.5 million tons of fruits yearly, including 1.5 - 2 million tons of apple, 156 thousand tons of sour cherries and 400 thousand tons of berries, mainly strawberries, currants and raspberries. About 70 % of the fruits is being consumed in the country The rest of production is exported, mainly as concentrated apple juice and frozen berries. In order to compete on the world marked the fruits and and fruit products have to meet the highest standards. Therefore it is desirable, they should be produced in integrated orchards. Also the domestic market increasingly gives priority to fruits originated from "integrated" orchards.

Development and status of IFP

The integrated fruit production (IFP) was established in Poland at 1991. The animator of IFP was Research Institute of Pomology and Floriculture at Skierniewice. Because of specific situation in the past imposed by government and not accepted by farmers (collectivization, only one farmer cooperative organization infiltrated by the government) we decided to start building IFP "from the bottom on the farmer level". The special attention was paid on initiative, activity and creativeness of the fruit growers. They had to be volunteers and organize the IFP groups by themselves, however with the assistance of governmental extension staff. The farmers had also to cover the costs of 2 days introductory IFP course when it was necessary.

Actually over 1000 fruit growers organized in 36 groups are running their apple orchards in different regions of the country on the total area of 7300 ha. This is being done according to European IFP guidelines actualized every 2 years. In 1999 as many as 625 growers obtained certificates for about 100 000 tons of apples what amounted about 13 % of total production of Polish table apples. The integrated production of strawberries was commenced
in 1995. Four years later (1999) 68 growers produced strawberries on an area of 215 ha harvested 2250 tons of certified strawberry fruits. In 1997, IFP guidelines were issued for pears and in 1999 preliminary guidelines were prepared for sour cherries. In nearest years the guidelines for currants and raspberries should be issued.

Section of Integrated Fruit Production belongs to The Association of Polish Fruit Growers. Section works on the basis of own regulations and IFP guidelines as well as on the statute of Association.

Control of the pests in IFP apple orchards

Only leaf rollers (Tortricidae) have to be controlled each year in all "integrated" apple orchards. The green apple aphid (Aphis pomi) and rosy apple aphid Dysaphis plantaginea have to be kept on low level by insecticides in majority of orchards. Against codling moth (Cydia pomonella) the insecticides are used once or some times twice a year but only in about 80 % of apple plantations. In some orchards it is necessary to control spider mites (Panonychus ulmi, Tetranychus urticae), apple blossom weevil (Anthonomus pomorum), apple sawfly (Hoplocampa testudinea) and leaf miners [Stigmella malifoliella and Leucoptera malifoliella (= Cemiostoma scitella)]. All pests may be effectively controlled with 13 insecticides (acetamiprid, bensultap, diflubenzuron, teflubenzuron, hexaflumuron, pirimicarb, parafine oil, bacterial preparations (Bt), baculovirus (cpGV), phosalone and fenitrothion) and 7 acaricides (chlofentezin, hexythiazox, fenbutatinoxyd, tetradiphon, propargite, cyhexatin, parafine oils). Insecticides and acaricides are usually used 3 times during the season. In some "integrated" apple orchards and in some years the pests may be effectively controlled by 2 treatments only. Rather rarely it is necessary to use insecticides 4 times. In comparison to standard orchards number of sprays is decreased by 30-50 %.

The orchardists against majority of the pests have for disposition 20 selective or semi-selective chemicals for control of noxious arthropods. However they use most often only fenitrothion (Sumithion, Owadofos) and acetamiprid (Mospilan), because those preparations are the cheapest ones and have rather broad spectrum properties. The more expensive insecticides often are used only against; leaf minners (acylurea preparations) and aphids (pirimicarb).

Bt preparations (Dipel, Thuridan, Bacilan) and granulosis virus (Carpovirusine) are very rarely applied in Poland, because of their high price and lower efficacy as compared to chemical insecticides.

The predatory mite Typhlodromus pyri has been introduced to our apple orchards since 11 years. But still this predator does not occur in majority of "integrated" apple orchards. During last two years the fruit growers are more interested in inhabiting their orchards by T. pyri which is resistant to fenitrothion and phosalone.

Control of the diseases

Apple scab is the most important disease in our orchards. In Poland the farmers practicing IFP may control the apple scab using about 30 different selective fungicides. Only pyrazophos (Afugan) and triforine (Saprol) are forbidden to apply. Few other fungicides containing mancozeb (Dithane, Pencozeb) and methiram (Polyram Combi) are recommended to be used very carefully during first two years after T. pyri introduction. From 8 to 14 sprayings with fungicides are usually applied against apple scab in Polish conditions. The number of treatments performed in "integrated" orchards are usually about 30 % lower compared to standard plantations. In the case of apple scab control, the orchardists first of all take into
account the efficacy of fungicides and not their price. The importance of powdery mildew during last years is not very high, because this disease is suppressed by many new compounds recommended for control of apple scab.

**Bioregulators in IFP apple orchards**

Bioregulators are not used commonly in IFP apple orchards. For thinning of apple fruitlets, NAA (Pomonit) and urea are applied in some orchards. For acceleration of ripeness of apples and their better coloration the trees are sprayed with etheaphon (Ethrel) in low number of plantations. However during the last few years some growers due to advertising and strong pressure of chemical companies want to use the other bioregulators especially prohexadione calcium (Regalis), after its registration.

**Fertilization**

In Polish orchards the usage of fertilizers and especially nitrogen has been distinctly decreased during last 10 years. This is also true in the case of IFP orchards, in which, according to the guidelines, the amount at fertilizers which have to be used are evaluated according to growth of the trees and of soil and leaf tissue analysis. Presently usually only 40 - 70 kg per ha of nitrogen is applied. Some IFP groups hired specialists who take soil and leaf samples for chemical analysis and then, according to the results recommend how to fertilize the particular orchards. Unfortunately during the last years, because of great activity and pressure of chemical companies some IFP growers applied the leaf fertilizers even when it is not necessary.

**Weed control**

In majority of the orchards only glufonisate (Randup or equivalents) and glyphosate (Basta) are used. Only in young orchards the low doses of simasine (Azotop) are also applied. In some orchards the weeds in the tree rows are being destroyed mechanically or are prevented to grow by mulching the soil with organic substrates or black polivinyle tapes.

**Advisory service**

The IFP has to be conducted in cooperation with advisory service. The extension officers are workers of three government institutions. During last four years also private advisers, paid by fruit growers have started to operate. The good advisers should be characterized by high professional and practical knowledge, they should be deeply engaged in IFP and respected by farmers. However only part of them fulfil these requirements. Majority of advisers can be ranked to the moderate level workers. Advisers collaborate with growers in different ways:

* Adviser visits particular orchard several times during season. At the time of survey the adviser records the appearance of the pests and diseases, determines their threshold levels and then informs the grower about the condition of his orchard and leaves the recommendations.

* Several times during the season, the adviser meets with the groups of orchardists in different villages. During the meetings he inform the farmers about the actual situations in their orchards, discusses the problems and leaves the recommendations.
Adviser visits the particular orchards only upon the request (calling) of the owner.

Activity of the IFP groups

Probably the most important advantage of IFP in Polish conditions is integration of the members of the groups. The particular IFP groups numbered from 10 to 150 persons. The large groups are divided into smaller sub-groups. Activity of each group always depends on the activity of 1 - 2 persons. If the leader of the group (usually adviser and rarely farmer) has high authority and can devote enough time for IFP, the activity of such group is also high or excellent. Such activity may differ and may cover several fields, for instance:
1. promotion of IFP by organizing temporary exhibitions, advertising the sell of "integrated fruits" in large shops, in local radio or in local newspapers,
2. selling the fruits collectively in super markets,
3. arranging the funds from different sources for different enterprises dealing with development of IFP,
4. providing all members of the group with different supplies for production of the fruits for lower prices (pesticides, fertilizers, insect traps),
5. organizing professional excursions and visits to different regions and countries.
6. organizing the meetings with best specialists.
7. organizing the different social events for group members and their families.

Financing of IFP activity

The activities of IFP groups are financed mainly by their members. Each member depending on the settlement of group pays certain amount of money. Usually each farmer pays about 40 Euro per year. During the first 5 years (1990 - 1995) almost all IFP groups were additionally supported by Ministry of Agriculture by so called "mini grants" amounted from 15 000 to 40 000 Euro. The costs of work of extension advisers is covered by Ministry of Agriculture. However, as it was mention already, some groups also hired and pay the private advisers.

The IFP members have also to cover membership and certification for Section of IFP (about 6,5 Euro) and for Fruit Grower Association (about 13 Euro per year). Similarly as it is in UE many IFP groups are registered themselves as official "farmer organization" and they believe, that in the future they may get financial support from European Union.

The evaluation of growers performance for IFP certificate

The growers may obtain the IFP certificate only on the base of their own application and opinion of 3 member's committee. The committee surveys the orchard and checks the grower's field books 2-4 weeks before harvest.

The protocol for actual year contain 37 questions dealing with situation and culture practices in the examined orchard. They concern occurrence and control of the diseases, pests, weeds and cultural practices as well as activity of the grower. The grower for performance of different questions earns the different number of points (0,10,15,20). He can obtain the certificate only when he accumulate a minimum of 336 points (70 %) of a possible 480 IFP points. Practices need to be documented by written records in the field book.

Such method of evaluation is simple, clear and allows to get concrete information concerning running of individual IFP orchards in different regions of the country. Additionally by creating the questions of different values (with different numbers of points) it is possible to introduce into IFP orchards the most actual and desirable practices.
Evaluation of IFP by fruit growers

In anonymous survey conducted recently (September 2000) the majority of the orchardists stated that they practiced IFP because: IFP is the future (93 % of the farmers), they accept the pro ecological principles of IFP (89 %), they may conduct orchard in more rational way (85 %), they may decrease the number of the sprayings against pests (91 %) and diseases (80 %), they may use less fertilizers (85 %), they have better contacts with advisers (95 %), they are sure, that IFP creates occasion for better professional knowledge (95 %) Contrary only 10 % of the growers stated that they may earn better price for "integrated apples" and only 20 % of the orchardists may sell their "integrated apples" easier both for export and for domestic market.

On the question concerning difficulties in conducting of apple orchards, about 50 % of the farmers responded that they have no problems with observations of the pests and fulfil the "field book". As many as 79 % orchardists expressed opinion that they have for disposal adequate amount of recommended fungicides, but only 50 % of the farmers thought the same in the case of insecticides, 54 % in the case of herbicides and 39 % in the case of bioregulators. For 91 % of the farmers the recommended selective insecticides are too expensive and for 75 % of them also fungicides are too costly.

Probably the most important statement resulted from presented situation is, that about 90% of the farmers accepted IFP, 87 % of them are convinced that there is weak interest of consumers and market for "integrated fruits", only 20 % of growers concluded that "integrated apples" are easy to sell and 10 % of producers think that for such apples one cannot obtain the higher price. The practice confirm such situation. The better marked for IFP fruits in Poland exists, but still is too small. The farmers who make good business selling "integrated apples" had to create personally the local marked for such fruits. The large farmer's organizations engaged in storing, grading and selling of the fruits produced by many individual orchardists are just start to develop. But it is also true, that actually still the most profitable for farmers is selling the fruits individually

References

Development of Integrated Fruit Production Programmes in the New Zealand horticultural industry

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Abstract: The New Zealand fruit industry has seen a rapid uptake of IFP production programmes over the last five years. The first New Zealand IFP programme based on the IOBC philosophy commenced in pome fruit in 1996 and in the four seasons to 1999-00 had over 85% industry adoption. IFP implementation has lead to a 50% reduction in insecticide use, with a 72% reduction in organophosphate insecticide use. The programme has increased grower adoption of insecticide and fungicide resistance management strategies. Use of fungicides disruptive to integrated mite control has been reduced to a point where miticide use is rare. The pome fruit IFP model has been used to develop similar programmes in other fruit crops, most notably for process peaches and more recently fresh market nectarines, cherries and apricots. The New Zealand wine grape industry has also implemented a sustainable production programme that follows most aspects of the IFP philosophy. There has been a smaller, but significant increase in organic fruit production over recent years, with approximately 6% of the national pome fruit crop now produced under an organic production standard. This paper describes the process of IFP implementation in pome fruit and stone fruit and documents problems encountered and the benefits achieved from the programmes.

Key words: IFP, pome fruit, stone fruit, pest management, New Zealand

Introduction

The New Zealand horticultural industry is small by international standards and is driven by exports, not domestic sales. Annual export returns from horticulture are approaching $NZ 2 billion and they form about 14% of the country's agricultural exports. Apples and kiwifruit each represented ca. 30% of total horticultural exports from New Zealand in 1999-00, with the balance made up from processed fruits, vegetables and flowers. Produce is exported to over 100 countries, with the European Union, UK, USA and Japan the primary markets. New Zealand’s ca. 1,500 apple growers produce just 1% of global production, with about 300,000 tonnes of export apples. Stone fruit production is primarily for the domestic fresh market and processing, with about 25% of the crop exported to Australia, Japan and the USA. Wine grape production has expanded recently to over 12,000 hectares and 27% of the wine production is exported.

With a domestic market of about 4 million people the New Zealand fruit industry’s focus has always been dominated by exports. Traditionally the apple industry differentiated itself in international markets through new cultivars and fruit quality. Phyto-sanitary requirements in international markets dominated crop protection practices and restricted opportunities for reducing pesticide use. However, since 1995, food safety and environmentally responsible production has become more important due to customer demands and customer assurance programmes driven by large supermarket chains. These demands have resulted in a rapid
uptake of Integrated Fruit Production (IFP) programmes within the apple industry over the last 5 years and this impetus has helped to catalyse this process in other horticultural sectors, including stone fruits (SummerGreen) and Integrated Wine Production (IWP). This paper describes the development and implementation of IFP pest management within the New Zealand apple and stone fruit sectors, including the outcomes and market access issues specific to our export fruit crops.

Methods

**Pome fruit** New Zealand has few serious pests of apples, with leafrollers (*Torticidae*), codling moth (*Cydia pomonella*) and scale insects (*Diaspididae*) the key pests requiring control. Mealybugs (*Pseudococcus* spp.), woolly apple aphid (*Eriosoma lanigerum*), apple leafcurling midge (*Dasyneura mali*) and European red mite (*Panonychus ulmi*) are occasional pests. The main diseases are apple black spot (*Venturia inaequalis*), powdery mildew (*Podosphaeria leucotricha*), crown and collar rots (*Phytophthora* spp.) and fire blight (*Erwinia amylovora*).

Development of the IFP programme for apples and pears commenced in 1995 with the establishment of a national IFP-Pipfruit Committee. Its principles were based on European IOBC guidelines and IFP was defined as: "The economic production of market quality fruit, giving priority to sustainable methods that maintain consumer confidence and are the safest possible to the environment and human health". The programme was based on continuous improvement and was developed through a structured decision-making process. ENZAFRUIT provided leadership of a committee which represented technical experts, growers, consultants, consumers, the environment, and the agrochemical industry.

New Zealand IFP guidelines for pome fruits were developed by 15 technical subcommittees covering site selection, rootstocks, varieties, soils and nutrition, water management, understorey management, tree management, spray application, pests, diseases, orchard environmental quality, industry operations, cleaner production, grower training and auditing. The pest management objective for the programme was to eliminate organophosphate (OP) insecticide use and, through the implementation of selective pest control, to maximise use of biological control. Other than OP insecticide use, many of the practices used by New Zealand fruit growers in 1996 already met IFP standards. Agrochemical use in orchards was highly controlled, growers were required to submit Pest Control Record (PCR) books to ENZAFRUIT or their exporter for auditing. Regular testing also ensured that residues were within the range of 0-10% of the lowest residue tolerance internationally.

To assist IFP implementation, consultants received training in facilitation, and pest and disease management. Growers and consultants were required to attend IFP discussion group meetings and practical training sessions. Implementation of IFP commenced in September 1996 when 88 orchards joined a pilot programme to test new guidelines for pest and disease management Walker *et al* (1997) and Manktelow *et al* (1997). Numbers of growers adopting IFP increased to 370 in 1997, 740 in 1998 and 1250 in 1999. IFP is now the minimum standard for all apples exported from New Zealand and all exports must meet IFP standards in the 2000/01 season. During implementation fruit quality was monitored annually to refine IFP procedures and to help build grower confidence in IFP recommendations. Pest thresholds and pesticide options for IFP in New Zealand are reported in Table 1.

Pest and disease management were focal points for review in the early stages of programme implementation. The risks associated with lower pesticide use presented potential quarantine and market access issue and required parallel development of two leafroller control thresholds to meet both customer demands in Europe and USA market access. Post-
harvest treatments were also developed to reduce these phytosanitary risks, including apple washing for occasional ‘passenger’ pests and controlled atmosphere storage regimes for some pests, e.g. mealybugs.

Some IFP pest management guidelines are based on pest phenology including pre-bloom use of mineral oil for the control of scale insects. For codling moth control tebufenozide, lufenuron or triflumuron, is recommended at petal-fall for and tebufenozide again, 2-3 weeks pre-harvest, to minimise the risk of leafroller infestation in harvested fruit. At other times growers are required to monitor for pests and respond with insecticide only if a pest thresholds are exceeded. Pest and disease monitoring must be recorded in an IFP Field Monitoring notebook. Applications must be justified, recorded and cross-referenced in the PRC book and submitted for auditing.

Table 1. Pest thresholds and recommended insecticidal responses for New Zealand IFP guidelines.

<table>
<thead>
<tr>
<th>Pest (and time)</th>
<th>Threshold</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple leafcurling midge</td>
<td>&gt;20% egg infested shoots</td>
<td>Diazinon¹</td>
</tr>
<tr>
<td>Codling moth</td>
<td>Either 5 moths in a trap in one week or &gt;2 moths/week or &gt;10 moths/week</td>
<td>Tebufenozide, lufenuron or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>triflumuron</td>
</tr>
<tr>
<td>Leafroller (November (December on)</td>
<td>Thinned fruit, 1/1000 fruit with damage &gt;30 moths/trap since last spray</td>
<td>Tebufenozide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or lufenuron</td>
</tr>
<tr>
<td></td>
<td>&gt;10 moths/trap (USA crops only)</td>
<td></td>
</tr>
<tr>
<td>Mealybug (Pre-bloom)</td>
<td>Presence on fruit last harvest</td>
<td>Oil + buprofezin²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or oil + chlorpyrifos</td>
</tr>
<tr>
<td>Scale (Pre-bloom (January))</td>
<td>Presence on fruit last harvest</td>
<td>Oil + buprofezin²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or oil + chlorpyrifos</td>
</tr>
<tr>
<td>Woolly apple aphid</td>
<td>Colonies on &gt;10% of shoots</td>
<td>Diazinon</td>
</tr>
</tbody>
</table>

¹ only recommended in young trees
² preferred treatment

**Stone fruit** There are relatively few pests of process peaches in New Zealand. The key pests are leafrollers, green peach aphid (*Mysus persicae*) and oriental fruit moth (OFM, *Grapholitha molesta*). The latter is absent from the South Island where the export stone fruit industry is centered in Otago. The New Zealand flower thrips (*Thrips obscuratus*) is also an important pest of fresh market stone fruit. The main diseases of stone fruit are brown rot (*Monilinia fructicola*), leaf curl (*Taphrina deformans*), and silver leaf (*Condisteria purpurem*).

Development of an IFP programme for stone fruits commenced with the process peach sector in 1996. This programme was driven by both the processor and by pome fruit IFP growers who also had stone fruit plantings. Most of these growers, encouraged by the apparent success of the apple IFP programme, converted their blocks across to new process peach IFP recommendations. Unlike the apple programme, which sought to progressively convert growers to new low pesticide use under IFP, these growers implemented IFP recommendations that were based on progressive and annual reduction of pesticide use. Pesticide records and fruit quality was also assessed at the end of each season and
recommendations modified to address any control issues. This programme subsequently provided the basis of SummerGreen, a pilot IFP programme that commenced in the 1999-00 season for fresh market stone fruit crops including peaches, nectarines, apricots and cherries.

Results

Fruit damage by insects and disease was monitored through field and packhouse assessments across many orchards nationally and found IFP guidelines produced fruit of equivalent quality to conventional programmes. Fruit quality outcomes for IFP production are reported in Walker et al (1997) and Manktelow et al (1997). Insect control improved under IFP pest management as biological control of some pests became more widely established within orchards. Initial control difficulties with woolly apple aphid have declined on most orchards as the parasitoid Aphelinus mali now plays an important role under the selective pest management programme. Decreased use of dithiocarbamate fungicides has resulted in more consistent mite control by the predator mite Typhlodromus pyri to a level where miticide use is now uncommon (Manktelow et al 2000). The incidence of mealybug in crops at harvest has declined with decreased OP insecticide use and several generalist predators now adequately control mealybug populations in IFP orchards. Apple washing technology was developed primarily for the elimination of mealybug and other pests infesting fruit at harvest. This technology has been implemented by many large packhouses and has improved the proportion of blocks passing USDA pre-clearance inspections for quarantine actionable species.

Figure 1. The decline in organophosphate insecticide use on the New Zealand apple crop occurring during implementation of IFP pest management between 1996 and 2000. Use will decline further as industry-wide adoption moves from 85% to 100% in the 2000-01 season.

Insecticide use was substantially reduced under IFP recommendations, 50% fewer applications were applied for insect control nationally in 2000 than were applied in 1996 (Figure 1). OP insecticide use has declined nationally by 72%, actual use in IFP orchards will decline even further as the IFP programme moves from 85% adoption to become a minimum export requirement for the 2000-01 season. Post-flowering OP insecticide use has been replaced by selective IGR insecticides with a typical use of 2-4 applications per season. Complete elimination of broad-spectrum OP insecticides from New Zealand apple production
is now a realistic goal that should be achieved by 2002. The quality of process peach crops has not declined despite a 60% decrease in OP insecticide use under IFP pest management. Leafroller damage has not increased and is well within the tolerance levels specified by the processor. OFM, a relatively recent arrival in New Zealand, has the potential to increase under this programme but mating disruption is already being used to successfully manage this pest in affected orchards. Aphicide use, for the control of *M. persicae*, has also declined while miticide use has been eliminated through the cessation of pyrethroid insecticide use.

Figure 2. The decline in insecticide use on process peach crops in New Zealand between 1995 and 1999 following implementation of IFP pest management recommendations.

**Discussion**

There have been no serious pest or disease management issues during the implementation of IFP programme throughout the main fruit growing regions of New Zealand. Leafroller and codling moth control has been excellent in most orchards and instances where damage has been higher than anticipated have usually been associated with growers not following IFP recommendations. This has included the use of products below recommended rates, inadequate spray coverage and improper use, or maintenance, of pheromone traps. Extensive fruit quality monitoring programmes, together with annual reviews of pesticide use and IFP programme recommendations have allowed refinement to pest and disease recommendations which are now widely accepted by growers. Pest management under IFP has had the biggest impact on orchard management. Reduced pesticide use has been offset by additional IFP pest monitoring costs (Walker *et al* 1997), but the new crop protection practices have simultaneously addressed important food safety and market access requirements for New Zealand growers. To ensure programme integrity IFP auditing is now completed by independent agencies on behalf of exporting companies. Other IFP management practices are also now widely adopted, including weed and understory management. Use of residual herbicides has declined markedly and most orchards now have weed free strips below 30% of their total ground cover. The role of the understory vegetation, grazing and soil fauna in the degradation of overwintering black spot ascospores is now widely accepted. IFP training programmes have improved grower and industry awareness of both pest and disease
management. The shift towards pest and disease monitoring, justification of pesticide use and selective insect control has only been achieved through comprehensive training for consultants and growers which is maintained through IFP Discussion Groups. New Zealand pome and stonefruit growers feel their IFP programme contains desirable elements of worker and environmental safety, with significant potential consumer and marketing benefits for their fruit, although these are largely unstated. Most growers like the IFP programme because they consider its safety better for themselves and their families. Other benefits include improved access to technical information to growers and access to other growers’ experiences through IFP Discussion Groups. The future of IFP pest management in the pome and stone fruit industries is now secure and was probably made easier through the initial leadership that ENZAFRUIT could apply to the programme through its export monopoly. With control over the marketing of export fruit now loosening the industry has collectively decided that IFP will be the minimum export standard. Leadership of the IFP programme for pome fruits has now been turned over to the grower-owned company, New Zealand Pipfruit Limited, which it will manage together with other ‘industry good’ functions. Perhaps the greatest challenge that IFP faces within the New Zealand pome fruit industry is the rapidly increasing interest in organic fruit production. IFP has unlocked many growers’ interest in organic production and there are now more than 100 either transitional or fully organic apple orchards. This interest is increasing rapidly, bouyed by higher financial returns and the progress made with some of the significant technological hurdles for pest and disease management and market access requirements.

Acknowledgements

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References


Integrated Production in Chile: peaches, nectarines and plums, two years of research and development

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Abstract: In 1998 the University of Chile started a research project on Integrated Production (IP) in stone fruits with the aim of developing a methodology of cropping, phytosanitary and postharvest management for peach, nectarine and plum trees. The project began with a diagnosis of the main producing areas in order to detect existing critical and limiting points for IFP. Such problems were oriental fruit moth, San José scale, aphids and mealybugs within the pests, and Monilinia, leaf curl, and powdery mildew within the diseases, mainly in peaches and nectarines. A trend to overthinning and very high nitrogen application in cropping, was also observed, whilst woolliness and internal browning were the main problems in postharvest. As derived from the diagnosis, specific trials were implemented and, for each species, two integrated systems were compared with a conventional one during two seasons. Results obtained so far have allowed by using IFP to produce, from a quantitative and qualitative point of view, similarly to the conventional system. The damage and presence of pest and diseases were higher than in the conventional system, but remaining under the tolerable thresholds of economic damage. In this third season the integrated systems under development are in the process of being commercially validated.

Key word: integrated fruit production, peaches, nectarines, plums.

Introduction

The stone fruit production is an important agricultural activity in Chile, intended both for internal consumption and to export. During last season Chile exported 5,6, 4,2 and 7,1 million boxes of peaches, nectarines and plums, respectively, being the main exporter of stone fruits in the South Hemisphere. The development of an IFP program in apple trees provided the stimulus resulting in that the University of Chile and 12 companies of the fruit sector, began working in 1998 in IP in these species, with the objective to develop the necessary technology for IP in stone fruits in the central zone of Chile.

Materials and methods

Diagnosis

In 1997, one year before the beginning of the trials, a diagnosis in orchards of the Metropolitan Region and VI Region of Chile was carried out, aimed at identifying the situation in Chilean orchards of peach, nectarine and plum trees, and to detect the specific problems and therefore the critical points that would have to be solved in an IFP program.

Season 1998/1999

Based on the information obtained in the diagnosis and on the "Guidelines for integrated production of stone fruit in Europe" of the IOBC/WPRS, in 1998 the trials were initiated by locating representative orchards in the Metropolitan Region near Santiago (Maipo). The
varieties Zee Lady, Autumn Star and Friar of peaches, nectarines and plums, respectively, were utilised. For each species, 3 experimental plots were established, two of them to be managed with integrated systems being tested (IST1 and IST2) and one with conventional management (CM). The orchards were characterised, and a “base line” was established in each one by describing soil-related, climate, irrigation water, soil fertility, composition of the orchard and yield and plant protection aspects. This “line base” served as guide, once finished the season, to determine the effect of the management systems -integrated and conventional- on the situation of the experimental plots. The main differences between the treatments are shown in Table 1. During the study season, following aspects were evaluated: a) evolution of the presence of pests, diseases, predators and weeds, b) vegetative growth, c) phenology states, d) blossom and fruit set intensity, e) nutrient status of the trees, f) yield, g) fruit quality for export in the total area for each system, and i) within a sample of 15 trees: fruit size, maturity, physiological disorders, damages of pests and diseases, pesticide residues and storage potential. Parallel to that, in another sector or fields of the Metropolitan Region, specific trials were established in order to find integrated solutions for critical points resulting from the diagnosis. These were the following:

1. Control of oriental fruit moth (*Cydia molesta* Busk) by mating disruption method. Two experimental units were located in a commercial orchard of stone fruit trees, the first was of 3 ha, with nectarines July Red (6 years old, 800 trees/ha) and the second, of 4 ha with plum trees Larry-anne (6 years old, 1250 trees/ha). In both sectors no specific applications of insecticides for the control of this pest were carried out during the season. The management of the other pests was conventional. The installation of the dispensers (Isomate 100M;180 dispensers/ha) started with the beginning of the males flight of the first generation. All the borders were reinforced with a greater number of dispensers. The evaluations were carried out on 2000 fruits/ha. The first was visual on fruits on the tree and the second was on picked fruit.

2. Effect of products used for control of Thrips of California (*Frankliniella occidentalis* Pergande) on *Neoseiulus californicus* (Dosse), a predatory red mite, in peaches. The trial was carried out in the variety Autumn Star (13 years old, 1000 trees/ha). The applications were done in post harvest with blowsprayer (2600 L/ha, pressure of 300 lb/pulg2) . A block design was used (according to the population of *N. Californicus*, determined in a pre-application evaluation) with 4 replicates and 4 trees by experimental unit. The treatments were: Spinosad (Success 48 SC: 0,075 and 0,015), Formethanate (Dicarzol 500 WP: 0.1%), Abamectina (Vertimec 018EC: 0,1%) and water (as absolute control). The evaluations were performed on 50 leaves for experimental unit, at 2 and 6 days post application, determining the number of mobile stages/leaf.

3. Control of oriental fruit moth (*Cydia molesta* Busk) with Attract and Kill (Appeal) in peach trees. The trial was carried out on September Sun variety (13 years old, 1000 trees/ha). The treated area was of 0,25 hectares per experimental unit (3). Treatments consisted of one application of Azynphos methyl (Gusathion 35 WP: 0,12%) when attaining 100 day-degrees after registering males captures in pheromone traps, to all the experimental units. 30 days later, 2, 3 and 4 drops were applied per tree in each one of the units, respectively. This last application was repeated 7 weeks later. A visual evaluation was carried out on 1000 fruits per treatment after the first application of Appeal and 2000 fruits per treatment at harvest, determining in both occasions percentage of fruits damaged by oriental fruit moth.
**Season 1999/2000**

With the results of the IST and the specific trials, a new experimental plot was established for each species, as known as experimental integrated systems (EIS). The varieties used were Early O’Henry in peach trees, September Red in nectarine trees and Friar in plum trees. The treatments are shown in Table 1. The evaluations were the same ones as already indicated for the previous year. Moreover, a trial on control of oriental fruit moth with Attract and Kill (Appeal), was carried out in the Metropolitan Region.

Table 1 Characteristics and main differences between IST1, IST2 and CM treatments being applied in 1998/1999 and 1999/2000 in peach, nectarine and plum trees.

<table>
<thead>
<tr>
<th>PEACH TREES</th>
<th>NECTARINE TREES</th>
<th>PLUM TREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>IST 1 (\Uparrow)</td>
<td>IST 1 (\Uparrow)</td>
<td>IST 1 (\Uparrow)</td>
</tr>
<tr>
<td><strong>Pests:</strong></td>
<td><strong>Pests:</strong></td>
<td><strong>Pests:</strong></td>
</tr>
<tr>
<td>Oil spray (1) for San José scale and red mite. Oriental fruit moth with MD and Triflumuron (2). San José scale with Penncap M (1). Green peach aphid with Imidacloprid (1). Thrips of California with Spinosad (1). Red mite with Clofentezine (1). Azinphos methyl in strip for Stripped weevil.</td>
<td>Oil Spray (1) for Red mite and San José scale. Oriental fruit moth with MD. Red mite with Clofentezine (1). San José scale with Penncap-M (1). Thrips of California with Abamectina (1) and Metamidophos (2). Azinphos methyl in strip for Stripped weevil.</td>
<td>Oil Spray (1) for San José scale and Red mite. Oriental fruit moth with MD. San José scale with Penncap-M. Azinphos methyl in strips for Stripped weevil.</td>
</tr>
<tr>
<td><strong>Diseases:</strong></td>
<td><strong>Diseases:</strong></td>
<td><strong>Diseases:</strong></td>
</tr>
<tr>
<td>ESI (2) and Dodiine (1) for Leaf curl, Brown rot blossom and Coryneum blight. Sulphur (1) and Propiconazol (1) for Powdery mildew.</td>
<td>ESI (2) and Dodiine (1) for Leaf curl and Brown rot blossom and Coryneum blight. Sulphur (2) and Propiconazol (1) for Powdery mildew.</td>
<td>Triforine (2), for Coryneum blight and Brown rot blossom.</td>
</tr>
<tr>
<td><strong>Weeds:</strong></td>
<td><strong>Weeds:</strong></td>
<td><strong>Weeds:</strong></td>
</tr>
<tr>
<td>Glyphosate (2).</td>
<td>Glyphosate (3).</td>
<td>Glyphosate (2), MCPA (1).</td>
</tr>
</tbody>
</table>

| IST 2 \(\Uparrow\) | IST 2 \(\Uparrow\) | IST 2 \(\Uparrow\) |
| Differences with the IST 1. | Differences with the IST 1. | Differences with the IST 1. |
| **Pests:** | **Pests:** | **Pests:** |
| To Oriental Fruit Moth control, 1 application of Tebufenozid was replaced for Triflumuron. The application for the Thrips control was not done. | Thrips of California with Imidacloprid (1) and Abamectina (1). | Scale only with 2 applications the Oil Spray. |
| **Diseases:** | **Diseases:** | **Diseases:** |
| one application of ESI was replaced with Triforine. | one application of ESI was replaced with Triforine. | one application of ESI was replaced with Triforine. |

| CM \(\Uparrow\) | CM \(\Uparrow\) |
| Differences with the IST 1. | Differences with the IST 1. |
| **Pests:** | **Pests:** |
| Oriental fruit moth with Diazinon (2). San José scale with Diazinon (1). Green peach aphid with Endosulfan (1). Thrips of California with Fornetanate HCL. (1). Red mite with Clofentezine (1). | Oriental fruit moth with organophosphate insecticides (1). San José scale with Clorpiriphos (1) and Diazinon (1). Thrips of California with Metamidophos (1) and Dicarzol (1). |
| **Diseases:** | **Diseases:** |
| Ferbam (1), Benomyl (1). | Captan (1), Benomyl (1). |

| ISE \(\Uparrow\) | ISE \(\Uparrow\) | ISE \(\Uparrow\) |
| Differences with the IST 1. | Differences with the IST 1. | Differences with the IST 1. |
| **Pests:** | **Pests:** | **Pests:** |
| To Oriental Fruit moth control only with Tebufenozid (1). Two applications of Penncap-M for the San José scale control. | To Oriental fruit moth control, only with Tebufenozid (1). Green aphid with Imidacloprid (1). | To Oriental fruit moth only with Dithufenzuron (1). Brown plum aphid with Imidacloprid (1), Scale with oil spray (2). |
| **Diseases:** | **Diseases:** | **Diseases:** |
| one application of ESI was replaced with Triforine. | Myclobutanil (1), Triforine (1) and Mancozeb (1). | only Triforine (4). |

The variety of peach Pomona (666 trees/ha) was used, being of delayed maturation (April) and, therefore more exposed to the pest attack. The work was performed in three experimental units of 0.5 ha each. The infestation level of the pest was medium. The treatments consisted of two applications of Azynphos methyl (Gusathion 35 WP: 0.12 %) when attaining 100 day-degrees, according to captures of males in pheromone traps, on the three experimental units.

30 days after the last one, 2, 3 and 4 drops of Appeal/tree were applied in each unit, respectively. This application was repeated 6 weeks later. A visual evaluation of 1000 fruits per treatment was performed the first application of Appeal, and also on 2000 fruits per treatment at harvest, determining in both occasions percentage of fruits damaged by oriental fruit moth.

Results and Discussion


<table>
<thead>
<tr>
<th>System Production</th>
<th>Yield (t/ha)</th>
<th>Export quality (%)</th>
<th>Small fruit</th>
<th>Oriental fruit moth</th>
<th>San José scale</th>
<th>Flower</th>
<th>Thrips</th>
<th>Begin of color development</th>
<th>Colour &lt; 50%</th>
<th>Russet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peach trees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IST 1</td>
<td>15.9</td>
<td>55</td>
<td>31</td>
<td>0.0</td>
<td>0.0</td>
<td>5.9</td>
<td>1.5</td>
<td>10.3</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>IST 2</td>
<td>12.7</td>
<td>41</td>
<td>35</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>7.2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>HMT</td>
<td>14.3</td>
<td>37</td>
<td>57</td>
<td>0.0</td>
<td>0.0</td>
<td>2.3</td>
<td>0.2</td>
<td>6.6</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>ISE</td>
<td>35.9</td>
<td>52</td>
<td>1</td>
<td>0.3</td>
<td>0.2</td>
<td>0.0</td>
<td>0.3</td>
<td>10.7</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td><strong>Nectarine trees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IST1</td>
<td>21.6</td>
<td>54</td>
<td>25</td>
<td>0.5</td>
<td>0.1</td>
<td>6.7</td>
<td>7.4</td>
<td>5</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>IST2</td>
<td>21.8</td>
<td>47</td>
<td>28</td>
<td>0.3</td>
<td>0.0</td>
<td>8.3</td>
<td>4.5</td>
<td>8.3</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>HMT</td>
<td>20.2</td>
<td>38</td>
<td>36</td>
<td>0.0</td>
<td>0.0</td>
<td>9.7</td>
<td>24.7</td>
<td>7.7</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>ISE</td>
<td>29.2</td>
<td>51</td>
<td>6</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>2.4</td>
<td>17.7</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td><strong>Plum trees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>IST 1</td>
<td>18.7</td>
<td>51</td>
<td>26</td>
<td>0.4</td>
<td>0.0</td>
<td>0.0</td>
<td>14.8</td>
<td>15.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IST 2</td>
<td>20.7</td>
<td>42</td>
<td>32</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>12.4</td>
<td>15.3</td>
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</tr>
<tr>
<td>HMT</td>
<td>21.2</td>
<td>51</td>
<td>30</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>7.4</td>
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<td></td>
</tr>
<tr>
<td>ISE</td>
<td>17.3</td>
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<td>3</td>
<td>0.1</td>
<td>0.4</td>
<td>4.1</td>
<td>14.1</td>
<td>13.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the Table 2 it is observed that in the three species yields were similar between the IST and the CM. In peaches and nectarine trees the quality of the fruit from the IST treatments was improved, and the proportion of fruit for export increased. Important problems of quality were not observed in harvested fruit from IST treatments in comparison with CM, except for a very low incidence of oriental fruit moth damage in nectarines. Larger size of the fruit in the IST was obtained too (Table 2). In the second season, good results in yield and quality of the fruit were obtained with EIS. Quality of the fruit after cold storage was good, in general, and no differences were observed as compared with conventional management. In plums, the quality of the fruit at the time of the harvest was similar between IST1 and the CM, whereas in the IST2 the smallest percentage of fruit with quality for export was obtained, due mainly to a higher proportion of small-sized fruit. With respect to the physiological disorders the fruit from integrated treatments presented similar characteristics to that from conventional system, after 10 days in cold storage.

Specific trials
In the trials of mating disruption for control of oriental fruit moth, carried out in nectarines and plums, the effectiveness of such control was very high without fruits damaged being observed.

In the trial for determining effect of products used for control of the thrips of California on population of Neoseiulus californicus (Table 3), the treatment with Formethanate (Dicarzol 500 SP; 0.1%) significantly reduced (50 % of survival) the populations, whereas Abamectina (Vertimec 018EC; 0.1%) showed a similar behaviour than the absolute control treatment. And in the trials carried out for the oriental fruit moth control with Attract and Kill (Appeal) in peach trees no differences existed between the treatments and the control treatment managed conventionally, in both seasons. Nevertheless, control treatment had a slightly inferior level of damage (Table 4).

Table 3. Effect of products used against Thrips of California (Frankliniella occidentalis Pergande) on Neoseiulus californicus (Dosse) in peaches.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>number of mobile stages of N. Californicus per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 0</td>
</tr>
<tr>
<td>Success 48 SC (7,5 cc/ml)</td>
<td>1,52 a</td>
</tr>
<tr>
<td>Success 48 SC (15 cc/ml)</td>
<td>1,57 a</td>
</tr>
<tr>
<td>Dicarzol 500 WP (100 gr/ml)</td>
<td>1,43 a</td>
</tr>
<tr>
<td>Vertimec</td>
<td>1,34 a</td>
</tr>
<tr>
<td>Water</td>
<td>1,87 a</td>
</tr>
</tbody>
</table>

Table 4. Control of Oriental fruit moth (Cydia molesta Busk), in peach with “Attract and Kill“ technique.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% of infested fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 drops</td>
<td>0.20 %</td>
</tr>
<tr>
<td>3 drops</td>
<td>0.10 %</td>
</tr>
<tr>
<td>4 drops</td>
<td>0.10 %</td>
</tr>
<tr>
<td>Commercial witness</td>
<td>0.05 %</td>
</tr>
</tbody>
</table>
Conclusions

In the integrated production systems developed, in general, good results were obtained: similar yield to the conventional system and good characteristics of fruit quality (fruit size, fruit colour, physiological disorders, rotting incidence), being superior, in many cases, than the conventional system. Pest and diseases could be controlled at an acceptable commercial level. The integrated systems assayed contribute indeed to reduce environmental contamination and risks for human health.

The technique of the mating disruption for the control of oriental fruit moth, as assayed in a given location, provides a real possibility of control with levels of damage at harvest near to 0.1 %. Applications of the Attract and Kill showed a good control on oriental fruit moth in locations with both high and low pest potential.

The applications of Formethanate significantly reduce (50 % of survival) the populations of *Neoseiulus californicus*, whereas Abamectina did not have effect.

The transformation of a conventional system to an integrated one is technically feasible in most cases, but the system IFP is not apt for "zero tolerance" as presence of arthropods in fruit destined to "demanding" markets cannot be ruled out.
Use of industry agrochemical use data in the development of Integrated Fruit Production Programmes in the New Zealand horticultural industry

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Abstract: There are over 2,000 pome and stone fruit growers in New Zealand. Growers who produce either fresh export or processed fruit crops are required to submit agrochemical use diaries as part of the process of obtaining submission clearance for their fruit. Since 1992 the pome fruit diaries have been entered by exporter to a mainframe database, where it has been screened for withholding period or other possible violations. Each year the agrochemical use data has been transferred to a PC database where it has been subjected to more detailed analysis and the data used to assist in the development and refinement of the IFP programme for New Zealand pome fruit. Subsequently a similar process was implemented to assist in the implementation of IFP for both the processed and fresh stone fruit industries.

This paper describes the SprayView suite of software tools developed to assist in implementation of New Zealand IFP programmes. These tools have been used to analyse agrochemical use patterns and to develop recommendations for IFP pest and disease management in pome and stone fruit. Examples of use of industry-level data given include: analysis of regional and grower variations in agrochemical use, grower adherence to fungicide resistance management guidelines, relationships between use of dithiocarbamate fungicides and miticides, and summaries of active ingredients used.

Keywords: agrochemical use analysis, decision support software, Integrated Fruit Production

Introduction

In order to improve the sustainability of their production systems and to remain competitive on world markets, New Zealand’s pome fruit, kiwi fruit, stone fruit and wine grape industries have embraced Integrated Fruit Production (IFP) systems. Common features of the sustainable production programmes being adopted in New Zealand are a shift to more selective pesticides applied in response to monitored pest thresholds or other risk factors. The introduction of IFP protocols to different crops in New Zealand has always resulted in a net reduction in insecticide use. IFP protocols have also provided improved documentation systems for growers from which they can justify pest and disease control activities and other management inputs. This audit trail has proved invaluable as a research tool for collecting and analysing data to help refine the IFP programmes. In all cases we have attempted to benchmark industry practices preceding IFP implementation and to use these data, plus data collected after IFP implementation, to refine the programmes. Agrochemical use issues are arguably the critical area affecting the environmental and market sustainability of the New Zealand fruit production industries. It is also an area in which significant changes to production practices have occurred as a result of implementing IFP.
While the majority of New Zealand growers have been required to record agrochemical use for some time, only the pome fruit exporter ENZA maintained a mainframe electronic database of grower’s agrochemical use. In all cases grower spray diaries (now usually termed pest control records, or PCR’s, to reflect the inclusion of pest and disease monitoring data) were usually only examined to confirm that approved agrochemicals had been applied within their withholding periods. Researcher access to the ENZA mainframe database of PCR’s was limited and it proved difficult to conduct any extensive analysis of the data on that platform. In order to collate and analyse agrochemical use information a series of software tools were developed. These tools are described in this paper, with examples of their use in the New Zealand export pome fruit and process stone fruit IFP production programmes.

**Materials and methods**

**Software tools for industry-level agrochemical use analysis**

Records identified as important sources of data for use in implementing IFP programmes include grower spray diaries, pheromone trap catch records, field pest and disease monitoring records and pack house reject reports. However, prior to the introduction of formal IFP programme strategies, there was little consistency in whether and how this type of information was collected and recorded. Software tools were developed to facilitate entry of such data into PC databases. All data entry and analysis tools were all developed using Delphi (Borland International).

Pest and disease scouting and pheromone trapping for codling moth and leafroller insects are key activities for apple growers under the IFP programme and some use of pheromone traps has been implemented in the stone fruit and wine grape IFP programmes. Grower records are collected as part of the programmes and used to review and refine pest and disease management thresholds and for monitoring seasonal or long-term changes in pest activity. An application called ‘TrapEntry’ was implemented in 1997 to capture pheromone trap information in a database format so that industry-wide analysis could be undertaken of the IFP recommendations for control of these pests. Records of pest and disease incidence on harvested fruit have also been handled in a database application that is available to pack houses. The ‘SprayEntry’ software has been used by a major fruit processor to aggregate spray diary records collected from different processing crops into a database. This tool has been used since 1995 to identify potential agrochemical use violations prior to acceptance of processing crops into inventory. Pome fruit spray diary data from the ENZA mainframe database were exported to the same Paradox (Borland) PC database, and up to seven years of agrochemical use data for our major fruit industries now exist in this format. For any given season data for process peach growers typically includes ca. 120 properties, some with multiple blocks, and contains ca. 2,200 records. In contrast, each season of ENZAFRUIT export apple data typically contains over 450,000 records from over 1,500 properties from nine geographic locations, each with multiple cultivars and/or blocks.

A software package called ‘SprayView’ was developed to allow researchers and industry technical personnel to easily summarise agrochemical use information from these databases. The SprayView tool has four main analysis functions which enable viewing of: 1) regional chemical use summaries, 2) individual grower diaries with associated summary information, 3) ‘use by date’ summaries to determine agrochemical use of a product by date within regions and 4) total industry product use summaries. Agrochemical use summaries can be aggregated or split as desired between geographic regions, crops, cultivars and/or production programmes (e.g. organic versus IFP). In addition, users can define their own chemical groupings (e.g. agrochemicals with similar modes of action, or for control of specific pests) for aggregated
Results and discussion

Examples of industry-level data use in development of IFP programmes

1: Regional and grower variations in use of insect growth regulator insecticides under the apple IFP programme. Under the New Zealand apple IFP programme the use of broad spectrum organophosphate insecticides for control of leafroller and codling moth pests has largely been eliminated and replaced with use of the insect growth regulators tebufenozide and lufenuron applied in response to monitored pest levels. To manage the risk of pest resistance developing to these insecticides, up to five applications per season are permitted. Given regional variations in insect pest pressures, it was important to identify regional use patterns and grower adherence to resistance management guidelines. To facilitate analysis of aggregated chemical groups SprayView allows users to define any number of their own chemical groupings which can then be used in various reports and database queries.

Figure 1: Screen shot from SprayView showing average use by region of IGR insecticides (tebufenozide plus lufenuron) across all apple cultivars and blocks.

A screen shot from SprayView showing a regional analysis summary for IGR insecticides is given in fig. 1 for all apple cultivars during the 1999-2000 season. Average use in each product region is displayed, allowing use patterns between regions to be quickly compared.
Clicking on a region brings up a regional use summary that ranks growers from highest to lowest use and provides a frequency histogram of the number of growers applying different numbers of the target chemical group (Fig.1). The Copy Grower Data and Copy Graph Data buttons in this summary allow raw data to be copied into other applications (e.g. MS Excel) for further analysis.

![Figure 2](image)

Figure 2: Screen shot from SprayView showing a regional (Hawkes Bay) use histogram for IGR insecticides.

In this example we found that average IGR insecticide use across all regions was well within the recommendation of no more than five applications per season and that regional variations in average usage were relatively low. Adherence to agrochemical resistance management guidelines is strongly recommended under the New Zealand IFP programmes, but is not a mandatory requirement. In the example shown in Figure, all of the growers who used more than five applications of the insect growth regulators would have received letters telling them that they had done so and explaining the importance of resistance management. Where appropriate, they may also have been asked to produce crop pest monitoring records to justify high agrochemical usage. This process of ongoing feedback to growers is an important part of the New Zealand IFP programmes.

The more or less normal distribution of insecticide use seen in Figure 2 is typical of the variations seen between growers for most agrochemicals. One of the improvements targeted under New Zealand IFP programmes is to inform growers who are high agrochemical users that they are overusing these products and to bring their use patterns more in line with average industry use. Data on fungicide use variations in the New Zealand apple industry prior to significant IFP implementation were presented by Manktelow et al. (1995). Since that time there has been a drop in overall fungicide use of ca. 13%.

2: Examination of individual grower diaries and extraction of summarised data. A screen shot of a typical individual diary summary page from SprayView is shown in Figure 3. The database can be searched by property reference or by orchard name to rapidly locate the blocks of interest. Data from the diary can be readily extracted from the database and copied to other applications for generating letters or reports. Under some production programmes there is a need for growers not to exceed somewhat arbitrary active ingredient use targets. To
facilitate estimation of active ingredient use a summary can be generated for selected chemical groupings. An example of the use of this summary tool to track fungicide active ingredient use in New Zealand organic apple programmes can be found in Tate et al. (2000).

3: *Use of summarised data to establish a relationship between dithiocarbamate fungicide and miticide use patterns.* EBDC fungicides have been shown to disrupt integrated mite control programmes based on the predatory mite *Typhlodromus pyri* (Walker et al. 1989). Analysis of the 1996-97 apple spray diaries indicated that the majority of growers who applied no more than five metiram or mancozeb fungicides did not require use of any miticides (Manktelow et al. 1997). A recommended use target of no more than five metiram or mancozeb applications was therefore implemented in 1997 for the New Zealand apple IFP programme as a practical first step towards eliminating miticide use. Analysis of the 1999-2000 spray diaries indicated that miticide use by IFP growers has been significantly reduced since IFP was introduced in 1996-97. For example, in Hawkes Bay miticides were applied to 15% of apple blocks in 1996-97, but to only 4% in 1999-2000.

Figure 3: Example of a typical spray diary summary page from SprayView. Note the numbers of applications falling into each of the user defined chemical groups is displayed at the bottom of the page. Note also the use of five EBDC fungicides with no use of miticides. The PRS refers to the Pesticide Rating System points accumulated for each pesticide input (Walker et al. 1997).
Example 4: Chemical “use by date” analysis. The SprayView software can produce a regional summary of chemical use patterns by date. This is presented as the numbers of applications of the specified chemical across the selected cultivar and production programme. This type of analysis has proved useful in identifying whether and how well growers respond to factors such as; recommended spray timings, weather events such as scab infection periods or, publicised pest or disease levels.

Example 5: Measuring changes in total chemical use. The SprayView software can produce summaries of use of different agrochemicals by active ingredient. This type of summary has proved useful in documenting changes over time in the types and quantities of agrochemicals used by on different crops or production programmes. Examples of changes in insecticide and fungicide use in New Zealand pome and stone fruit crops can be found in Walker et al. (2001).

Conclusions

The SprayView software is essentially a flexible database query tool that has been used by scientists and industry support staff to make use of agrochemical use data to help refine IFP programmes and to establish research priorities. It has greatly facilitated researcher access to data as it does not require any specialist database knowledge to use.

The ability to measure change in an industry’s agrochemical use has provided important annual feedback to growers and exporters alike. The information obtained has given growers the confidence to make significant changes and reductions in pesticide use. Through use of the SprayView software we have been able to document our decreased reliance on the use of broad-spectrum pesticides to our customers. We have also monitored continuous improvements in grower adherence to agrochemical resistance management guidelines and to the general crop protection principles of IFP.

References


Integrated Fruit Production in Brazil

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Abstract: The Integrated Fruit Production (IFP) was initially discussed widely in Southern Brazil during 1996, time when after a joint decision of research and technical assistance institutions and growers association, this system began to be established in the country. After the formulation of the technical guidelines for apples, a research project was initiated with the objective to define the economical and technical feasibility of IFP, comparing with the traditionally used. After two growing season, it was verified that is possible to grow apples in Brazil using the IFP principles and results showed that the main difference between both systems is the less amount of agrochemicals used in the IFP system. The same approach is being used to study IP of peaches and to discuss the system to wine grapes. Using the apple model, this year other groups had began IP in tropical and subtropicals regions with the purpose to develop IP of fruit crops such as table grapes in a irrigated condition and also with mangoes, banana, citrus and coconut. Brazilian government is given support to this system establishing national regulation and financial support to research.

Key words: pesticides, diseases apple.

Introduction

Concepts of competition with fruit products on the international market relying solely on abundant natural resources and low wages are no longer accepted as sufficient to guarantee a good performance of the producers. Thus, a country's competitiveness is, to a large extent, related to its capacity to create a logistic structure and to define sustainable production systems which meet satisfactorily the requirements of an – in all respects – increasingly demanding and selective market. Both Brazilian government and fruit growers are aware about those statements and decided to invest on Integrated production of fruits.

In Brazil, the fruit production of the tropical and the one of the mild climate have a great intrinsic economic importance, since they generate a great number of jobs, as well as exchange value, be it as a result of exportation or be it through import substitution. The productive processes of apples, grapes and mangoes are especially interesting because of features they have in common and make them different from others.

Apple production emerged 25 years ago through private investment with governmental incentives in a region with high soil fertility, 1000 -1800 mm rainfall, at 800 -1400 m altitude, with mild winters. At that time, domestic consumption was almost completely supplied through importation. The sector developed a production system with high technological level, adjusted and adapted to the characteristics of the regional ecosystem and to the use of IPM. In the 1999-2000 season 900,000 tons of apples were produced on an area of 29,000 ha. Due to this production, Brazil has been able to replace a part of the imports, and, more recently, also to export to the European Union, the USA and other countries. In 1997, Embrapa Uva e Vinho recommended the creation of an integrated apple production system in Brazil, as a consequence of the concerns expressed by all segments involved with apple production. A multi-institutional and multi-disciplinary research project was devised in 1997 and a work group was formed in order to formulate the first PIF guideline in Brazil, based on the standards of OILB/WPRS (Nachtigall et al.,1997).
Mango and grape production, was introduced 15 years ago in a semi-arid region located in the valley of the Sao Francisco River one of the largest rivers in Brazil, a fact that made the use of irrigation possible and require the use of technologies developed for this particular condition. These productive chains occurred as a result of combined public and private funds. The production of these crops is marketed in the domestic as well at the international market. The IFP project for these crops developed tools to monitor the production activities and the environmental impact of the fruit growing process. Presently actions are being implemented that will define guidelines for IP for both crops.

**Integrated Fruit Production research in Brazil**

**Apple**

Following an ample discussion of the IFP in 1997, to get her with the different sectors of the productive chain of apples and with the important contribution of European, North-American and Argentinian consultants, the Brazilian guidelines for the AIPS were established. After this, during 1998 and 1999 a R&D project was implemented in the field in five orchards located in the three main apple producing regions (Fig. 1). In each one, about 5 h plots of the cvs. Gala and Fuji are being conducted in the AIPS, based on the Technical guideline mentioned above and another plot managed according to the system traditionally used by the grower, totalling 20 ha per orchard and a total experimental area of 100 hectares.

![Fig. 1. Brazilian regions with Integrated Production of apples and peaches](image)

It is expected that the research actions that will be developed during the year 2001 conclude the first phase of the work, providing, as a result, a definition for the Integrated Apple Production System (AIPS).

The results obtained during the second evaluation year have shown that productivity, quality, fruit storability, incidence of pests and diseases, and the presence of residues in apples are no significantly different in both production systems. However, it is noticeable the
reduction of agrochemicals obtained in the AIPS (Fig. 2 and 3). Growers evaluation is similar as the research’s and, as a consequence, are managing by their own, 2,400 ha using the AIPS.

Figure 2. Amount of pesticides used in Gala orchards with Integrated Fruit Production (IFP) and Traditional Fruit Production (TFP) systems in Brazil

Figure 3. Gala fruit losses from two apple orchards managed with Integrated Fruit Production (IFP) and Traditional Fruit Production (TFP) in Brazil

**Peach**
The experience gathered with the research group on apple and the demand of grower organisations, has fostered the emergence of work on peach, a crop that is commercialised almost exclusively on the internal market. In this case the group has defined the wording of the first version of Guidelines of the IP of Peaches in 1998 and began carrying out the project of comparison of both systems of production. The experimental plots were evaluated in 1999
and the initial results showed that in this crop, probably, the reduction of pesticides will be greater than that observed in apples (Fig. 4).

**Figure 4. Pesticides use and losses by pests in peach orchards managed with Integrated Fruit Production (IFP) and Traditional Fruit Production (TFP)**

**IFP in other crops**

The success of the programme of AIPS and the support of the Brazilian government to the IFP has stimulated other productive chains to organise themselves in order to implement this system. Presently, research projects to establish IP of citrus, coconuts, papaya and of grapes for wine, among others, are being implemented.

**Related research projects**

During the definition of the Technical Guidelines critical deficiencies were detected in the knowledge of the agro-eco-systems under study, as well as in the requirement of validation of the technical fundaments defined in this document. Work is being carried out to offer these answers in a multidisciplinary research project. Among them, studies about the elucidation of the secondary effects of agrochemicals on relevant beneficial organisms in the country, on pests and diseases and on the quality of apples, as well as studies of monitoring the environmental impact of the fruit production, are specially important.

**Consequences of the IFP for research, extension and the sector’s organization**

Beyond the strategic importance of the implementation of the IFP in Brazil for the productive chain, there exist other implications that impact positively the different links of the productive chain, insofar as it will qualify them to look for a share of the international market.

In the specific case of the APIS, as commented previously, other R&D project in been conducted composed of a set of converging and harmonic actions that aim at the establishment of the production system as a whole. This systemic approach, besides favouring multidisciplinarity in the research actions, makes possible the interinstitutional relationships, supporting competence and avoiding duplicity of actions. From a pragmatic point of view, for the research institution, the development of a programme with this systemic focussing offers
solution for important steps of the process such as the prospection of demands and definition of priorities, then the development of the project and the evaluation of its results allows the technical staff involved to identify the bottle necks which, automatically, turn into priority research actions.

Still under the technical point of view, another chain link that profits is the rural extension and technical assistance services, then the strategy of the establishment of IP comprehends a rigorous programme of training for technicians involved and/or people that are interested in working on the system. Furthermore the same conditions of access for all interested are assured, avoiding as a consequence the circulation of misinformation that confound technicians and growers.

Finally it is worthwhile to underline that with implementation of IP in the case of Brazilian apple, there has been a mobilisation of all segments that make up the productive chain, giving political and financial support in the beginning to the actions of R&D and later to those related to the officialisation and certification of the system. The national structure that provides the legal frame of IFP in Brazil is in development and constitute a government priority. As a synthesis, it can be stated that IFP has help to consolidation of the Brazilian fruit production.

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Certification of Integrated Fruit Production in Argentina and Uruguay

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Abstract: The aim of the Integrated Fruit Production Programs in Argentina and Uruguay is to enhance and identify the quality level of regional fruit, in order to: 1) Ensure the presence of regional production in the most demanding markets, 2) Consolidate a favourable image of the region as for human health and the environment, and 3) Preserve the natural resources of the region and human health, through the implementation of a sustainable production system.

The idea of developing a program that would allow to fulfill the above-mentioned goals was born in 1993 in Río Negro, Argentina. This project started to gain importance in the light of the successful experiences of several European programs.

The first pilot field experience was carried out during the 1995/96 season, with a total surface of 100 hectares. The second pilot experience took place during the 1996/97 season, with the participation of 1718 has., conformed by 96 orchards of 39 growers and 24 integrated companies. During this same season, the first experience was carried out in Uruguay with 100 hectares, with the participation of 27 pear and apple growers, as well as peach and table grape growers.

Production in the Argentine Patagonia was certified for the first time during the 1997/98 season. Certification was implemented though the use of a numbered wafer issued by IRAM – Fundación ArgenINTA Joint Certification System. A total surface of 1262 hectares distributed among 95 orchards participated in the process. The Uruguayan production was identified during the 1999/2000 season, reaching a total surface of 435 has., with a total of 75 growers.

Both regions share the same product certification system. However, each region develops its own protocol for each product by common consent.

Unlike developed countries, where these programs are used to subsidise production, directly or indirectly, in developing countries, growers do not receive any kind of contribution for the use of techniques that have a lower environmental impact. Sometimes, as is the case of Argentina, they even have to afford the cost of the program by themselves

Keywords: Integrated Fruit Production Programs; Pears; Apples

Introduction

The aim of Integrated Fruit Production programs in Argentina and Uruguay is to enhance and identify the quality level of regional fruit, in order to:

- Allow exports to maintain and increase;
- Ensure the presence of regional production in the most demanding markets;
- Consolidate a favourable image of the region as for human health and the environment;
- Preserve the natural resources of the region and human health, through the implementation of a sustainable production system.
The idea of developing a program that would allow to reach the above-mentioned goals was born in 1993 in the High Valley region, Rio Negro, Argentina. This project started to gain importance in the light of the successful experiences of several European programs.

The first set of guidelines was presented in 1994, together with farm and packing records. More than 50 professionals from public organisations and private companies, as well as several independent advisors, organised in commissions and in open meetings, drafted the first regional guidelines. The project was particularly interesting for two different aspects: 

a) Strong technological support due to its professional profile, and 
b) Consensus-based farm and packing guidelines.

The first pilot field experience was carried out during the 1995/96 season, with a total surface of 100 hectares, distributed in 30 orchards of 10 growers and 17 integrated companies.

The second pilot experience was conducted during the 1996/97 season, with the participation of 1,718 has., conformed by 96 orchards of 39 growers and 24 integrated companies. The first experience in the post-harvest area was also carried out during this season, with 19 packing plants.

Likewise, during this season Uruguay had its first experience with 100 hectares, and the participation of 27 pear and apple growers, as well as peach and table grape growers.

During these seasons, production was not certified; the main goal was to test the monitoring and tracking systems, to prepare the documentary basis and to verify that traceability could be guaranteed.

The production in the Argentine Patagonia was certified for the first time during the 1997/98 season. Certification was implemented through the use of a numbered wafer issued by IRAM – Fundación ArgenINTA Joint Certification System. A total surface of 1,262 hectares distributed among 95 orchards belonging to 16 companies, 3 farmers unions and 34 independent growers, participated in the process (Magdalena 1999). The production in Uruguay was identified during the 1999/2000 season, reaching a total surface of 435 has., with a total of 75 growers.

**Certification procedure**

Both Argentina and Uruguay share the same product certification system. The different types of control processes scheduled by the program are described in IRAM–IACC–ISO E 9000 regulations:

a) Conducted by or on behalf of the organism itself (first parties)  
b) Conducted by its customers (second parties)  
c) Conducted by independent organisms (third parties)

Programs for Argentina and Uruguay have the three control processes scheduled. First party controls are carried out by the grower through the different self-control mechanisms scheduled by the program (farm records, monitoring spreadsheets, etc.).

Control processes at the orchards (farm and packing house) are performed by the joint certification system.

External audits of the program and the certification processes are also contemplated, at least once a year. This task must be carried out by professionals outside the program.

**The documentation and its role**

IRAM–IACC–ISO E 9000 regulations define the role of the documentation as follows:

- Obtain the product quality required.
- Evaluate the quality system.
- Enhance quality.
- Maintain improvements.
Apart from the importance of the documentation for auditing purposes, it is also an objective evidence of the following:

- The process has been defined.
- The procedures have been approved.
- Changes to the procedures are under control.

In the Programs of Argentina and Uruguay, farm and packing house records have the importance of a minute book.

Documentation as a complement to enhance quality has a fundamental roll. If the procedures have been developed, implemented and documented, it is possible to determine what actions are normally taken and measure the current performance. Thus, it is possible to assess the effect of change more accurately.

**Consensus**

Each region drafts its own consensus-based guidelines for every product.

The regulation IRAM 50–1 defines consensus as: “the general agreement obtained after having considered the opinions of all the sectors involved, and where any possible divergent position has been overcome (consensus does not imply unanimity).”

Based on this concept, the commissions in charge drafted the guidelines, aware that if they were too strict, they would eventually fall into disuse, due to the impossibility of putting them into practice. On the other hand, it would make no sense to have regulations that are just a description of what is being done.

**Traceability**

The regulation IRAM-IACC-ISO E 8402 defines Traceability as: “the ability to rebuild the history, the use or the location of an entity, by means of registered identifications.”

Entity: something that can be described and considered individually (note: activity or process, product, organism, or any combination thereof).

According to this brief frame of reference, how do programs in Argentina and Uruguay guarantee traceability?

The unit of certification of the above mentioned programs is a box or a bin of classified and packed fruit. If a user in the destination country requests to the joint certification system information about a certain box of fruit identified with a numbered wafer, the database of the joint certification system and the program executive unit can provide this information. With the wafer number, it is possible to know which company of the program received the wafer. Likewise, with the information contained in the farm and packing records, it is possible to rebuild the process backwards.

**Concluding remarks**

In the High Valley of Rio Negro and Neuquen, the program appeared as a solid technical agreement. However, there was no institutional agreement that would support it through time.

In Uruguay, the program was born from the commitment of all the institutions related to the fruit growing activity (Junagra, INIA, Universidad de la República, Predeg-GTZ), which may give it a greater strength and continuity through time.

These integrated fruit production programs can provide a structure of technological order to the reorganisation process that is currently going on in our countries. Moreover, it gives a framework of respect to the consumer, the environment and human health.

Both in Uruguay and Argentina, integrated production does not entail economic differences with respect to the price obtained with conventional production.
Unlike developed countries, where these programs are used to subsidize production, either directly or indirectly, in developing countries, growers do not receive any kind of contribution for the use of techniques with lower environmental impact. Moreover, pesticides that allow production in an environment-friendly way have to pay the same domestic and export taxes than any other traditional pesticide. On the other hand, participation in the Argentina program implies an additional cost of about $0.15 / kg, even though the consumer will not pay extra money for this fruit.

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Development of integrated fruit production at the Research Station for Fruit Tree Growing Baneasa- Bucharest -Romania

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2 Research Institute for Plant Protection, B-dul Ion Ionescu de la Brad, nr.4, sector 1, Bucharest, Romania;

Abstract: Integrated fruit production has been carried out on 88 ha pomicultural plantation with resistant apple, apricot, peach, nectarine, cherry, plum, and 6 ha fruit-tree nursery.

The focused area of management for integrated fruit production monitoring of diseases and pests action, as related to genetic resistance of cultivars and with development of antagonists and predators.

Use of pesticides from "ecological" or "biological" groups led to increase of predator populations in orchards of Research Station for Fruit Tree Growing Baneasa (SCPP).

Steady occurrence with medium populations of predators from families Coccinellidae, Chrysopidae and Miridae did not imposed chemical intervention in apple orchard with cvs resistant to scab, or to scab and powdery mildew: Prima, Florina, Jonagored, Surprise and Pionier.

Use of traps with specific pheromones for Cydia molesta Busk. and Anarsia lineatella C. in peach and apricot orchards revealed presence of populations below the economic damage threshold (EDT), leading to suppression of treatments against these pests.

Study of fruit-tree biocenosis rendered obvious Populus sp. as a host plant for Stereum purpureum in apricot and Acer campestre for Pseudomonas syringae pv. syringae, also in apricot.

Key words: integrated fruit production, fruit-tree biocenosis, ecological balance, life quality

Introduction

In 1998, Dr. Walter Muller, Chairman of the Scientific Committee of “International Conference on Integrated Fruit Production” Leuven, Belgium, mentioned in the opening ceremony occasion definition of integrated fruit production for Pome Fruits”. Within the frame of the IOBC definition for Integrated Production, Integrated Fruit Production (IFP) is defined as the economical production of high quality fruit, giving priority to ecological safer methods, minimizing the undesirable side effects and use of agrochemicals, to enhance the safeguard of the environment and human health.

Starting from this definition, which we agreed, at the Research Station for Fruit Tree Growing Baneasa – Bucharest, Romania, investigation have been developed regarding the "Managing the Integrated Fruit Production Orchard”.

Material and methods

First, the components of fruit tree biocenosis components have been specified and studied: species, cultivars, spontaneous vegetation around the plantations, herbaceous plants occurring within orchards, attacks by diseases and pests, development of antagonists and predators, soil
microflora and microfauna, air temperature and humidity, insolation, water quality, proximity or distances from noxious areas.

Growth and fructification prunings have been effected, according to species, cultivars and age of trees, while fertilizers have been applied to foliage, based on leaves analysis.

Surface of plantations analysed is 88 ha with resistant cvars or with increased resistance to diseases, from species: apple, apricot, peach, nectarine cherry and plum.

Capture of pest and beneficial entomofauna and that from surrounding of orchards was bimonthly performed, using the shaking method.

A number of 100 shakings has been carried out.

The material gathered was analysed in laboratory under a stereoscopic microscope and divided by systematic groups (order and families).

Pheromone traps were installed (3 traps in each orchard) at the start of April, before presumptive apparition of moths.

In peach and apricot plantations the specific pheromone of species Cydia molesta and Anarsia lineatella have been used.

In the cherry orchard coloured (white and yellow) adhesive traps for Rhagoletis cerasi have been placed.

For monitoring the second generation of Cydia funebrana its specific pheromone was used in the plum orchard.

**Results and discussion**

Lignicolous species from spontaneous flora, showing share in the biocenoses of pomicultural species referring to: Rubus caesius, Potentilla argentea, Hibiscus sp., Spirea sp., Ligustrum sp., Rosa canina, Populus sp., Prunus sp., Jasminum sp., Syringa vulgaris, Populus alba, Salix babylonica, Morus alba, Acer campestre, Acer negundo, Clematis vitalba, Ulmus sp., Juglans regia.

Among the herbaceous species, the following showed share: Trifolium repens, Vicia sp., Daucus carota, Convolvulus arvensis, Plantago lanceolata, Cirsium arvense, Rumex acetosella, Urtica dioica, Agropyron repens, Cynodon dactylon.

Occurrence of lignicolous species near by plantation ensured inoculum for the cropped pomicultural species, the lignicolous fungi being dangerous: Eutypa sp., whose hosts are: Populus alba, Salix babylonica and Morus alba; Cytospora cincta, its host plant being Populus alba; Stigmina carpophilla, having as hosts Salix alba, Nectria cinnabarina, Armillaria mellea, Polyporus sp., Conyothirium amygdalis and Phoma sp., whose host plants are Clematis vitalba and Ulmus sp.; Diplodia sp., having as hosts Rosa canina and Juglans regia; Schizophyllum commune and Verticillium sp., appearing on the host plant Populus alba (table 1).

In the summer of 2000 year in the apricot plantation with cvars Timpurii de Chisinau, Rosii de Baneasa, Saturn, Neptun, Selena, the attack by the bacterium Pseudomonas syringae pv. syringae was noted.

On the host species Acer campestre and Acer negundo near by the orchard, the bacterium Pseudomonas syringae pv. tenuis has been detected.

Based on these data, the management programme of plantations included elimination of lignicolous plants with the highest danger as inoculum source for the pathogenic fungi involved in the phenomenon of apricot-tree drying, and namely: Populus alba, Morus alba, Salix babylonica, Clematis vitalba, Rosa canina and Juglans regia.

Research data revealed common diseases in apricot and peach trees, involved in early drying, and namely: Cytospora cincta (Valsa cincta telemorph ), Phoma sp. and Schizophyllum commune.
Table 1. Species from spontaneous flora constituting host-plants for pathogenic fungi involved in drying apricot-trees

<table>
<thead>
<tr>
<th>Spontaneous flora</th>
<th>Pathogenic fungi common for fruit-trees plantation</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Populus alba</em></td>
<td><em>Venturia, Phaelinus, Schizophillum comune, Cytospora cineta, Eutypa, Verticillium</em></td>
</tr>
<tr>
<td><em>Salix babilonica</em></td>
<td><em>Eutypa, Valsa, Stigmina</em></td>
</tr>
<tr>
<td><em>Morus alba</em></td>
<td><em>Eutypa, Valsa</em></td>
</tr>
<tr>
<td><em>Acer campestre</em></td>
<td><em>Pseudomonas syringae p.v. tenuis</em></td>
</tr>
<tr>
<td><em>Acer negundo</em></td>
<td></td>
</tr>
<tr>
<td><em>Rosa canina</em></td>
<td><em>Sphaetoteca pannosa, Diplodia sp., Phoma, Stigmina carpophilla</em></td>
</tr>
<tr>
<td><em>Clematis vitalba</em></td>
<td><em>Conithyrium, Phomapsis, Phoma, Armillaria</em></td>
</tr>
<tr>
<td><em>Ulmus</em></td>
<td><em>Nectria cinobarina, Polyporus, Verticillium albo-atrum</em></td>
</tr>
<tr>
<td><em>Juglans regia</em></td>
<td><em>Stereum purpureum, Diplodia</em></td>
</tr>
</tbody>
</table>

Table 2. Structure and abundance of useful entomofauna from spontaneous flora around the SCPP Baneasa orchards

<table>
<thead>
<tr>
<th>Species groups</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARANEAE</strong></td>
<td>63</td>
</tr>
<tr>
<td><strong>DERMAPTERA</strong></td>
<td>4</td>
</tr>
<tr>
<td>Fam. Forficulidae</td>
<td>4</td>
</tr>
<tr>
<td><strong>NEUROPTERA</strong></td>
<td>3</td>
</tr>
<tr>
<td>Fam. Chrysopidae</td>
<td>3</td>
</tr>
<tr>
<td><strong>RAPHIDIOPTERA</strong></td>
<td>2</td>
</tr>
<tr>
<td>Fam. Raphidiidae</td>
<td>2</td>
</tr>
<tr>
<td><strong>HETEROPTERA</strong></td>
<td>17</td>
</tr>
<tr>
<td>Fam. Anthocoridae</td>
<td>3</td>
</tr>
<tr>
<td>Fam. Miridae</td>
<td>14</td>
</tr>
<tr>
<td><strong>HYMENOPTERA</strong></td>
<td>48</td>
</tr>
<tr>
<td>Suprafam. Chalcidoidea</td>
<td>43</td>
</tr>
<tr>
<td>Suprafam. Ichneumonoidea</td>
<td>5</td>
</tr>
<tr>
<td><strong>COLEOPTERA</strong></td>
<td>37</td>
</tr>
<tr>
<td>Fam. Coccinellidae</td>
<td>26</td>
</tr>
<tr>
<td>Fam. Cantharidae</td>
<td>11</td>
</tr>
<tr>
<td><strong>DIPTERA</strong></td>
<td>17</td>
</tr>
<tr>
<td>Fam. Syrphidae</td>
<td>2</td>
</tr>
<tr>
<td>Fam. Sciaridae</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>201</td>
</tr>
</tbody>
</table>

In order to prevent dangers of disease, besides elimination of the most harmful host plants, in the young apricot and peach plantations, resistant phenotypes to the most common fungi
involved in early drying, such as: *Cytospora cineta*, *Stigmina carpophila*, *Schizophyllum commune*, *Eutypa* sp. have been introduced.

Comparative evaluation of structure and abundance of entomofauna found in the biotope of spontaneous flora surrounding apple, apricot, peach, nectarine, cherry and plum plantations revealed a visible difference between the two components, useful and dangerous.

The damaging entomofauna was superior to that useful, both as range of insect families, and as population densities.

Population of pest fauna was represented by Coleoptera, insects from Fam. Curculionidae being prevalent, these insects being also detected in tree plantations. The species *Sitona crinitus* Herbst and *Phyllobius oblongus* F. being the main pests of apricot, peach and apple trees, in spring and summer start. Their populations represented 1/3 from the total of pest fauna.

Table 3. Structure and abundance of pest entomofauna from spontaneous flora around the SCPP Baneasa orchards.

<table>
<thead>
<tr>
<th>Species groups</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACARINA</td>
<td>10</td>
</tr>
<tr>
<td>THYSANOPTERA</td>
<td>17</td>
</tr>
<tr>
<td>ORTOPTERA</td>
<td>43</td>
</tr>
<tr>
<td>Suprafam. Grylloidea</td>
<td>23</td>
</tr>
<tr>
<td>Suprafam. Acridoidea</td>
<td>20</td>
</tr>
<tr>
<td>HOMOPTERA</td>
<td>71</td>
</tr>
<tr>
<td>Cicadidae</td>
<td>11</td>
</tr>
<tr>
<td>Cixiidae</td>
<td>39</td>
</tr>
<tr>
<td>Aphididae</td>
<td>21</td>
</tr>
<tr>
<td>HETEROPTERA</td>
<td>28</td>
</tr>
<tr>
<td>Tingidae</td>
<td>8</td>
</tr>
<tr>
<td>Piesmidae</td>
<td>2</td>
</tr>
<tr>
<td>Lygaeidae</td>
<td>4</td>
</tr>
<tr>
<td>Pentatomidae</td>
<td>5</td>
</tr>
<tr>
<td>Coreidae</td>
<td>9</td>
</tr>
<tr>
<td>HYMENOPTERA</td>
<td>53</td>
</tr>
<tr>
<td>Formicidae</td>
<td></td>
</tr>
<tr>
<td>COLEOPTERA</td>
<td>225</td>
</tr>
<tr>
<td>Elateridae</td>
<td>5</td>
</tr>
<tr>
<td>Buprestidae</td>
<td>9</td>
</tr>
<tr>
<td>Nitidulidae</td>
<td>32</td>
</tr>
<tr>
<td>Cerambycidae</td>
<td>7</td>
</tr>
<tr>
<td>Chrysomelidae</td>
<td>6</td>
</tr>
<tr>
<td>Curculionidae</td>
<td>148</td>
</tr>
<tr>
<td>Helodidae</td>
<td>14</td>
</tr>
<tr>
<td>Lathridae</td>
<td>4</td>
</tr>
<tr>
<td>DIPTERA</td>
<td>18</td>
</tr>
<tr>
<td>Chironomidae</td>
<td>10</td>
</tr>
<tr>
<td>Agromyzidae</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>465</strong></td>
</tr>
</tbody>
</table>
As to the beneficial component of entomophages (table 2), the Orders Aranea and Hymenoptera prevailed.

Diversity of species identified in the fauna hosted by the spontaneous flora represents a potential danger for orchards, and at the same time a favourable environment for dispersal of pest populations.

The management of plantations, referring to the control of diseases and pests has been achieved by monitoring relationships developed between the host plants, resistant cultivars, pest and useful entomofauna, captures of pests specific to pomicultural species and application of treatments from the ecological group, on warning.

In peach-trees, the frequent danger is represented by the green aphid *Myzus persicae*.

Application of a Zolone 0.2% treatment in the development phase of this pest, when the useful entomofauna was not yet developed, solved the problem of its outbreak. Subsequent generations can be maintained below the damaging threshold, by appearance of relationships pest/predator, mainly within the Fam. Coccinelidae.

In apricot, the most frequent pests in the area were – in the last period – those belonging to Fam. Curculionidae, and namely *Phyllobius oblongus* and *Sitona crinitus*.

The adult population limitation has been achieved with a Victenon 0.075% application.

Use of pheromone traps specific to *Cydia molesta* and *Anarsia lineatella* in peach and apricot orchards demonstrated presence of a population located below the economic damage threshold. As a result, no treatments against these pests were needed. The attack degree at harvest was negligible.

In the plum orchard, captures of *Cydia funebrana* in the 2nd generation have been performed.

High temperatures recorded during the development of this generations (August), reaching 36-38° C, have hampered the moth fecundity. This fact explains the relatively low level of trap captures.

Consequently, it was decided to not apply the control treatment, a routine work in the area. Thus, the attack degree to fruits little exceeded the economic damage threshold of 5%.

In the apple orchard with cultivars resistant to scab and powdery mildew, the management of pest control was mainly based on establishing an equilibrium between the pest and useful entomofauna.

References


The possibilities of IPM in the Hungarian sour-cherry orchards

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Abstract: In lack of any applied integrated pest management methods we are forced to use broad-spectrum insecticides against European cherry fruit fly. Against the European cherry fruit fly we are recommending the use of phosalone or other insecticide with similar active ingredient, which are not or less dangerous to beneficial insects and mites. To prevent the development of the high density of pear tingid (Stephanitis pyri), the pear leaf blister moth (Leucoptera malifoliella), fruit tree red spider mite (Panonychus ulmi), Hawthorn red spider mite (Tetranychus viennensis) the same way is suggested. The Bacillus thuringiensis insecticides have suitable effect against the Hyphantria cunea. Against cherry bark tortrix moth (Enarmonia formosana) it is necessary to use broad-spectrum insecticides spraying only the trunks. The application of the pyrethroid insecticides is not recommended in sour-cherry orchards.

Introduction

Since sour-cherry is exported in large quantities, the farmers are planting increasing number of sour-cherry orchards, we are striving to develop a suitable integrated pest management.

The keystone pest of sour-cherry is the European fruit fly (Rhagoletis cerasi L.) which endangers a great part, both quality and quantity of the yield. The main requirement is to prevent the damage of cherry fruit fly.

Although several experiments have been done with significant results in the last decades, there is no IPM method applicable in the practice against this pest. The insecticides recommended and registered against the European cherry fruit fly are broad-spectrum insecticides. Therefore the growers are compelled to use broad-spectrum insecticides, like the phosphorous and pyrethroid compounds. Depending on ripening phosphorous insecticides once or twice or one phosphorous and one pyrethroid, or twice pyrethroid insecticides are applied. After harvesting at least once is to use insecticide against Hyphantria cunea. Compared to the apple or pear orchards the application of the insecticides in sour-cherry orchards is relatively less. Nevertheless, the broad-spectrum insecticides still have obvious effect on the arthropod communities.

The potential pests in the sour-cherry orchards are pear tingid (Stephanitis pyri F.), cherry blackfly (Myzus cerasi F.), San Jose scale (Quadraspidiotus perniciosus Comstock), pear leaf blister (Leucoptera malifoliella Costa), cherry bark tortrix moth (Enarmonia formosana Scopoli), fall webworm (Hyphantria cunea Drury), European red mite (Panonychus ulmi Koch), hawthorn red spider mite (Tetranychus viennensis Zacher) under Hungarian climatic conditions (Balás 1966).
Material and methods

We have the opportunity to study the possibilities how to develop IPM program in sour-cherry orchards, where three plots were treated in different ways.

In choosing the insecticides to be applied against the cherry fruit fly caused difficulties. The IGR insecticides have no effect against this insect. Therefore we were obliged to choose one of the phosphorous insecticides. The A (IPM) plot once, B (conventional) plot twice with a.e. phosalone, C plot twice with pyrethroid insecticides were treated before harvesting. After harvesting the A plot with BT insecticides, B plot with phosalone, C plot with pyrethroid were treated. Beyond that the abundance of arthropod predators was observed in an abandoned orchard in the vicinity of the experimental orchard.

Results and discussion

In summarising the experiences obtained in the different types of sour-cherry orchards in the last decades with the data of our experiment, the following can be stated.

Cherry blackfly frequently occurs on the sour-cherry tress, so from time to time it is necessary to use insecticides against it.

The susceptibility of sour-cherry varieties to the San Jose scale is different. Some varieties suffer serious damage. As a result of a sour-cherry breeding program about 4000 hybrids were grown in Experimental Station Érd Elvira of the Horticultural Research Institute, Budapest. Among them both resistant and susceptible hybrids were found (Jenser and Sheta 1969).

The population density of San Jose scale could be reduced by male control, in spring. Because the larvae of the hibernated generation appear at ripening of most the sour-cherry varieties, it is not possible to use insecticides against it. One of the possibilities to reduce its density is to use insecticides against the males. Because only the first instar may hibernate, the males reach pronymphal and nymphal stages at the same time, at the beginning of May. These stages are sensitive to insecticides. Therefore it is possible to kill the males of the population by a single application of the insecticide. Since San Jose scale is unable to reproduce parthenogenetically it cannot bear larvae without fertilization. The density of the population could be significantly depressed in this way (Jenser and Sheta 1972).

Susceptible varieties are not cultivated in the Hungarian orchards, at present.

High population density of *L. malifoliella* was observed frequently in the orchards. Besides the cherry fruit fly it is the most important pest in the Hungarian sour-cherry orchards, treated with broad-spectrum, mainly pyrethroid insecticides. The regular application of broad-spectrum, mainly pyrethroid insecticides could induce the increase of the population density of *L. malifoliella*. According to our data their parasitoids are able to control their population density in the IPM orchards (Fig.1, 2, 3).

Same situation was observed in our experiment also. Among the leaf miners the population density of *L. malifoliella* increased in the first year. The percentage of the infested leaves was 3% in the IPM plot and 9.7% in the plot treated with pyrethroid. The proportion of parasitised larvae is 14.8% in the IPM plot and 2.6% in the plot treated with pyrethroid. The percentage of the infested leaves increased in the following year (Fig. 4) (Balázs 1997, 1992, Jenser et al. 1999).

The cherry bark tortrix (*E. woebberiana*) is frequently in high population density and endangers the condition of the orchards. In the conventional orchards broad-spectrum insecticides are used against it. It was present in all three plots of the experimental orchard but, its number caught by sex pheromone traps was lower in the IPM (Fig. 5).
*Hyphantria cunea* appears in the sour-cherry orchards after harvesting, and therefore it is necessary to apply insecticides against it. So in the conventional orchards broad-spectrum insecticides are used. In our IPM experiment the BT insecticide proved to be suitable, and the fall webworm colonize the treated plot.

Figure 1. The population density of leaf miners (Újfehértó, 1999)

Figure 2. Percentage of sour-cherry leaves infested by leaf miners (Újfehértó, 1999)
Among the tetranichyd mites the increase of the population density of European red mite (*P. ulmi*) and of hawthorn red spider mite (*T. viennensis*) was high. Their population density was regulated by phytoseiid mites, mainly *Euseius finlandicus*, as well as *Scolothrips longicornis* and *Orius* specimens, in case beneficial arthropod safe insecticides are used.

Owing to the immigration of the specimens significant differences among the density of arthropod predators did not developed in the different plots of the experimental orchard. Substantial differences were found between the abundance of arthropod predators occurring in
the abandoned and in the treated orchards. Above all the spider populations react to the effect of the applied insecticides.

Figure 5. *Enarmonia woeberiana* collected by pheromone traps (Újfehértó, 1999)

**References**


Valuations about mating disruption method application in *Cydia molesta* (Busck) control on nearly 400 hectares of peach tree in the Plane of Sibari (Calabria, South Italy)

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Abstract: Since 1990 in the peach orchards of the Plane of Sibari (Calabria, South Italy) the mating disruption method for *Cydia molesta* control was carried out. At first very good results of the experimental application of the method were obtained; in the following years the method was extended on a more big area (in year 2000 about 400 hectares). The results of this big application of the method are still in course of elaboration. Anyway, it’s possible to assert that the mating disruption method is totally efficient when the pest population is not very big. The weekly monitoring of the peach orchards allows to reduce the damages when the pest attack is higher than the profitable limit. In these situations it’s necessary to use insecticides (integration of the mating disruption method with chemical interventions that allows to reduce these ones).

Key words: I.P.M., *Cydia molesta*, mating disruption, pheromone dispenser, peach.

Introduction

In the last decade, an ever bigger number of producers of the agricultural world has been demanding for production techniques that respect environment.

The reasons of this interest are the following:

– reduction of use of chemical production factors that are dangerous to the operators and the environment;
– possibility of having aids from E.U. (Reg. 2078/92);
– need of meeting the supermarket chain demand for “safe” products more and more.

Because of these considerations, Sibarit-Osas group has been carrying out an integrated production program with the application of sexual pheromones in mating disruption for the control of *Cydia molesta* in peach orchards.

In figure 1 the trend of mating disruption application is illustrated.

At first, the application of mating disruption method had a slow spreading because of the high cost and the small possibility of choice among dispensers. Anyway the good results got in the first years allowed to increase the area with mating disruption application (from 5 hectares in 1990 to nearly 400 in 2000). Besides now it’s possible to choose among more dispenser producers and among more pest management methods as “false trail following” (Molinari *et al*., 2000).
Materials and methods

According to the first experiences in mating disruption application (Cravedi et al., 1992), dispensers Basf RAK 5 were used. They contain the synthetic pheromone of Cydia molesta (cis-8-dodecenyl acetate and trans-8-dodecenyl acetate). Their amount was about 600 per hectare.

Table 1. Cultivar groups with mating disruption application

<table>
<thead>
<tr>
<th>RIPENING TIME</th>
<th>Mating disruption area per year – ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Middle-early cultivars (ripening time 15-30 June)</td>
<td>5</td>
</tr>
<tr>
<td>Middle cultivars (ripening time 30 June-20 July)</td>
<td>0</td>
</tr>
<tr>
<td>Middle-late cultivars (ripening time 20 July-15 August)</td>
<td>0</td>
</tr>
<tr>
<td>Late cultivars (ripening time 15 August-10 September)</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL HECTARES</td>
<td>5</td>
</tr>
</tbody>
</table>

The peach orchards where mating disruption was carried out were chosen according to:
- regularity of the orchard form;
- minimum area of the orchard of 2 hectares;
- possibility of having a wide farm area where mating disruption can be carried out;
- ripening time of the cultivars with choice of the middle-late ones (ripening since the third decade of June);
- zones that traditionally have a low population density of Anarsia lineatella (Zeller).

In March, sexual pheromone traps (“Traptest” by Isagro) were installed in the peach orchards for monitoring Cydia molesta captures. In the orchards where the intervention threshold (20 captures/trap/week in two following weeks) was crossed, a chemical treatment
against the first generation larvae was carried out. Mating disruption dispensers were installed between the third decade of April and the first one of May.

During the whole vegetation period, a weekly monitoring of the shoots and traps was carried out. When a larva was found in the shoot, its species was examined. At harvest time, fruit damages were controlled examining the discard in the orchard (not less than 200 fruits). Besides pheromone release of 20 dispensers was measured every 15 days.

Results

In the first years, since 1990 to 1993, mating disruption was carried out on orchards with middle-early ripening cultivars (Junegold and Flavorcrest); no damage either on fruit or on shoots was observed. In the orchards where only chemical pest management was carried out, no damage on fruit was observed but an high percentage of shoots was damaged in September (last generation of pest), 30-40%.

Since 1994 to 1998, mating disruption was carried out also on middle and late ripening cultivars (Elegant Lady and O’Henry). In the orchards where method was carried out, no damage was observed on fruit at harvest time (0-1 %); a little damage (1-5 %) was observed on shoots in September (third generation). In the orchards where only chemical pest management was carried out, an appraisable damage was observed either on fruit (5-10 %) or on shoots (40-50 %) notwithstanding several treatments.

Pheromone delivery was good enough (see figure 2 and 3 for thermic and hygrometric data). The threshold of 20-25 mg per hectare per hour (Audemard & Leblon, 1989) was widely crossed up to harvest time; average values of over 45 mg per hectare per hour referred to 500 dispensers per hectare were observed.

Figure 2: *Cydia molesta* pheromone delivery (Average data 1994-1998)
Because of what happened in these first years, since 1999 the area with mating disruption application increased and good results either for fruit or for shoots were got. In fact, considerable damages were observed in the orchards with only chemical pest management (10-20 % on fruit and 50-60 % on shoots). Nevertheless, in year 2000, in two orchards with late ripening cultivars (Babygold 9 and Merriam) where mating disruption was carried out, a value of 5-10 % of fruit damage was observed. However this value is lower than the one observed in the orchards with only chemical pest management (10-20 %). On shoots damages were more serious, like the ones observed in the orchards with only chemical pest management (50-60 %). A high population density of *Cydia molesta* in that zone can explain this matter (figures 4 and 5).

![Figure 3](image-url) Figure 3: Trend of temperature and relative humidity per week (average values 1994-1999) – Castrovillari (CS) – c/da Cammarata

![Figure 4](image-url) Figure 4: Trend of *Cydia molesta* captures – year 2000 – Altomonte (CS) zone with high pest population density
Discussion

Mating disruption application can certainly reduce the number of chemical specific treatments against Cydia molesta (about 60% less, that is 2 rather than 6). Anyway, in the zones with high pest population density, the only mating disruption application isn’t enough to limit the damages into a profitable way (3% of damaged fruit). So it can be better to integrate mating disruption with chemical interventions making a timely monitoring of shoots and traps which are installed in the neighbouring orchards without mating disruption application.

Therefore, in the strategy for Cydia molesta control, for the middle and late ripening cultivars (since third decade of June) mating disruption should be used; where insect population density is high, mating disruption must be integrated with chemical pest management.

Besides it’s under consideration the possibility of reducing the pest population density level using mating disruption in the same orchards for more years.

Acknowledgements

We thank Dr. Paolo Molinaro for his active collaboration.

References


Protecting peach orchards by *Cydia molesta* and *Anarsia lineatella* using sex pheromones through the method of “disorientation”

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3 Servizio Fitosanitario Regionale - Bologna

**Abstract:** Experimental trials and demonstrative tests on a large scale have been conducted during a two year period, 1998-1999, on an area of over 200 hectares for the control of *Cydia molesta* and *Anarsia lineatella* by means of a new methodology denoted “Disorientation”. Specific, biodegradable dispensers were placed in the number of 2000/ha for a total amount of 20 g a.i./ha for each application which has an average duration of 45-50 days. Two different applicable protocols were used: the first (A) consisted in the application of dispensers at the start of the flight of the first generation of *Cydia molesta* while in the second one (B) the dispensers were applied at the start of the flight of the second generation of the pest followed by an insecticide treatment with the purpose to reduce the population. In 1998 damages less than 5% were registered on 159 of the 186 demonstration tests (81%), while in 1998 on 186 of the 209 tests (89%). Damages less than 1% were registered in 74 tests in 1998 and in 119 tests in 1999.

**Key words:** Disorientation, *Cydia molesta*, *Anarsia lineatella*, sex pheromones

**Introduction**

The orchard protection from *Cydia molesta* (Busck) and *Anarsia lineatella* (Zell.) has been going through a significant technical evolution in the last few years. The remarkable presence and aggressiveness of these two pests, the ever-increasing difficulty in controlling them by traditional insecticides, and especially the need for integrated defence techniques (EC Regulation 2078 and others) pave the way to the development of new defence strategies which do not rely only on chemicals.

Currently, a suitable alternative to chemical treatments is the mating disruption method, which is executed by shielding the natural female call through the saturation of the environment with a high dose of synthetic pheromone. The efficacy of this method has been tested for years in many countries (Audemard *et al*., 1989; Gentry *et al*., 1974; Jones *et al*., 1984; Rotschild, 1975 and 1979) and also in Italy at the end of the eighties (Capizzi *et al*., 1987; Cravedi & Molinari, 1992; Molinari & Cravedi, 1988, 1990 and 1991), in very wide areas (Cravedi *et al*., 1991).

The disorientation technique, instead, is based on the creation of several, predominant, pheromonic traces, which are released by a sufficient number of low-charge dispensers, and drive males to follow them, thus visiting the various release points, rather than the females actually present in the treated area.

This technique, besides bringing about a remarkable saving of pheromone, is very flexible, e.g. it permits single applications combined with insecticide treatments.

This work describes the results of demonstrative tests carried out on more than 200 ha of peach orchards with the disorientation method for protection against *Cydia molesta* and *Anarsia lineatella* in the two-year period 1998-99.
Materials and methods

Experimental plots
Demonstrative tests were carried out in peach-growing Regions in 1998-99, under the supervision of public and private technical support bodies such as “Servizio Fitosanitario della Regione Emilia Romagna” and “Centro Ricerche Produzioni Vegetali”-CRPV in Cesena, ARSIA Tuscany, the “Osservatorio per le Malattie delle Piante” in Veneto and the “Cooperativa Ortofrutticola OSAS” in Castrovillari (Cosenza). Table 1 indicates the number of farms involved, the overall treated areas and the number of tests (single cultivars within the same plot). Cultivars have been divided into three categories: early, i.e. harvest within 10 July, medium, i.e. harvest between 10 July and 10 August; late, i.e. harvest after 10 August. In both the above-mentioned years the test distribution reflects the actual cultivar distribution (approx. 50% medium, approx. 25% for both early and late).

Table 1. Stone fruit demonstrative tests

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of farms</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Hectares</td>
<td>41</td>
<td>162</td>
</tr>
<tr>
<td>No. of tests</td>
<td>186</td>
<td>209</td>
</tr>
</tbody>
</table>

Monitoring with pheromone traps
Some pheromone traps (model Traptest Isagro) for *Cydia moesta* and *Anarsia lineatella* were placed in the orchards where the disorientation method was applied, but also in the surrounding plots. The traps were inspected weekly.

Pheromone dispensers
Isagro ECODIAN ® dispensers are made of Mater-Bi ®, which is a mixture of biodegradable materials, impregnated with the specific pheromone blend. The hook shape (Fig. 1) has been designed to assure easier installation on the branches, with no need for plastic or metal devices which may cause problems in the orchard.

Approximately 2000 dispensers per hectare were needed for each application in orchards of suitable extent (> 1 ha) with medium infestation; the above-mentioned figure was increased in plots with a large population and in orchards with very tall and strong plants.

The dispensers were placed on the plants at various heights (approx. 1.75-2.50 metres). Approx. 4 dispensers/plant were placed in plots with 4 x 5 m plant density (500 plants /hectare).

ECODIAN ® dispensers have a working life of approx. 45-50 days and the efficiency reduction was recorded after the first trap captures, which were not attributable to other factors. The release time was also confirmed by the gas-chromatographic analysis of the dispensers collected at set intervals.

Figure 1. Ecodian dispenser
**Dispenser application methods**

The demonstration tests were carried out following two different application methods. The first one (Procedure A) was based on the installation of dispensers at the beginning of the flights of the first generation, usually during the first ten days of April for *Cydia molesta* and mid-May for *Anarsia lineatella*; the second installation of dispensers was carried out after the first captures inside the plot.

In the second method (Procedure B), the dispensers were installed before the beginning of the flights of the second generation; moreover an insecticidal treatment (on second-generation larvae and eggs) was carried out according to the indications provided by the forecast model and/or captures of the traps located in the surrounding plots. With reference to medium-late cultivars, the second installation was carried out 45-50 days after the first installation of dispensers, i.e. after recording the captures in the test plot.

**Checks**

The main three-pronged control of method efficiency consisted of:

- Weekly check of pheromone traps for captures
- Visual checks on 500 shoots and 300 fruits in 5 positions, representative of the plot, at the end of the second generation (mid-July);
- Evaluation of the damage caused to the harvest, divided as follows:
  - from 0 to 1% of attacked fruits, out of total production
  - from 1 to 5% of attacked fruits, out of total production
  - from 5 to 10% of attacked fruits, out of total production
  - more than 10% of attacked fruits, out of total production.

**Results and discussion**

The tests carried out in the two-year period have provided very interesting results. The presence of both *Cydia molesta* and *Anarsia lineatella* was recorded in 95% of the involved farms; hence the need for a combined defence method. Therefore the final results refer to the total damage caused by both pests.

Fig. 2 shows the damage class distribution of the harvest during the first year of the test; in 159 tests (81%) out of 186 evaluated tests, affecting 91 hectares, the harvest damage was less than 5%.

![Figure 2. 1998 Classes of damage](image-url)
During the second year, in 186 tests (89%) out of 209 evaluated tests (162 hectares), the fruit damage was less than 5%. (Fig. 3).

Figure 3. 1999 Damage distribution

During these two years, in approximately 75% of the tests, no additional actions, apart from those included in the procedure, were needed; in 21% of the cases an insecticidal support treatment was needed (18% in 1998 and 25% in 1999); see table 2 for the insecticidal treatment causes and frequency. In some cases (6% in 1998 and 1% in 1999) the tests were discontinued to prevent excessive damage.

Better results were achieved during the second year, probably thanks to a more precise definition of the application system. The test errors caused by deviations from the set procedure were minimised in 1999, while some important cases occurred in 1998. These deviations mainly affected the application times of pheromone and Procedure B insecticides. Moreover, special attention was paid to the selection of plots and small plots, or plots of irregular shape, were not included. Furthermore, pheromone traps were accurately and regularly checked, dispensers were timely installed and insecticidal treatments were timely executed.

Table 2 - Incidence of tests with insecticidal treatments and interrupted tests

<table>
<thead>
<tr>
<th>Causes</th>
<th>Support insecticides Incidence (%)</th>
<th>Interrupted tests Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuitable plots</td>
<td>4.30</td>
<td>0.48</td>
</tr>
<tr>
<td>Wrong application</td>
<td>2.15</td>
<td>0.96</td>
</tr>
<tr>
<td>Strong pressure of pests</td>
<td>3.23</td>
<td>4.78</td>
</tr>
<tr>
<td>Dispenser depletion</td>
<td>8.06</td>
<td>8.13</td>
</tr>
<tr>
<td>Other pests</td>
<td>---</td>
<td>11.00</td>
</tr>
</tbody>
</table>

1 Dispenser depletion indicates the partial efficiency loss shortly before the harvest (7-10 days before); therefore in some cases a short-efficacy insecticide was used rather than carrying out the second installation of dispensers.
Figure 4 shows that the results obtained following the two different procedures are equivalent.

Figure 4. Adopted procedures / damage classes – 1999

Conclusions

Thanks to the disorientation technique, which was adopted on more than 200 hectares of peach-orchards, the *Cydia molest*a and *Anarsia lineatella* populations were successfully kept under control and the results are comparable to those of the chemical defence method.

The orchards were protected by applying this technique at the beginning of the flights both of the first and the second generation, i.e. with late installation, which makes for a flexible system, since it can be used not only in an organic farming schemes, but also in an integrated defence procedure.

The Procedure B strategy (chemical approach during the second generation against the first generation) was adopted because it is very difficult to execute the treatment during the first generation and obtain satisfactory results, due to the continuous laying of eggs and hatching of larvae.

The “disorientation and monitoring” combination is to be recommended; as a matter of fact, the captures of the traps located inside the disorientation plot, although they do not completely replace the efficacy recording, provide timely information on risky situations such as excessive pest populations, dispersion of traces caused by a strong wind, early depletion of pheromone in the dispensers.

Acknowledgements

We are grateful to the following public and private bodies: ARSIA Tuscany, OMP Veneto and CRPV Cesena for their practical co-operation. Special thanks to all the technicians of the Integrated Defence service, to the technicians of the fruit and vegetables co-operatives and related bodies, who have actively contributed to this work, and to all the farms in which the tests were carried out.
References


Infestation of roots of stone-fruit rootstocks by larvae of two Capnodis species (Buprestidae) and its relation to level of cyanogenic compounds

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Abstract: Flatheaded rootborers Capnodis spp. (Coleoptera: Buprestidae) are serious pests of cultivated stonefruits (Prunus spp.) in all Mediterranean countries. The larvae colonize the roots and kill the trees. To evaluate the potential of Prunus rootstocks for resistance to Capnodis spp., 10 such rootstocks were challenged with neonates of C. tenebrionis L. and C. carbonaria Klug. Eight weeks later the percentages of infested saplings and the numbers of larvae per sapling were determined. To correlate the potential for resistance with the content of cyanogenic glycosides, the cyanide potential in the root cortex of the tested plants was determined by an enzymatic cyanide assay procedure. Although all tested Prunus rootstocks were colonized to some extent by both species, the intraspecific variations among the rootstocks were extreme. The lowest indexes of susceptibility (number of larvae per sapling X percentage of infested saplings) to C. tenebrionis and C. carbonaria were displayed by Hansen 536 (P. amygdalus x P. persica) and Mahaleb (P. mahaleb), respectively. The patterns of susceptibility index displayed by the other rootstocks were similar for both borer species: 677 (P. persica x P. amygdalus) < bitter almond (P. amygdalus) < Citation (P. domestica x P. persica) < Baladi (P. persica) < Mariana (P. domestica) < Nemagaurd (P. persica x P. davidiana) < bear plum (P. ursina) < apricot (P. armeniaca). The cyanide potential (mmol kg⁻¹) varied considerably among the tested Prunus taxa. However, there was no direct relationship between resistance to Capnodis and level of cyanogenic compounds in the root cortex. Despite the high resistance against the borers shown by Mahaleb and Hansen, both cultivars had the lowest cyanide potentials. Apricot, the most susceptible rootstock displayed the highest cyanide potential, 89 mmol kg⁻¹. The study demonstrated a wide range of resistance against neonates of both Capnodis spp. in Prunus rootstocks. The findings suggest that, contrary to the findings of other studies, cyanide potential is not necessarily a reliable indicator of the degree of resistance to these borers of various Prunus rootstocks

Key words: Capnodis, Buprestidae, rootstock, resistance, stonefruit

Introduction

Larvae of Capnodis tenebrionis L and C. carbonaria Klug destroy the roots of both sapling and mature trees of cultivated stone-fruits (Prunus spp.). Damage caused by C. tenebrionis has been reported mainly from southern European and Mediterranean areas (Garrido 1984), and economic losses attributed to C. carbonaria have been reported so far mainly from Israel and Egypt (Ben-Yehuda et al. 1997). Outside cultivated lands, both species are rare and are seldom found on wild host plants. Management of both Capnodis spp. is problematic, since, association of natural arthropod enemies with Capnodis is very rare, and no fully effective control measures are available against either the adult or the neonates. To reduce losses, frequent applications of nonselective insecticides or intensive irrigation are required. Control of the larvae that have penetrated the roots is not practicable. Bitter almond rootstocks have been considered for decades to be a valuable source of resistance to C. tenebrionis.

Many species of Prunus contain two cyanogenic glycosides: amygdalin and prunasin. The former, a diglucoside, occurs chiefly in the kernels (e.g. Santamour 1998). The latter, a monoglucoside, is found in all tissues including the roots. The relationships between the
resistance to C. tenebrionis and the level of cyanogenic glycosides in the root of Prunus spp. Have been examined in several studies (D’Hallewin et al. 1990, Malagón & Garrido 1990, Usai & D’Hallewin 1990, Mulas 1994, Dicenta et al. 1998), and it has been suggested that resistance to the borer is directly related to the concentration of cyanogenic glycosides of the rootstock (e.g., Malagón & Garrido (1990).

The objectives of the present study were (1) to determine the relative resistance to root colonization by larvae of C. tenebrionis and C. carbonaria of nine major rootstock taxa of stonefruits in Israel, (2) to document the variation of cyanogenic glycosides contents in those rootstock taxa, and (3) to examine the relationship between the cyanogenic glycosides contents and the root colonization by these buprestids.

**Materials and methods**

**Insects**
Adults beetles were collected in apricot, peach and plum orchards. In the laboratory, they were kept in ventilated glass cages. The eggs were incubated at 27°C. One day old neonates were used for artificial infestations.

**Rootstock materials**
Ten taxa of Prunus and one Pyrus were tested; nine of them routinely utilized by stonefruit producers, were: Hansen 536 P. persica x P. amygdalus, Mahaleb P. mahaleb, 677 P. persica x P. amygdalus, bitter almond P. amygdalus, apricot Prunus armeniaca, Citation P. domestica x P. persica, Baladi P. persica, Marian P. domestica and Nemagaurd P. Persica x P. davidiana. The bear plum, P. ursina, a wild species native to the East Mediterranean region, and the common apple rootstock, Hashabi Pyrus malus were also included. The tested plants were 2 yr old saplings growing in 10 l polyethylene bags on red sandy soil.

**Plant infestation with Capnodis and determination of larvae in the roots**
We stopped the irrigation 3 days before the introduction of the neonates. 15 neonates of C. carbonaria or C. tenebrionis, 12 to 24 h after hatching, were placed on the topsoil 10 cm from the base of the stem. Eight weeks later the roots of each sapling were washed and dissected, and the numbers of larvae per sapling and the percentages of infested saplings were determined.

**Index of susceptibility**
The index of susceptibility of the rootstocks for each Capnodis species was determine by comparison with the infestation of apricot, the most susceptible taxa, after exposure to C. tenebrionis or C. carbonaria. The index was calculated by means of the following equation:

\[
\text{Susceptibility index} = \frac{\text{mean number of larvae per sapling} \times \text{percentage of infested saplings}}{\text{mean number of larvae per sapling of apricot} \times \text{percentage of infested saplings of apricot}}.
\]

**Determination of cyanide potential**
The cyanide potential was determine as % w/w of the dry biomass subjected to the following procedure and calculated as mmol kg⁻¹. The samples were analyzed according to Lambert et al. (1975) and Patton et al. (1997). The cyanide concentration in the 0.1N NaOH solutions was performed according to a colorimetric method used for the determination of cyanides in water (Anon. 1995).

**Statistical analysis**
The differences between mean cyanide potentials and mean larvae per plant were tested for each rootstock by a parametric one way ANOVA (SAS 1996); the sum of squares was used for computing all F values. Differences between means were tested by SNK procedure.
difference between percentages of sampling infestation was subjected to the CATMOD procedure (SAS 1996) for maximum likelihood analyses. Differences between predicted values for response functions and percentages were tested by Chi square.

Results

General effect of rootstock and Capnodis species on infestation

Infestation (excluding the apple rootstock) as indicated by larvae per sapling varied significantly among Capnodis species ($F_{9,9} = 3.92$, Pr > $F = 0.0485$) and plant species ($F_{9,9} = 12.31$, Pr > $F = 0.0001$). The mean numbers of larvae per sapling were 1.21 and 1.05 for C. tenebrionis and C. carbonaria, respectively. The percentages of infested saplings were 52.1 and 47.3% for C. tenebrionis and C. carbonaria, respectively, and there were no significant differences between beetles ($\chi^2 = 3.39$, Prob. = 0.065). The level and percentage of infestation varied significantly among rootstocks for each tested Capnodis species (see below). Among the tested rootstocks, only infestation density of Mahaleb differed significantly between the Capnodis species ($F_{1,38} = 5.41$, Pr > $F = 0.025$). None of the Hashabi saplings was colonized by either Capnodis species.

Table 1. Index of susceptibility for two species of Capnodis and root cortex cyanide potential (mean ± SD, dry mass basis), as determined for 11 taxa of Rosaceae

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Susceptibility index</th>
<th>Cyanide potential (mmol.kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C. tenebrionis</td>
<td>C. carbonaria</td>
</tr>
<tr>
<td>Apricot</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Bear plum</td>
<td>66.0</td>
<td>35.6</td>
</tr>
<tr>
<td>Nemagourd</td>
<td>59.3</td>
<td>41.6</td>
</tr>
<tr>
<td>Mariana</td>
<td>46.2</td>
<td>32.4</td>
</tr>
<tr>
<td>Bitter almond</td>
<td>34.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Baladi</td>
<td>23.9</td>
<td>29.4</td>
</tr>
<tr>
<td>Citation</td>
<td>17.9</td>
<td>14.0</td>
</tr>
<tr>
<td>Mahaleb</td>
<td>14.4</td>
<td>0.6</td>
</tr>
<tr>
<td>677</td>
<td>10.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Hansen 536</td>
<td>6.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Hashabi</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Means within the column followed by a common letter do not differ significantly at $P=0.05$

Rootstock infestation

The mean infestation densities by C. tenebrionis were in the following order from the highest to the lowest number of larvae per sapling: Apricot > Bear plum > Nemagourd > Mariana > Bitter almond > Baladi > Citation > Mahaleb > 677 > Hansen. Infestation of the apricot rootstock differed significantly only from those of the last three rootstocks; Hansen the least infested rootstock, differed significantly only from the first four of the above listed rootstocks. The percentage of the infested saplings per rootstock showed a similar pattern. The mean infestation densities by C. carbonaria were in a similar order from the highest to the lowest numbers of larvae per sapling, to that of infestation by C. tenebrionis: Apricot > Baladi > Nemagourd > Bear plum > Mariana > Citation > Bitter almond > Hansen > 677 > Mahaleb.
Infestation of the apricot rootstock differed significantly only from that of the last four rootstocks; Mahaleb, the least infested rootstock, differed significantly from the former five rootstocks. Hansen and 677 were also lightly infested and differed significantly from the five most colonized rootstocks. The percentages of infested saplings per rootstock showed a similar pattern. Table 1 shows the indexes of rootstock susceptibility to each beetle species.

Cyanide potential and its relation to rootstock susceptibility

The endogenous cyanide potential, as measured from the tested rootstock taxa (Table 1), ranged from 89 mmol kg⁻¹ in apricot to <0.01 mmol kg⁻¹ in Mahaleb and Hashabi, a level which was too low for accurate measurement by the current procedure. Cyanide potential in the apricot roots was significantly higher than that of the other tested taxa.

Discussion

Apricot rootstock was the most susceptible to both species of borers. Strong resistance to the borers was displayed by Mahaleb, *P. mahaleb* and by two crosses of *P. persica* x *P. Amygdalus*: 677 and Hansen. Concerning the level of resistance to the borer, our results tend to agree with the findings of Salazar et. al. 1991 and Mulas 1994, although our most resistant rootstock were not examined during the course of these studies. Our results, indicating that 677 maintains higher resistance to the borers than that of bitter almond, do not match the findings of Mulas (1994), which suggested that 677 was significantly more infested than peach and plum rootstocks by *C. tenebrionis*. The moderate resistance exhibited by bitter almond in the present study was unexpected, since many workers have found it the most resistance rootstock for *C. tenebrionis*. However, data presented by Mulas (1994) showed that several clones of bitter almond containing similar amount of prunasin, displayed considerable variation in resistance to *C. tenebrionis*.

The resistance patterns were similar for both tested *Capnodis* species, except that Mahaleb was significantly more resistant to *C. carbonaria* than to *C. tenebrionis*. One possible explanation may be that the high level of coumarins in *P. mahaleb* (e.g., Fung & Herrebout 1987) affects *C. carbonaria* more than *C. tenebrionis* - encounters between *C. carbonaria* and *P. mahaleb* are probably rare in nature since their habitats scarcely overlap. Bear plum, the sole non-cultivated taxon tested was highly susceptible to both *Capnodis* spp. This result contradicts our original thought that, being a wild species it should display high resistance to these borers.

Both Malagon & Garrido 1990 and Mulas 1994 demonstrated that resistance to *C. tenebrionis* was directly related to the cyanide content of roots and suggested that prunasin is probably involved in the resistance. Our results showed a different picture, i.e., the resistance was inversely proportional to the prunasin content with significant correlation between the indexes of susceptibility of both tested *Capnodis* species. Thus, the highest level of this monoglucoside occurred in the apricot rootstock and the lowest in Hansen and Mahaleb, taxa displaying the strongest resistance.

The present data herein suggest that resistance to *C. tenebrionis* and *C. carbonaria* is not due to the toxicity of prunasin to the larvae. Both tested *Capnodis* spp. develop solely on members of the genus *Prunus*, suggesting that accumulation of prunasin is not directed against them, but to deter more general phytophagous insects and/or that it serves other functions. Therefore, we consider that the prunasin content is not a reliable indicator for resistance against these *Capnodis* spp.

The high resistance of Mahaleb, Hansen and 677 to both *Capnodis* spp. suggest that crosses with bitter almond and possibly with *P. mahaleb* have a potential for breeding resistant rootstock. Our findings highlight the lack of information and the confusion
concerning the mechanism of resistance of Prunus taxa to Capnodis. More reliable knowledge is needed for rootstock breeding and improvement programs based on traditional selection, as well as for genetic engineering procedures to develop Prunus taxa expressing new toxins and resistance mechanisms. Enhanced resistance of Prunus taxa to Capnodis offers great potential for breeding rootstocks derived from transgenic plants, that might express immunity against the borer neonates.

Acknowledgments

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References

The stone fruit bud weevil *Anthonomus bituberculatus* Thoms. - sometimes an important pest on plums and apricots in Austria

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**Abstract:** The curculionid beetle *Anthonomus bituberculatus* Thoms. has become a local important pest on apricots and plums in the eastern part of Austria. The beetles feed in autumn on young buds and place their eggs there. In spring the larvae feed inside the buds and pupate there in late spring. During summer the beetles cannot be found in the orchard. Occurrence, appearance and biology of this species is rather close to the well known pear bud weevil *Anthonomus piri* Kollar and only professional entomologists can distinguish the adults. *A. piri* is only recorded on pears in Austria, *A. bituberculatus* makes damages in apricot and plum orchards. *A. bituberculatus* can be found in deciduous woods too. The main host of *A. bituberculatus* may be wild *Prunus* species. From this source *A. bituberculatus* immigrants into stone fruit orchards. It needs some years till the population density of *A. bituberculatus* is high enough to make recognisable damages. Without control actions *A. bituberculatus* can cause total loss of fruit setting in extreme situations. Strike samples can be used for timing of applications against the beetle in autumn before egg laying.

**Key words:** *Anthonomus bituberculatus, Anthonomus piri*, apricots, plums, bud damages

**Introduction**

Plums and apricots are not many fruit crops in Austria, but they have local importance for the local fruit market.
From about 1985 onwards there have been some records from growers and regional advisors on unknown bud damages on apricot trees in the Wachau valley in Lower Austria, the most important apricot growing region of Austria. Since 1992 there are local records on similar damages in some plum orchards in Lower Austria and Styria. Nearly all affected orchards were situated adjacent to deciduous woods. The level of damages went up to total loss of bloom in some cases.
In 1989 the scientific work on this damages started.

**Results**

In most of the damaged buds a single typical weevil larva could be found. Shoots with infested buds were stored in breeding rooms and after pupation adult weevils emerged and could be determined by a taxonomist. This way the curculionid weevil *Anthonomus bituberculatus* was recognised to be the damaging insect.

During the years a lot of observations on this beetle have been carried out by collecting infested buds at different times, strike samples and visual controls in the field. Table 1 summarises all observations on the occurrence of the different stages of the beetle.
The beetle does not only look rather close to A. piri, even the time tables of A. bituberculatus and A. piri are comparable. Pupation is finished some weeks after bloom and the beetles leave the buds.

Till early summer they stay on the fruit trees and can be observed feeding on green plant materials. During the hot period of summer it is nearly impossible to find adult beetles. They come back in September and stay active till it is getting cold in late October. In this period they can be found feeding on young buds. Later the females start egg laying into buds. The number of buds with feeding damage is much higher than the number of buds which get an egg laid inside. At bud burst organs coming from buds with feeding damage often show more or less deformations. Even in orchards with a high infestation level of A. bituberculatus the number of beetles in strike samples stays very low compared with the situation in orchards with A. pomorum or A. piri damages. Even in apricot orchards close to total loss of fruit setting the number of beetles per 100 strikes increased the number 10. The mortality of larvae and pupae seems to be rather high on apricots and plums. In literature wild Prunus species are recorded as main hosts of A. bituberculatus. It looks like that from this source A. bituberculatus immigrates into stone fruit orchards. It needs some years till the level of infestation gets economic importance.

In field trials applications of insecticides well known to be effective against beetles carried out in autumn just before starting of egg laying showed good results against A bituberculatus.

In regions with A. bituberculatus damages the regional advisory service recommends checks at and just after bloom to recognise the actual level of infestation. From early autumn onwards strike samples are taken in infested orchards and based on this results application are carried out. After an successful treatment it needs some years till the population density of A. bituberculatus is high enough to cause recognisable damages again.

Table 1

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<tbody>
<tr>
<td>Weevil</td>
<td></td>
<td>☎☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎☎</td>
<td>☎☎☎☎</td>
</tr>
<tr>
<td>Egg</td>
<td></td>
<td></td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎☎</td>
<td>☎☎☎☎</td>
</tr>
<tr>
<td>Larvae</td>
<td>☎☎☎☎</td>
<td>☎☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎☎</td>
<td>☎☎☎☎</td>
</tr>
<tr>
<td>Pupae</td>
<td>☎☎☎☎</td>
<td>☎☎☎☎</td>
<td>☎☎☎</td>
<td>☎☎☎</td>
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</tbody>
</table>

Acknowledgement
Many thanks to Mr. Wolfgang Suppantzschitsch for his help as taxonomist.

References
Frankenhuyzen, A. van, 1988: Schadelijke en nuttige insecten en mijten in fruitgewassen. Wageningen, NFO.
Comparison between Conventional and Integrated Peach Pest Management in Emilia-Romagna (Italy)*

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2 Istituto Sperimentale per la Frutticoltura – Sez. di Forlì, Via Punta di Ferro, 2. 47100 - Forlì Italy.
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Abstract: With the aim of investigating the influence of IFP application on orchard performance and environment, two identical peach orchards were planted in 1993 in Forlì. One was then managed according to IFP rules, while the other was managed conventionally. Compared to the conventional, the IFP strategy succeeded in reducing the number of sprays to control *Myzus persicae*, *Cydia molesta* and *Anarsia lineatella* with little or no effect on the percentage of fruit damaged. Due to the environmental characteristics of the area where the trial was set up and the susceptibility of the cultivar chosen (a nectarine), more problems were however found in preventing damage to fruit by thrips. Differences in disease control between the two strategies were mostly on the quality and number of chemical applications allowed but not in application criteria, in both orchards of preventive type.

Key words: peach, pests, diseases, IFP

Introduction

In Italy, the application of Integrated Production in orchards has spread rapidly, especially in some regions of the centre and north. In Emilia-Romagna, IP strategy is nowadays applied on more than 20,000 ha, over 25% of the regional fruit growing area (Schipani, 1999). In 1993, the Italian Ministry of Agriculture financed the P.A.N.D.A. Project with the aim of boosting research on low impact cultivation methods in agriculture. A multidisciplinary group was constituted to study the effect of IFP on the environment and production in the Peach Industry. One of the objectives pursued by the group was to compare the effects of conventional and integrated methods on the agronomical behaviour of two peach orchards. The results given here focus on the phytosanitary aspects.

Materials and methods

In 1993, two identical peach orchards (table 1), 5000 m² each, were set up in Forlì (44.3° lat. N, 34 m a.s.l.), 200 m apart from each other. One orchard (Conventional, PC) was managed according to the current local practices, the other one (Integrated, PI) according to the Regional Guidelines of IPM (Regione Emilia Romagna, 1994-2000).

The main agronomical differences were soil management (tillage in PC vs. permanent

* Finalized Project PANDA, Subproject 2, Series1, Paper No.145.
grass in PI) and N fertiliser quantity and distribution schedule (Giovannini, 1996).

In the years between 1995 and 2000, periodical surveys were carried out in both orchards, recording:
- pest and disease presence or symptoms on 300 shoots (weekly);
- OFM and PTB adult flight, by means of pheromone traps (weekly);
- the pheromone release rate, by weighing sample dispensers at 7-14 day intervals;
- pest and disease damage on production, sampling 50-100 fruits per tree on 30 trees (from 1996).

**Pest control**

In PI was carried out according to the Regional Guidelines for IFP, based on selective active ingredients (a.i.) applied over the suggested thresholds; in PC, sprays were applied in advance or at the presence of the pest. The main difference was the application, in PI, of pheromone dispensers (mod. RAK 5-6 BASF) for the control of *Cydia molesta* (Busck) (OFM) and *Anarsia lineatella* Zell. (PTB) at the rate of 500 per hectare.

**Disease control**

Was similar in the two plots, with preventive sprays, but with some limitation in PI as to the number of applications of the same a.i.

Table 1. Experimental peach orchards

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Nectaross (+25 days Redhaven)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rootstocks</td>
<td>GF677 (peach x almond), PSA5 (peach)</td>
</tr>
<tr>
<td>Spacing</td>
<td>5.0 x 4.0 m (500 trees/ha)</td>
</tr>
<tr>
<td>Training system</td>
<td>Vase</td>
</tr>
<tr>
<td>Irrigation system</td>
<td>Microjet</td>
</tr>
</tbody>
</table>

Table 2. Active ingredients applied against major pests and diseases.

<table>
<thead>
<tr>
<th></th>
<th>PI</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PESTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphids</td>
<td>imidacloprid, pirimicarb, ethiofencarb</td>
<td>fluvalinate, pirimicarb, ethiofencarb</td>
</tr>
<tr>
<td>Aphids, Thrips</td>
<td>acefate</td>
<td>acefate, metamidophos</td>
</tr>
<tr>
<td>Scale insects</td>
<td>barium polysulphide</td>
<td>barium polysulphide</td>
</tr>
<tr>
<td>OFM/PTB</td>
<td>pheromones, tefubenzuron</td>
<td>azynphos m., carbaryl, tefubenzuron</td>
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<tr>
<td><strong>DISEASES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf Curl</td>
<td>dodina, ziram, copper</td>
<td>dodina, ziram, copper</td>
</tr>
<tr>
<td>Mildew</td>
<td>sulphur, penconazole, propyconazole</td>
<td>sulphur, penconazole, propyconazole</td>
</tr>
<tr>
<td>Bacteria</td>
<td>copper</td>
<td>copper</td>
</tr>
</tbody>
</table>

**Results**

**Pests**

In PI, infestation by *Myzus persicae* Sulz. was controlled with fewer treatments than in PC (tab. 3), with no differences in the average percentage of fruit damaged by this pest (tab. 4). Significantly heavier damage by thrips on fruits of PI was instead recorded compared to PC.
OFM and PTB pheromone release rate was 3-4 mg/disp/day for 120-130 days (end of August), as shown in fig. 1 (data collected in 1999). Almost no males were caught by pheromone traps in PI (fig. 2). No sprays against Lepidoptera were applied in PI in 4 years, while in the others only 1 compared to 2.7 sprays/year in PC (tab. 3). Some fruit injuries were caused by PTB, against which Mating Disruption is not as reliable as against OFM (Cravedi & Molinari, 1993). Fruit damage percentage by OFM and PTB was statistically no different in the two orchards (tab. 4). Scale insects (*Quadraspispidiotus perniciosus* Comst.) were controlled by a single barium polysulphide spring application in both orchards, except for 1998 (table 4).

Table 3. Number of sprays applied against pests (1995-2000).

<table>
<thead>
<tr>
<th></th>
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<tr>
<td></td>
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<td>Aphids-thrips</td>
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<td>2</td>
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<td>4</td>
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<tr>
<td>OFM/PTB</td>
<td>0</td>
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<td>2</td>
<td>1</td>
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<td>1</td>
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<tr>
<td>TOTAL</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>4</td>
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</table>

(*) significant difference (t test, p=0.05); n.s.= non significant.

Table 4. Pest-damaged fruit (%)

<table>
<thead>
<tr>
<th></th>
<th>OFM/PTB</th>
<th>Thrips</th>
<th>Aphids</th>
<th>Scales</th>
</tr>
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<tr>
<td></td>
<td>PI</td>
<td>PC</td>
<td>PI</td>
<td>PC</td>
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<tr>
<td>1996</td>
<td>14.7 *</td>
<td>5.3</td>
<td>30.6 n.s.</td>
<td>27.3</td>
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<tr>
<td>1997</td>
<td>1.2 *</td>
<td>2.0</td>
<td>0.3 n.s.</td>
<td>0.6</td>
</tr>
<tr>
<td>1998</td>
<td>6.6 *</td>
<td>9.2</td>
<td>17.2 *</td>
<td>3.5</td>
</tr>
<tr>
<td>1999</td>
<td>7.0 n.s.</td>
<td>6.6</td>
<td>14.7 *</td>
<td>3.9</td>
</tr>
<tr>
<td>2000</td>
<td>7.0 n.s.</td>
<td>6.4</td>
<td>6.3 n.s.</td>
<td>7.8</td>
</tr>
<tr>
<td>avg</td>
<td>7.3 n.s.</td>
<td>5.9</td>
<td>13.8 *</td>
<td>8.6</td>
</tr>
</tbody>
</table>

(*) significant difference (t test, p=0.05); n.s.= non significant.

Table 5. Number of fungicides applied in the period 1995/2000.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PI</td>
<td>PC</td>
<td>PI</td>
<td>PC</td>
<td>PI</td>
<td>PC</td>
<td>PI</td>
</tr>
<tr>
<td>Leaf Curl</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Mildew</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Brown rot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

(*) significant difference (t test, p=0.05); n.s.= non significant.

**Diseases**

Leaf Curl (*Taphrina deformans* Berk.) symptoms were recorded on leaves only (table 6). The site of the trial, located near the hills, and the cultivar Nectaross, sensitive to Mildew (*Oidium leucoconium* Desm), lead to the application of an average of 3-5 sprays/year in both orchards.
(table 5). A slightly higher percentage of fruit injured by this disease was found in the PI compared to PC (table 6). Although no treatments were done against Brown rot (*Monilia laxa*, Ehrenb), no flowers and, at harvest time, little fruit (tab. 6) resulted damaged by this disease in both the orchards.

Table 6. Disease-damaged fruits (%)

<table>
<thead>
<tr>
<th></th>
<th>Mildew</th>
<th>Brown rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PI</td>
<td>PC</td>
</tr>
<tr>
<td>1996</td>
<td>11.4 *</td>
<td>5.8</td>
</tr>
<tr>
<td>1997</td>
<td>1.3 n.s.</td>
<td>0.6</td>
</tr>
<tr>
<td>1998</td>
<td>0.5 n.s.</td>
<td>1.0</td>
</tr>
<tr>
<td>1999</td>
<td>0.5 n.s.</td>
<td>0.0</td>
</tr>
<tr>
<td>2000</td>
<td>6.1 *</td>
<td>4.2</td>
</tr>
<tr>
<td>Avg</td>
<td>4.0 *</td>
<td>2.3</td>
</tr>
</tbody>
</table>

(*) significant difference (t test, p=0.05); n.s.= non significant.

Discussion

The overall results can be considered positively, as OFM and PTB are the peach pests usually requiring the highest number of sprays: Mating Disruption consistently reduced insecticide application in PI, although the experimental orchards were small and with a very high PTB population; there is still a lack of information concerning life history and behaviour in the presence of pheromone of PTB, which is increasingly damaging to peach production in Italy. Damage by thrips was heavy in PI: reduction of sprays during the sensitive stages must be carefully considered, especially on nectarines and in areas with high populations.

Disease control in both Integrated and Conventional orchards is still based on preventive sprays; as a consequence, the number of sprays against diseases has been only slightly lower
in PI compared to PC; IP guidelines limit the use of some active ingredients or the number of sprays, but pay special attention to agricultural practices that can reduce tree susceptibility to pests and diseases (Daane et al., 1996). In the future, the set up of previsional models will improve the efficacy of fungicide application (Giosuè et al., 2000).

Today nectarines represent 37% of Italian and 50% of Emilia-Romagna’s peach production: research has pointed out once more some constraints on protecting nectarines according to the high market standards, on which further work is needed.

References

Integrated fruit production of peach tree in the Plane of Sibari (Calabria, South Italy). Analysis of organisation

Francesco Guarino and Adriano Tocci
OP-Sibarit APOA, C/da Ciparsia, 87012 Castrovillari (CS), Italy
Soc. Coop. OSAS Ortofrutticola, C/da Ciparsia, 87012 Castrovillari (CS), Italy

Abstract: The organisation of the integrated fruit production of peaches in the Plane of Sibari (Italy) is pointed out. Particular attention is devoted to the monitoring of the most important pests and cryptogamic diseases and to a guided fertilization program application. The strategies of intervention against pests and cryptogamic diseases are pointed out. A computerized system for the recording of captures, infestation degree and meteorological data and its use for setting up the pest management strategies of the following years are reported. Strategies and prospects of guided fertilization application are reported.

Key words: integrated fruit production, peaches, Plane of Sibari.

Introduction

In 1962, the 2 of September, 14 farmers of Plane of Sibari founded a cooperative society named “OSAS”. At first the area of the orchards was small. In 2000 the number of members came to 111 (among them there is a co-operative society of 307 citrus farmers) and the total area came to 3.229 ha.

The area of the fruit orchards is 1.858 ha (peaches, 564 ha; nectarines, 835 ha; industry peaches, 308 ha; seedless grape, 79 ha; other fruits, 72 ha) and the total yield is 39.240 tons (peaches, 12.500 t; nectarines, 16.300 t; industry peaches, 9.150 t; seedless grape, 560 t; other fruits, 730 t). The area of the citrus orchards is 1.371 ha (oranges, 520 ha; clementine, 851 ha) and the total yield is 33.000 tons (oranges, 16.200 t; clementine, 16.800 t).

The technical assistance service consists of a general head, an agronomist as fruit section head, an agronomist as citrus section head and a chemist as analysis laboratory head. Besides there are 27 farm technicians that provide direct assistance to farmers.

Aims of the integrated fruit production program

IPM section
The guidelines of integrated pest management program are the following:

- reduction to the minimum of pesticide use through the monitoring of the most important pests;
- use of selective pesticides for useful insects respect. It would be better to use pesticides which are low toxic to the operators. A pest management planning is carried out every year; this planning is given to all the farm technicians;
- monitoring of the most important pests using pheromone traps or various attractive ones;
- application of mating disruption in Cydia molesta (Busck) control where possible;
- pesticide residue tests on fruit samples which are drawn 2 or 3 days before the harvest in every orchard;
• pheromone trap installation in the orchards according to pest biological cycle;
• on every trap a bar code is applied; this bar code identify the trap univocally. The bar code is made by a computerized system called "AGROBIO";
• weekly monitoring of traps, fruits and shoots. The data are recorded by a “PSION” organizer with an optical pen which reads the bar code. In the “PSION” there’s a software for each pest. The data recorded in the “PSION” are transferred to the software “AGROBIO”. So the data can be elaborated in a short time.

According to this IPM program, it’s possible to get a reduction of pesticide application number (50% in the early ripening cultivars as Maycrest, Springcrest, Springlady and Armking, 30% in the medium-late ripening cultivars as Elegant Lady, O’ Henry, Stark Red Gold, Venus and Sirio, 60 % in the orchards where mating disruption in carried out).

The prospects of the IPM program application are the following:
• linking up meteorological data with pest flight curve to get forecasting models and reducing the number of traps;
• increase of mating disruption application;
• farm area data survey with “GPS” system;
• weekly data about every pest for each zone.

**Guided fertilization section**
The guidelines of guided fertilization are the following:
• getting the best yield either as amount or as quality through a better plant equilibrium;
• environmental respect (reduction of chemical fertilizer use);
• plant sanitary state improvement;

The guided fertilization strategies are the following:
• choice of reference yield units (15 representative units);
• choice of yield units which are the same for 3 years (about 100 basement units);
• choice of supporting yield units (about 50-60 in a year);

Reference yield unit management is the following:
• leaf analysis every 15 days (from May to September);
• soil analysis in autumn every 5 years;
• historical data collection: irrigation systems, soil management, vegetation behaviour, growing system, etc.;
• annual data collection: pruning, setting, thinning out, amount and quality of yield, vegetation behaviour, nutriment wants (N-P2O5-K2O), estimated yield, etc.;
• fertilization planning with an expert system.

Basement yield unit management is the following:
• leaf analysis in spring (May);
• leaf analysis in summer (end of July);
• data comparing with the ones of reference yield units;
• soil analysis in autumn every 5 days;
• historical data collection: irrigation systems, soil management, vegetation behaviour, growing systems; etc.;
• annual data collection: pruning, setting, thinning out, amount and quality of yield, vegetation behaviour, nutriment wants (N-P2O5-K2O), estimated yield, etc.;•fertilization planning with expert system.
The supporting yield unit is chosen considering the several nutriment problems which can appear during the year; the management is carried out as the basement yield units. About 1/3 of co-operative society area is monitored through these strategies.

The results of the application of the guided fertilization program are reported in the following table:

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Before Program Beginning</th>
<th>After Program Beginning</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FU N / HA</td>
<td>FU N / HA</td>
<td></td>
</tr>
<tr>
<td>Peaches</td>
<td>200</td>
<td>125</td>
<td>-38%</td>
</tr>
<tr>
<td>Nectarines</td>
<td>230</td>
<td>125</td>
<td>-46%</td>
</tr>
<tr>
<td>Industry Peaches</td>
<td>270</td>
<td>149</td>
<td>-45%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phosphorus</th>
<th>Before Program Beginning</th>
<th>After Program Beginning</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FU P₂O₅ /HA</td>
<td>FU P₂O₅ /HA</td>
<td></td>
</tr>
<tr>
<td>Peaches</td>
<td>60</td>
<td>40</td>
<td>-33%</td>
</tr>
<tr>
<td>Nectarines</td>
<td>60</td>
<td>37</td>
<td>-38%</td>
</tr>
<tr>
<td>Industry Peaches</td>
<td>60</td>
<td>49</td>
<td>-18%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potassium</th>
<th>Before Program Beginning</th>
<th>After Program Beginning</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FU K₂O /HA</td>
<td>FU K₂O /HA</td>
<td></td>
</tr>
<tr>
<td>Peaches</td>
<td>200</td>
<td>70</td>
<td>-65%</td>
</tr>
<tr>
<td>Nectarines</td>
<td>200</td>
<td>70</td>
<td>-65%</td>
</tr>
<tr>
<td>Industry Peaches</td>
<td>200</td>
<td>110</td>
<td>-45%</td>
</tr>
</tbody>
</table>

The prospects of guided fertilization program are the following:

- integration of “PEPISTA SYSTEM” with soil tensiometric and meteorological data for a best water management;
- total automation of irrigation systems.

Acknowledgements

We thank Dr. Paolo Molinaro for his active collaboration.
Fatty acid control trials on some peach and almond arthropods

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Abstract: Every year we can observe infestations of Aphids on stone fruits in Apulia (South Italy). The Genera *Myzus* and *Brachycaudus* often occur in peach and almond orchards. The Genus *Hyalopterus* (Rhynchota: Aphididae) is less represented. In the last years mites too have been recurrent during summer. Since May we can observe almonds infested by *Monosteira unicostata* M.R. (Rhynchota: Tingidae), which is becoming a pest for cherry trees too. The farmers control Aphids, Mites and *M. unicostata* using carbamates, phosphoric esters and pyrethroids. The treatments are numerous but ineffective, because generally delayed. The Entomology Institute of the University of Bari in the last years carried out researches about bio-ethology and population dynamic of Aphids, Mites and *M. unicostata* in Apulia. The effectiveness of fatty acids was tested to control Rhynchota and Tetranychidae pests. The pesticide was used at the top of the infestation. The fatty acids are more effective in deionized water against Aphids. Otherwise they were not very effective against *M. unicostata* and Mites. The fatty acids gave good effect for a few days, therefore the sprayings, at the interval of one week, seemed more effective. Useful insects weren't damaged.

Key words: mediterranean environment, stone fruits.

Introduction

Aphids (Rhynchota: Aphididae) and *Monosteira unicostata* M. R. (Rhynchota, Tingidae) attacks are reported every year on stone fruits.

In particular, in the Mediterranean environment, attacks by aphids of genus *Brachycaudus, Myzus* and *Hyalopterus* occur frequently. The first two induce direct damages on the leaves, thereby impairing plant photosynthesis and at the same time, they may transmit virus diseases. Their populations develop on stone fruits from March until early June, with a peak between end April and early May (Moleas, 1990). The genus *Hyalopterus*, more thermophile, is prevalently observed in May.

*M. unicostata* causes yellowings and early leaf fall mainly on almond and cherry. This Rhynchota is reported from May to September (Moleas, 1985; Moleas, 1987) and reaches its peaks at end June, early July and in August.

Number of treatments are carried out to combat these stone fruits pests by using synthetic insecticides. Many of these treatments are useless because they are done too late, when damages have already occurred and the aphids are protected by the rolled leaves. Moreover, late treatments may also be harmful because they destroy predators which, in this period, increase their populations and because they favour the occurrence of Tetranychidae mites.

Besides developing proper monitoring and sampling for the timely control of stone fruits pests, the Institute of Agricultural Entomology of Bari University (that last year has merged with the Agro-forest and Environmental Biology and Chemistry Department), has undertaken control trials with new environment-friendly insecticides, some of which have not been registered in Italy yet. Among these insecticides, a fatty acid compound, supplied by Mycogen and identified by the MYX-I-4020-It acronym, has been tested.
Materials and methods

The trials were conducted on the experimental farm of Bari University, located in Valenzano (Bari), during 1995. They were aimed at assessing the fatty acid action against:

i) Brachycaudus and Myzus on peach;
ii) Hyalopterus on almond;
iii) M. unicostata on almond;
iv) Tetranychidae mites on almond.

For the pests of the first group, 4 trees were chosen, two of which were treated with fatty acids in distilled water and two with fatty acids in spring water, to assess the limestone impact on fatty acids. As regards the pests of the II, III and IV group, 4 trees were selected, 2 of which were treated with fatty acids in distilled water and the two were used as control. No other insecticide treatment was performed on the test-trees. The plants were sprayed through a knapsack sprayer, by diluting 200 grams of MYX-I-4020-It in 10 litres of water. Approximately 3 litres of water and 60 grams of insecticide were used for each plant.

In order to test the compound efficacy, treatments were done during the pest peak period. Two treatments were carried out with a week interval for aphids. Furthermore, the efficacy of a single treatment on M. unicostata and Tetranychidae mites was assessed.

Table 1 reports the insecticide treatment periods and the sampling dates to assess the fatty acids action.

Table 1: Treatments and sampling dates

<table>
<thead>
<tr>
<th></th>
<th>Brachycaudus and Myzus</th>
<th>Hyalopterus spp.</th>
<th>M. unicostata</th>
<th>Mites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatments</td>
<td>11/5; 18/5</td>
<td>7/6; 15/6</td>
<td>14/7</td>
<td>14/7</td>
</tr>
<tr>
<td>Samplings</td>
<td>24/5; 9/6; 15/6</td>
<td>17/6; 22/6</td>
<td>18/7; 24/7; 1/8</td>
<td>18/7; 24/7</td>
</tr>
</tbody>
</table>

The treatment efficacy was evaluated by taking a leaf sample per trial on which living aphids (larvae and adults), living monosteiras (larvae and adult colonies) and living mites (larvae, adults and eggs) were counted. The significance of the different trials was compared by Student t.

Results and discussion

Efficacy of treatments against peach aphids (Brachycaudus spp. and M. persicae)

Table 2 reports data relating to the observations (living aphids/leaf) and their statistical analysis. In the first sampling, six days after the second treatment, the number of aphids (larvae and adults) on the test-plants treated with fatty acids in distilled water was lower compared to the test-plants treated with fatty acids in spring water.

In the second sampling, the situation remained the same, despite the increase in the number of larvae and adults in both trials.

In the third sampling, no significant difference was observed between the two trials.

On these grounds, it can be concluded that, during the first week after the last treatment, fatty acids mixed with distilled water may have a significantly limiting action which, little by little, decreases in the second week and is completely exhausted in a month.
### Table 2: Samplings on trees infested by *Brachycaudus* and *Myzus*

<table>
<thead>
<tr>
<th>Dates</th>
<th>24/5/95</th>
<th>9/6/95</th>
<th>15/6/95</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
</tr>
<tr>
<td>F. acids</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.22</td>
<td>2.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Mean</td>
<td>0.22</td>
<td>2.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Student t</td>
<td>4.69*</td>
<td>4.36*</td>
<td>9.27*</td>
</tr>
</tbody>
</table>

F. ac. 1 = Fatty acids + distilled water; F. ac. 2 = Fatty acids + spring water.  
**t** values marked by an asterisk (*) indicate significant comparison for \( P \leq 0.01 \).

### Table 4: Samplings on trees infested by *Monosteira unicostata*

<table>
<thead>
<tr>
<th>Dates</th>
<th>18/7/95</th>
<th>24/7/95</th>
<th>1/8/95</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
</tr>
<tr>
<td>F. acids</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.52</td>
<td>3.57</td>
<td>0.21</td>
</tr>
<tr>
<td>Mean</td>
<td>1.52</td>
<td>3.57</td>
<td>0.21</td>
</tr>
<tr>
<td>Student t</td>
<td>2.39*</td>
<td>3.8*</td>
<td>2.26*(1)</td>
</tr>
</tbody>
</table>

F. ac. = Fatty acids; C = Control;  
* = significant; n.s. = non significant; (1) = significant in favour of the untreated control

### Table 5: Samplings on trees infested by Tetranychidae

<table>
<thead>
<tr>
<th>Dates</th>
<th>18/7/95</th>
<th>24/7/95</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larvae</td>
<td>Eggs</td>
</tr>
<tr>
<td>F. acids</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>14.7</td>
<td>3.62</td>
</tr>
<tr>
<td>Mean</td>
<td>14.7</td>
<td>3.62</td>
</tr>
<tr>
<td>Student t</td>
<td>5.93*</td>
<td>6.07*</td>
</tr>
</tbody>
</table>

F. ac. = Fatty acids; C = Control;  
* = significant; n.s. = non significant; (1) = significant in favour of the untreated control
Efficacy of treatments against Hyalopterus

Table 3: Samplings on *Hyalopterus* infested trees

<table>
<thead>
<tr>
<th>Dates</th>
<th>17/6/95</th>
<th>22/6/95</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larvae</td>
<td>Adults</td>
</tr>
<tr>
<td></td>
<td>F. acids</td>
<td>Control</td>
</tr>
<tr>
<td>Mean</td>
<td>0,49</td>
<td>19,86</td>
</tr>
<tr>
<td></td>
<td>0,2</td>
<td>4,39</td>
</tr>
<tr>
<td>Student t</td>
<td>5,44*</td>
<td>4,87*</td>
</tr>
</tbody>
</table>

F. acids = Fatty acids; C= Control; n.s.= non significant

As regards *Hyalopterus* spp., Table 3 shows that the efficacy of the fatty acid treatment was highly significant on both larvae and adults during the first sampling, i.e two days after the last treatment. Concerning the second treatment, the significance could be evaluated for the larvae but not for the adults. The waxy production, typical of this aphid genus, was supposed to limit the fatty acid action.

**Treatment against Monosteira unicostata**

Table 4 indicates that fatty acid treatments against *M. unicostata* have a certain significance only 4 to 5 days after the treatment, whilst the two other samplings show quite contradictory results. Indeed, on 24/7/95, the control contained significantly less larvae than the treated sample and the difference between the adults was not significant. Probably, the hot and dry climatic conditions, which typically characterise the *Monosteira* pullulation period, may hamper the fatty acid efficacy against this Tingidae.

**Treatment against Tetranychidae mites**

Insofar as Mites are concerned, Table 5 demonstrates that only the first sampling, five days after the treatment, yielded highly significant results in favour of the fatty acid-treated plants. As a matter of fact, the average number of larvae, adults and eggs per leaf was lower compared to the control. In the following sample, no significant difference was recorded for the larvae and the adults. Concerning the eggs, even the control displayed lower values than the treated plants. It may be inferred that for mites too, fatty acid treatments done in full summer are effective only for 5 to 6 days.

**References**


Integrated pest management strategies for *Frankliniella occidentalis* on peach tree in the Plane of Sibari (Calabria, South Italy)

Francesco Guarino and Adriano Tocci
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Soc. Coop. OSAS Ortofrutticola, C/da Ciparsia, 87012 Castrovillari (CS,) Italy

Abstract: The strategies of interventions against *Frankliniella occidentalis* are reported. The integrated pest management strategies and the conventional ones are compared. At present, the integrated pest management strategy is not as good as the conventional one, to avoid the damage caused by the pest.

Key words: IPM, *Frankliniella occidentalis*, peach, Plane of Sibari.

Introduction

The identification of *Frankliniella occidentalis* in the Plane of Sibari was done in 1992 but in 1989 probable thysanoptera damages on nectarine fruits were observed near harvest time.

Environmental conditions influence the presence of *Frankliniella occidentalis*: a very rainy winter and spring reduces pest population density, while it increases when weeds get dry (first half of June).

Pest presence can be soon detected using chromotropic traps or monitoring the leaves on the top of the shoots.

Damages

There are decolourizations along the main ribbing of young leaves and/or on the edge of the still bent leaves with border deformation. Besides, the bent leaves stand for pest cover.

Peach and nectarine fruits show decolourizations without deformations. The most damaged fruit sides are the ones covered by leaves or under the shadow of the tree foliage, the ones in contact with another fruit and the peduncular cavity which is partially covered by the carrying branch.

A different damage between the first and the last harvest time can be observed; at the last harvest time damage can be 20% higher.

Integrated Pest Management (IPM)

*Weed management*

The removal of weeds standing along the orchard rows, between the rows and in the ditches not always can reduce pest population. Sometimes, an appropriately management of some weeds such as *Solanum nigrum* can reduce fruit damages because of an higher presence of predators like *Orius* spp. and because of an attraction to *F. occidentalis*. A delay of soil tillage until springtime can favour the presence of predators.
**Monitoring**

Execution of regular samplings on the young leaves since the beginning of April till the fruit colour change; since this time also fruits are monitored. The intervention profitable limit is 1-2 pests per leaf on the top of the shoots or per fruit.

**Chemical pest management**

When the economic thresholds are reached, it is necessary to treat using the pesticides which are allowed in the “UE IPM Reg. 2078/92 - Calabria District”: Acrinatrine and Fenitrothion\(^1\) MI. Not more than 2 interventions in total can be carried out.

Results got with the use of these pesticides depend on pest population density. Pest population density is low when the number of pests per fruit is lower than 2-3 while is high when the number is about 8-10.

When pest population density is low damages on fruit are small: 3-4 % of damaged fruits which have a skin decolourized surface not higher than 5%. In this situation there is no problem for sale.

When pest population density is high damages on fruit are more serious: 7-10 % of damaged fruits that have a skin decolourized surface over 10%. These fruits are note salable (see table 1).

<table>
<thead>
<tr>
<th>Population density</th>
<th>Skin decolourized surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5%</td>
</tr>
<tr>
<td>Low</td>
<td>60-70%</td>
</tr>
<tr>
<td>High</td>
<td>30-10%</td>
</tr>
</tbody>
</table>

**Traditional pest management**

When the economic thresholds are reached, pesticides are used. These pesticides are the ones allowed on peach but without limitation of toxicological class and selectivity to useful insects. Usually just one treatment using a mixing of 2 pesticides is done and its timing is at infestation beginning, when pest can be only in the leaves. This treatment allows to repress damage into a profitable limit until the end of the harvest. The damaged fruits are lower than 3% and skin decolourized surface is not higher than 5%.

**Conclusion**

*Frankliniella occidentalis* control is difficult when pest population density is high; in this situation pesticides which are allowed in the “UE IPM Regulament 2078/92 – Calabria District” are not very efficacious as much as the traditional ones.

Therefore it should be necessary to introduce new active principles with toxicological, ecologic features that respect the requisites of the “Integrated production principles and technical guidelines” issued on IOBC/WPRS Bulletin 16 (1)/1993.

\(^1\) When “Lufenuron” is used against *Cydia molesta*, a collateral action against *F. occidentalis* crawlers is observed.
In fact the easy resort to traditional pesticides must be excluded for the following reasons:
- high toxicological class and danger to operators;
- low selectivity to the useful insects.
- possible high pesticide residue level in fruit.

Acknowledgements

We thank Dr. Paolo Molinaro for his active collaboration.

References


The control of *Cydia molesta* in pome fruit orchards using sex pheromones through the method of “disorientation”

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** Istituto di Entomologia e Patologia vegetale – UCSC Piacenza
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Abstract: Experimental tests for the control of *Cydia molesta* on pome fruit were carried out in a two year period 1998-1999 and involved an area of 32 ha, using a new technique denominated “Disorientation”. It could be considered an ulterior defence strategy which employs limited quantities of pesticide. 2000 biodegradable dispensers per hectare, a total of 20 g a.i./ha, were employed. The experimental tests were carried out in a two year period 1998-1999 and involved an area of 32 ha in the Regions of Emilia Romagna and Trentino Alto-Adige. They were conducted in collaboration with the Servizio Fitosanitario della Regione Emilia Romagna, the Centro Ricerche Produzioni Vegetali (CRPV) and the Ente di Sviluppo Agricolo del Trentino (ESAT). The dispensers for *Cydia molesta* were applied in mid-July on fields where, for the most part, the mating disruption was practiced with Ecopom Isagro dispensers for the defence against *Cydia pomonella*. On the 22 demonstration trials in 1998, only 1 suffered damage of 2%, while in the other 21 the control was total. An excellent control of *Cydia molesta* was also achieved in 1999, only 1 out of the 31 tests suffered a damage higher than 5% (mainly due to the border effect) while on 24 tests the attack was contained under 1%.

Key words: *Cydia molesta*, pome fruits, disorientation, sex pheromones

Introduction

*Cydia molesta* (Busck) larvae attacks to pome fruits have been recorded for a number of years. This phenomenon is described in the literature (Balachowsky, 1966; Roerich, 1961; Tremblay, 1986) and mainly occurs, with unusual intensity, in northern Italy, (Pollini & Bariselli, 1993). A similar behaviour has also been reported in other areas (Gonzalez, 1980; Reis *et al.*, 1988; Zhao *et al.*, 1989).

This pest may also be permanently present in apple orchards, but damage usually occurs in the summer and additional measures are needed shortly before harvest. As a consequence, the participation in “zero-residue” sales programs can be jeopardised and all the measures taken to keep *Cydia pomonella* under control, with the confusion method or by *Bacillus thuringiensis* preparations, can be rendered ineffective (Arsura *et al.*, 1992; Boscheri *et al.*, 1986; Charmillot *et al.*, 1993; Ferrari, 1992; Grande *et al.* 1992; Ioriatti *et al.* 1997; Pontalti & Dallago, 1992; Rama *et al.*, 1997; Waldner, 1997).

The possibility of using pheromones to limit the attacks of *Cydia molesta* had already been demonstrated (Rotschild, 1975; Molinari & Cravedi 1989, 1991, 1992). Hence the decision to include a *Cydia molesta* control system in different defence strategies; this system is based on the diffusion of synthetic sex pheromones by means of biodegradable dispensers, according to the “disorientation” method.
Materials and methods

Experimental plots
Demonstrative tests were carried out on a 30-hectare area located in Emilia Romagna, under the supervision of “Servizio Fitosanitario della Regione” and “Centro Ricerche Produzioni Vegetali” (CRPV), in 1998-99.

Ten farms, with a total area of 15 hectares every year, which had experienced significant problems in the defence against *Cydia molesta*, were selected according to the commercial destination of the products (organic or zero-residue products). Tests were equally divided between apple and pear orchards.

In 1999 the experiment was expanded to 6 apple orchards (total: 2.5 ha in the area south of Trento) where chemical defence against *Cydia pomonella* was used. These tests were co-ordinated by ESAT.

Table 1 shows the affected area and the number of tests carried out (single cultivars within the same plot).

<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Emilia Romagna</td>
<td>8.4</td>
<td>6.4</td>
<td>6.2</td>
<td>8.1</td>
<td>8.7</td>
</tr>
<tr>
<td>Trentino Alto Adige</td>
<td>--</td>
<td>--</td>
<td>2.5</td>
<td>3</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>8.4</td>
<td>6.4</td>
<td>8.7</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
</table>

Monitoring with pheromone traps
Some pheromone traps (model Traptest Isagro) for *Cydia molesta* and the Carpotrap model for *Cydia pomonella* were placed in the orchards where the disorientation method was adopted and in the surrounding plots. The traps were inspected on a weekly basis.

Pheromone dispensers for Cydia molesta (ECODIAN ®)
Isagro ECODIAN ® dispensers are made of Mater-Bi ®, that is a mixture of biodegradable materials impregnated with the specific pheromone blend. The hook shape (Fig. 1) has been designed to assure easier installation on the branches, with no need for plastic or metal devices which may cause problems in the orchard.

![Figure 1. Ecodian dispenser](image1)

![Figure 2. Ecopom dispenser](image2)

Approximately 1500-2000 dispensers/hectare, depending on the type of fruit orchard, were needed in case of medium infestation.
The dispensers were placed on the plants at various heights (approx. 1.75-2.50 metres). Approx. 1-2 dispensers/plant were placed in plots with 4 x 2 m plant density (1250 plants/hectare).

The dispensers were installed at the beginning of the capture of the summer generations of *Cydia molesta*, usually after mid-July.

ECODIAN® dispensers have a working life of approx. 50-60 days and the efficiency reduction was recorded after the first trap captures, which were not attributable to other factors.

**Pheromone dispensers for Cydia pomonella (ECOPOM®)**

ECOPOM® dispensers for defence against *Cydia pomonella* are made of biodegradable fibrous material (Fig. 2). 300 dispensers/hectare were needed for each application.

The dispensers were placed on the plants at various heights (approx. 1.75-2.50 metres) at the beginning of the flights of *Cydia pomonella*, usually during the last ten days of April. The dispensers were then re-installed after two months according to the same procedure.

**Insecticide treatments**

Preparations based on *Bacillus thuringiensis* were used in some farms for the defence against *Cydia pomonella*. Due to their timing and short life, these treatments had no effects on *Cydia molesta* populations.

As concerns the area round Trento, the traditional chemical control against *Cydia pomonella* was adopted, according to the procedure proposed by ESAT in the Autonomous Province of Trento. Table 2 shows the treatment period and type.

<table>
<thead>
<tr>
<th>Period</th>
<th>Chemical defence</th>
<th>Disorientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning of May</td>
<td>Growth regulator</td>
<td>Growth regulator</td>
</tr>
<tr>
<td>Mid-May</td>
<td>Growth regulator (for Leafrollers)</td>
<td>Growth regulator</td>
</tr>
<tr>
<td>Mid-June</td>
<td>Growth regulator</td>
<td>Growth regulator</td>
</tr>
<tr>
<td>Last ten days of July</td>
<td>Phosphoric ester</td>
<td>Phosphoric ester</td>
</tr>
<tr>
<td>End of July-beginning of August</td>
<td></td>
<td>Dispenser installation</td>
</tr>
<tr>
<td>Mid-August</td>
<td>Phosphoric ester</td>
<td></td>
</tr>
</tbody>
</table>

In some farms in Emilia Romagna where the presence of *C. pomonella* was not significant no insecticide treatment was carried out after the installation of dispensers against *C. molesta*.

**Checks**

Assessment of the method efficacy included:

- Weekly check of pheromone traps catches
- Visual checks, before the installation of dispensers, of approximately 100 fruits in 5 positions, representative of the plot and differentiation of damage caused by *C. molesta* and *C. pomonella*, whenever possible.
- Evaluation of total damage at harvest, divided in four classes:
  - from 0 to 1% of attacked fruits, out of total production
  - from 1 to 5% of attacked fruits, out of total production
  - from 5 to 10% of attacked fruits, out of total production
more than 10% of attacked fruits, out of total production

the damage caused by C. molesta and C. pomonella was differentiated, whenever possible.

Results and discussion

Both Cydia pomonella and Cydia molesta were present in all the farms involved in the test. Therefore a combined defence strategy was followed.

Figure 3 shows the various strategies against C. pomonella after the application of Ecodian dispensers during the two-year test.

![Figure 3. Control strategies against C. pomonella](image)

Ecodian- Bacillus thuringiensis combination

In some farms the tests were carried out by combining the disorientation technique against C. molesta, with insecticide treatments against C. pomonella before the installation of dispensers and continuing with B.t.-based treatments. This strategy was very efficient on both apple and pear and the total damage was limited to 1%.

Ecodian-Ecopom combination

A good fruit protection was also achieved by combining the two pheromone-based techniques (Ecopom and Ecodian). This method was adopted for approximately half the tests in 1998, more than 60% of the apple, and all the pear orchards in 1999.

The incidence of the damage caused by the two pests and its distribution in the two years are shown in Figure 4.

![Figure 4. Damage distribution in Ecodian – Ecopom combination](image)

As far as apple orchards are concerned, the Ecodian method has proved to be efficient in limiting C. molesta. In fact, only one test (Fuji cultivar) out of 16 recorded an 8% damage in
the two-year period. It was harvested during the first ten days of October, approximately 80 days after the installation of disorientation, i.e. when the dispensers had lost their efficacy long before.

The results obtained in keeping *C. pomonella* under control with Ecopom were also satisfactory. Remarkable damage was recorded only in 4 tests, carried out in an organic farm with large pest populations in 1998, where the dispensers had been installed during the second generation only.

In pear orchard, although the combination of *Cydia pomonella* mating disruption/*C. molesta* disorientation was successful, the Passacrasana cultivar (harvest: first ten days of October) and the Conference cultivar recorded some damage near the borders of the plots.

The results obtained by mating disruption on *Cydia pomonella* were successful.

**Ecodian-insecticide combination**
Excellent results (damage less than 1%) were also achieved with three tests carried out on apple orchards in the Trento district. In these cases the chemical defence against *Cydia pomonella* was combined with the Ecodian disorientation. The results were similar to those obtained with the chemically treated control plot.

**Ecodian without insecticides**
In the pear tests, where no insecticides were applied after mid-July, damage caused by *C. pomonella* increased, according to the various ripening stages, ranging from 1% for the Conference cultivar (mid-August) to 6% for the Abate cultivar (approx. mid-September). A chemical spray was hence carried out on the Passacrasana cultivar. *C. molesta* was kept under control almost completely; recorded damage was less than 1% in three different tests and 2.3% only in one test.

**Conclusions**

The tests demonstrated that the disorientation method for the control of *Cydia molesta* on pome fruits can be efficiently used to integrate various defence strategies against *Cydia pomonella*. The combination of two different pheromone-based methods, applied to different pests in different periods, seems to be very interesting.

In any case, since damage caused by *Cydia molesta* to pome fruits is more evident in the period immediately before the harvest, the control of this pest without insecticides guarantees products without any residues.

**Acknowledgements**

We are grateful to all the private and public institutions which have provided their technical support: CRPV – Cesena and ESAT – Trento, for their concrete co-operation. Special thanks also to Fausto Grimaldi for his organising help, to the technicians of the fruit and vegetables co-operatives, who organised the tests, and to all the farms involved.

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Coccinellidae in peach orchards in connection with agricultural practices

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Abstract: Data are presented on the presence and activity of coccinellids in peach orchards related to the presence or absence of a ground cover under the trees. Populations of aphids and coccinellids in the two different conditions are compared. Possible applications of ground cover in biological control are also exposed.

Key words: peach, aphids, coccinellids, agricultural practices

Introduction

Authors recorded a positive influence of intercropping on the presence and activity of coccinellids (Coll & Bettrel, 1995). Nicoli et al. (1995) found that hedges on field margins can be attractive to many common species of aphidiphagous coccinellids. In Europe, Uroleucon cirsii (L.) and Aphis fabae cirsiacanthoidis Scop. develop on Cirsium arvense, and are preyed on by Coccinella septempunctata (L.), Adalia bipunctata (L.) and Propylea quatuordecimpunctata (Völlk, 1998). Alfalfa fields also have a positive effect (Pruszynski e Lipa, 1971; Whitcomb, 1981; Molinari et al., 1999). Some cultural practices can exert a strong influence on coccinellid populations: cutting of the ground cover, correctly timed, can determine a movement of adult coccinellids on orchard trees (Savoiskaja, 1966). The influence of soil cover on the presence and activity of aphidiphagous coccinellids was determined in peach orchards in Emilia Romagna.

Materials and methods

Two peach orchards, one managed with organic farming methods and the other with advanced IPM (Mating Disruption against Cydia molesta) were chosen in Emilia Romagna. Two plots of the same variety were defined in each orchard and 10 sample trees in each plot were marked. The two plots differed only in the management of the soil cover: in the first plot the grass was regularly cut (RC), while in the second (NC) the grass was left until the end of the experiment. MD was applied on both orchards; no aphicide sprays were applied on the IPM orchard, while on the organic orchard 2 sprays (pre and post-blooming) were applied.

Aphids

The A.C.T.A. method was used to evaluate the infestation level of aphid population, ranking trees according to the number of infested shoots:

- 0 : no infested shoots
- 1 : 1 to 5 infested shoots
- 2 : 6 to 25 infested shoots
- 3 : > 25 infested shoots
The average of the ranks in the plot was calculated and considered as the “infestation index”. More detailed information on *Myzus persicae* (Sulzer) development was obtained by checking different levels of damage to the shoots by aphids (Niemczyk & Pruska, 1986; modified); 3 different ranks were identified:
- undamaged shoots (*starting colonies*);
- leaf curl damage (*active colonies*);
- leaf curl damage with no aphids (*destroyed colonies*)

**Coccinellids**
The number of coccinellids per tree (Lövei & Radwan, 1987) was obtained by “visual sampling”, that is, a non-destructive sampling technique (Michels & Behle, 1992). Specimens of coccinellids were collected every week by beating tray from heavily infested trees, randomly selected.

**Results and discussion**

A higher number of species was recorded in NC, as expected. *A. bipunctata* was the dominant species in both plots. Aphid infestation was heavier in RC and lasted for a longer period.

![Figure 1. Distribution of coccinellid species. Visual count. (RC=Regularly Cut; NC=No Cut)](image)

A remarkable difference was observed after a period of lower temperatures at the end of May: the populations of coccinellids in NC recovered much faster than in RC, with the return of favourable weather conditions.

Two distinct peaks of aphid infestation and two related peaks of coccinellid presence were recorded in RC: *A. bipunctata* was dominant in the first, while in the second one different species were almost equally present. Coccinellid populations in NC never reached high numbers, but were constantly active during aphid infestation.

Checking different levels of damage to the shoots by aphids showed a different predator/prey ratio in the two plots: the maximum presence of starting colonies was synchronous with a first coccinellid peak, that in RC was 1 specimen/colony, while in NC up to 2 coccinellids/colony were recorded in the same period.
A higher number of species and specimens was collected by beating tray compared to visual count; this is due not only to the different sampling technique, but also to the fact that the beating tray technique was used on particularly infested trees.

*A. bipunctata* was recorded earlier than other species, and its peak was tightly related to aphid infestation. The other 2 major coccinellid species, *C. septempunctata* and *P. quatuordecimpunctata*, reached higher population levels only 15-20 days later.

A non-aphidiphagous coccinellid, *Stethorus punctillum*, that preys on mites, was recorded in different numbers in the two plots: although no mites were recorded, a considerable number - more than 50% of the specimens collected in NC - belonged to this species. This presence could be explained by a presence of mites on spontaneous vegetation.
Figure 4. Distribution of coccinellid species. Beating tray. (RC=Regularly Cut; NC=No Cut).

References

Improving the prediction of adult codling moth (*Cydia pomonella* L.) emergence in a natural environment

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**Abstract:** The precise prediction of moth flight is a key-factor for an efficient monitoring and a successful and sustainable control of codling moth *Cydia pomonella* (L.) (Lepidoptera: Tortricidae). Nevertheless, forecasting is generally complicated by the large variability of the individual post-diapause developmental times. The spatial distribution of the hibernation sites and the corresponding microclimate were investigated in order to improve the understanding of the scattered emergence pattern of adult moths in spring.

*Cydia pomonella* was found to have no preference for a particular trunk sector for hibernation. Diapausing larvae were equally distributed around the tree trunk, independent from the time of diapause entrance. However, temperature varied considerably between southern and northern trunk sectors, particularly in winter and early spring when tree trunks were heated by incident radiation. Based on continuous temperature recordings from four consecutive years trunk temperature was described as a function of air temperature and incident radiation. Using this relationship site specific temperature sums were approximated to predict the beginning of moth flight. The approach was validated with independent observations on the hatching of adults from southern (sun exposed) and northern (shaded) trunk sectors. It was concluded to improve the accuracy of codling moth forecasting and hence to contribute to an optimization of monitoring an control measures.

**Keywords:** Codling moth, *Cydia pomonella*, post-diapause development, forecasting, microclimate, trunk temperature, radiation

**Introduction**

The codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), is possibly the single most important insect pest of apple world-wide (Hill, 1987). It is therefore not surprising that a considerable part of all insecticide treatments in commercial apple orchards is applied to control this pest. The precise prediction of the emergence of adult moths is a prerequisite for an optimal timing of monitoring and control measures and hence a key-factor for a successful and sustainable pest management in apple. However, forecasting of codling moth phenology is complicated by the large variability of the individual post-diapause developmental times generally perceived in the field.

Several factors such as weather conditions in winter and spring (Geier, 1963; Wildbolz & Riggenbach, 1969) or the time of diapause entrance in the previous year (Höhn *et al*., 1999) have been reported to affect the duration of the post-diapause development, but only partly explain the observed variance. Evenhuis (1953), Post & de Jong (1958) and Jermy (1964) already pointed out the variability of the microclimate at the hibernation sites and its effects on the phenology of the codling moth.

In the present study we investigated the spatial distribution of diapausing larvae on the tree trunk and the corresponding microclimate (i.e. temperature) in order to improve the understanding of the scattered emergence pattern. Temperature was recorded continuously during four years in different trunk sectors, and linear regressions were applied to describe
the relationship between incident radiation and temperature differences between trunk and air. Based on these regressions temperature sums were calculated for both sun exposed and shaded trunk sectors using commonly measured parameters like air temperature and solar radiation. The approach was validated with observations on the emergence pattern of codling moths overwintering in the southern and the northern trunk sectors.

Materials and methods

Spatial distribution of hibernating larvae
Codling moth larvae hibernate mainly in bark crevices and other hiding-places on the tree trunk of the host plant (Audemard, 1991). The spatial distribution of diapausing larvae was studied in order to identify the relevant points for temperature measurements. Beginning of July 1996 corrugated cardboard bands with a width of 10 cm were attached on 25 untreated fruit bearing high stem trees, 15 in Zizers (Upper Swiss Rhine-Valley; 530 m a.s.) and 10 in Gommiswald (Eastern Swiss Pre-Alps, 550 m a.s.). The bands were fixed around the trunk at roughly 1.50 m above ground and protected against birds with jute bands. On each band the cardinal points North, East, South and West were marked. The bands were replaced three times in monthly intervals in August, September, and October, and the larvae counted separately in each sector.

Temperature and radiation recordings
Trunk temperature was measured in Wädenswil (490 m a.s.) on 4 trees cv. James Grieve planted in 1978 on rootstock M26 and aligned in a row from North to South. On each tree thermistor temperature probes were implanted into the bark in the southern and in the northern trunk sectors where the temperature extremes were expected. On one tree additional probes were inserted in the western and the eastern sectors. Air temperature and humidity were recorded with a Rotronic® MP100A probe in an unaspirated radiation shield 2 m above ground. All probes were linked to a Campbell® CR10 data logger and measurements were taken continuously in 12 min intervals from February 1996 till December 1999. For the entire measurement period the differences between air temperature and trunk temperature in the southern and the northern sectors (ΔT-trunk-air) were calculated.

Solar radiation (global radiation in Wh/m²) was recorded in an automatic weather station of the Swiss Meteorological Institute 80 m from the orchard where trunk temperatures were measured.

Approximating trunk temperatures
Solar radiation is the main factor causing temperature differences between different trunk sectors i.e. hibernation sites. In order to develop a broadly applicable method the difference between air and trunk temperature was described as a linear function of incident radiation by means of regression for both the southern and the northern trunk sectors. To this end incident radiation was quantified by global radiation corrected for the light interception of the tree canopy. A sigmoidal function was used to describe the increase of leaf area from bud break to termination of shoot elongation, and Beer’s Law (Monsi & Saeki, 1953) was applied to assess light interception as a function of the leaf area. Based on these calculations temperature sums were approximated for the southern and the northern trunk sectors using air temperature and solar radiation, both commonly measured weather parameters.

Validation
Larvae hibernating in the southern trunk sectors are likely to develop faster than those in the northern sectors since post-diapause development is mainly driven by temperature. The validity of the approach was tested by observing the temporal dynamics of adult emergence.
in southern and in northern trunk sectors respectively. In September 1999 250 diapausing larvae were collected in a commercial apple orchard in Trèlex (Lake of Geneva; 420 m a.s.) and put on corrugated cardboard strips for hibernation. In January 2000 the larvae in the strips were exposed to field conditions in Wädenswil in a 22 year old orchard cv. Spartan on rootstock M26. The larvae were equally distributed in six 7x7x5 cm$^3$ wire cages half in the southern and half in the northern trunk sectors of three different trees. Starting mid April emergence of each individual was recorded in daily examinations. In order to compare standard air temperature based predictions with the trunk temperature based approach the emergence patterns of adult moths from southern and northern trunk sectors were drawn on the corresponding physiological time scales i.e. temperature sums.

**Results and Discussion**

**Spatial distribution of hibernating larvae**

On the 25 trees in Zizers and Gommiswald a total of 2000 larvae were caught in the corrugated cardboard bands, the majority (1250) in August and a similar number in July (410) and September (340).

![Figure 1: Spatial distribution of diapausing codling moth larvae in different sectors of the tree trunk. Observations were made in July, August and September (Bars with the same letters do not differ significantly after Fisher’s PLSD (p>0.1)).](image)

Independent from the time of diapause entrance codling moth larvae had no preference for a particular sector of the tree trunk (Fig. 1). They were equally distributed in the North (490), East (510), South (570) and West (430). In a natural environment individuals of a population are therefore likely to experience different temperatures. Depending on the hibernation sites they will develop at different rates and hence emerge at different times.

**Temperature conditions on the tree trunk**

In most cases temperature on the tree trunk was higher than in the air. On sunny days in winter and spring the temperature difference between air and sun exposed trunk sectors repeatedly reached extremes of 25°C and more.
The average deviations from air temperature ($\Delta T$-trunk-air) ranged from $-1.8^\circ$C to $+6.7^\circ$C in southern trunk sectors and from $-2.2^\circ$C to $3.5^\circ$C in northern trunk sectors (Fig. 2). Generally the differences decreased in the course of the vegetation period and increased again in fall, a pattern, which was observed in all four years. Since temperature differences are mainly caused by incident solar radiation the pattern can be explained by changes in the shading of the tree trunk, which depends on the leaf area of the tree canopy.

Trunk temperatures exceeded air temperatures mainly in spring during the post-diapause development of the codling moth. Hence the reliability of a forecasting method could possibly be improved by using trunk temperature instead of air temperature.

**Approximating trunk temperature from incident radiation**

The effect of incident solar radiation on the temperature differences between air and southern and northern trunk sectors is shown in Fig. 3.
Apparently solar radiation has a stronger effect on temperature in the southern than in the northern trunk sector. This is mainly due to the fact, that the northern sector is permanently shaded even in spring when the tree canopy hardly absorbs any light. Based on these regressions temperature sums were calculated for both sun exposed and shaded trunk sectors. Until the end of May only 20 to 40 day-degrees more were added up in the northern sector than in the air, but a difference of 100 to 120 day-degrees was accumulated in the southern sector. For individuals hibernating in the northern trunk sector the standard air temperature based approach is certainly applicable, but it is not representative for individuals hibernating in the southern trunk sector. Since the first codling moths are likely to emerge from the southern trunk sector the corresponding temperature sum has to be used to predict the beginning of moth flight.

Validation of the approach
As it was anticipated from the temperature conditions on the tree trunk the first moths hatched from the southern sector on May 2nd, 11 days earlier than from the northern sector. Moreover, almost 90% emergence was reached in the south before the first moth was observed in the north. The temporal dynamics of codling moth emergence from southern and northern trunk sectors is shown on different physiological time scales in Fig. 4. When the physiological time scale was based on air temperature the first moths in the southern trunk sector emerged after 100 day-degrees, but in the northern sector only after 180 day-degrees (Fig. 4). This difference indicates that air temperature insufficiently describes the thermal conditions at the tree trunk.

However, when temperature sums were based on trunk temperature, moth emergence began at 270 day-degrees in both the southern and the northern sector (Fig. 4). This is in close agreement with the temperature sum for post-diapause development determined under controlled conditions (Höhn et al., 1999).

As a result we conclude that the temperature conditions may vary considerably depending on the site of hibernation. The accuracy of codling moth forecasting can therefore be improved when temperature sums are based on trunk temperature instead of air.

Figure 4: Adult emergence from different trunk sectors on different physiological time scales (left: TSum-Air; right: TSum-Trunk-South and TSum-Trunk-North respectively).
temperature. If trunk temperature cannot be measured directly it can be approximated from air temperature and solar radiation as described above.

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Cydia molesta and Cydia pomonella: comparison of adult behaviour

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Abstract: Cydia molesta, originally considered to be typically a pest of peach, has in recent years also been responsible for considerable damage to apples, particularly in the later phase of the growing season. Pest management of C. molesta in apples is often based on pheromone trap catches of males. The purpose of this study was to quantify the laboratory flight performance of males and females and to compare it to known data for Cydia pomonella. Surprisingly, flight-mill studies with virgin C. molesta showed a four to five times greater flight capacity in females than in males. Overall, flight performance of C. molesta is lower than for C. pomonella, but females still exhibit considerable dispersal capacity. We conclude that male pheromone trap catches seem to be a suboptimal tool for extrapolating female C. molesta presence in a pome fruit orchard, and that effective attractants for C. molesta are desirable for meaningful monitoring strategies.

Key words: Cydia molesta, Cydia pomonella, apples, flight mill, dispersal, volatiles

Introduction

The two Cydia species dominating fruit orchards throughout the temperate regions of every continent are Cydia pomonella L. (Lepidoptera: Tortricidae) and Cydia (Grapholita) molesta Busck (Lepidoptera: Tortricidae). Whilst C. pomonella is known as a pest of pome fruit, C. molesta is generally considered to be a pest of stone fruit, infesting in particular peach, but also nectarine, apricot, plum and cherry (Hill, 1987). However there are overlapping niches in the habitats of the two species. Bovey (1979) summarised that C. molesta can also cause considerable losses on pears at the end of the season, and that it more rarely attacks apples as well. The low frequency of infestation of apple orchards was confirmed by Roehrich (1961), in particular with respect to attack of shoots.

However, during recent years the frequency of C. molesta recovery from apple orchards has changed drastically. Heavy infestation of pome fruit orchards were observed from July onwards in the region of Emilia-Romagna in Italy (Marzocchi, 1993; Pollini & Bariselli, 1993). A similar host shift from peach to apples was noted in Brazil after 1982, prior to which time C. molesta had not been found on this crop. Since then it increased sharply from 15 to 85 moths per trap per week from 1984/85 to 1985/86, reaching a damage level of up to 90% of apples in Santa Catarina State in 1986/87. In northern China, the first and second generations infested the new shoots of peaches and apples, the second and third generations infested peach, and the third to fifth generations infested apples and pears, as was reported by Zhao et al. (1989) from a study carried out between 1983 and 1986. A recent report from the province of Südtirol in Italy documents trap catches of up to 250 moths per trap per week in a 160 ha area of apples as early as the end of April, with an average of 3 shoots per apple tree (var. Jonagold) infested by mid May. Fruits were attacked from the end of May, resulting in damage levels of 3.5% as early as the beginning of June (Bradlwarter et al., 1999). These
authors report a renewed infestation of apple shoots at the end of July/beginning of August and of apple fruit in August/September.

Although this host shift has been documented from various continents, the mechanisms underlying this change are not yet known. Dispersal of this insect species as well as factors influencing female orientation remain to be elucidated. Only host plant acceptance has been previously studied (Roehrich, 1961). After landing on the apple, *C. molesta* is capable of producing viable progeny. Survival rate of larvae on green apple fruits amounts to 86% as compared to 37% on peach fruit, but a prolonged development period, as well as the relatively high larval mortality, on shoots indicate that apples may represent a suboptimal host plant for *C. molesta*.

To date, the only available method to determine occurrence of *C. molesta* in an orchard is monitoring of males by means of pheromone traps (Cravedi & Molinari, 1995). Catches of males in a given orchard are usually followed by a spray, although the correlation between dispersal of males and females has not yet been investigated. Thus it is unknown whether or not catches of males indicate simultaneous presence of females.

In the dominant *Cydia* pest species of apples, *C. pomonella*, it has been demonstrated that (1) both sexes have a comparable flight capacity (Schumacher et al., 1997; Dorn et al., 1999), and that (2) host plant odours can influence the orientation of the females (Hern & Dorn, 1999; Dorn & Hern, 1999). Taking a comparative approach, this paper will address the flight capacity of both sexes of *C. molesta* and compare it to the previous findings with *C. pomonella*. The aim of this work is to develop a perspective for further studies on the orientation of female *C. molesta*.

**Material and methods**

**Insects**

*Cydia molesta* pupae were obtained from the University of Piacenza. These pupae were produced from larvae which were reared on an artificial diet.

**Flight mill**

A computer-linked flight monitoring device, the flight mill, was used to simultaneously quantify the individual flight performance of 30 moths. To secure the moths to the flight device, a pin was glued on the thorax of each moth. The pin was pushed vertically through a flight arm which started to rotate with flight initiation of the moth. Each revolution was registered by an infrared beam and recorded by a computer. (Schumacher et al., 1997). The duration of a trial was 14 hours.

**Results**

A marked sexual difference was observed in the tethered flight performance of virgin *C. molesta* moths (Tab. 1). Females made more flights and flew longer distances than males. Females also maintained flight activities over a longer period of time (Tab 2). The average total distance flown by females amounted to 4.2 kilometres as compared to 0.8 kilometres for males (n = 25). Whilst female average longest single flight was 980 metres on the flight-mill, the male equivalent was only 20 metres.

*Ad libitum* feeding of the moths increased flight performance by 30 to 50% (Tab. 2). The flight duration increased as did the distances flown. Both sexes responded to feeding in a similar way. The differences in flight performance between the sexes remained marked even in fed moths.
Table 1. Influence of sex on the number of flights, total distance flown, longest single flight and velocity of virgin *Cydia molesta* (*C.m*) (age 5d; n = 25). Comparison to *Cydia pomonella* (*C.p.*) is based on Schumacher *et al.*, 1997; and Dorn *et al.*, 1999.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Parameter</th>
<th><em>C.m.</em></th>
<th>Ratio of parameter <em>C.m.</em> : <em>C.p.</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Total number of flights</td>
<td>353.70</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Total distance flown (km)</td>
<td>4.24</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (km)</td>
<td>0.98</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Mean velocity (m/sec)</td>
<td>0.38</td>
<td>0.7</td>
</tr>
<tr>
<td>Male</td>
<td>Total number of flights</td>
<td>227.09</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Total distance flown (km)</td>
<td>0.77</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (km)</td>
<td>0.02</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td></td>
<td>Mean velocity (m/sec)</td>
<td>0.31</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 2. Influence of nutritional status on flight-mill measured flight parameters of virgin *C. molesta* moths. Fed: *ad libitum* feeding with honey. Unfed: insects in cages sprayed with water (age 5 d; n = 25)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Parameter</th>
<th><em>C.m. fed</em></th>
<th><em>C.m. unfed</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Total duration flown (sec)</td>
<td>15055.04</td>
<td>9484.88</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (sec)</td>
<td>2521.84</td>
<td>1766.42</td>
</tr>
<tr>
<td></td>
<td>Total distance flown (km)</td>
<td>6.51</td>
<td>4.24</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (km)</td>
<td>1.22</td>
<td>0.98</td>
</tr>
<tr>
<td>Male</td>
<td>Total duration flown (sec)</td>
<td>2650.88</td>
<td>1935.38</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (sec)</td>
<td>82.96</td>
<td>77.13</td>
</tr>
<tr>
<td></td>
<td>Total distance flown (km)</td>
<td>1.06</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Longest single flight (km)</td>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Discussion

Suprisingly, *Cydia molesta* females flew much longer distances than their conspecific males on the flight-mill. Females were capable of flying on average 4 to 5 times as long and as far as males.

When flight performance is compared to that of *C. pomonella* which has been tested previously on the same flight device (Schumacher *et al.*, 1997), *C. molesta*, exhibits major differences (Tab. 1). *C. molesta* adults make more but shorter flights than *C. pomonella*. The total flight distance of unfed moths is lower for *C. molesta*. It accounts to 10 to 30% of the flight distance assessed for *C. pomonella*, in which both sexes had a similar flight capacity. Virgin *C. pomonella* adults flew mean distances of 10 to 15 km on the flight mill (Dorn *et al.*, 1999) which corresponds with recaptures in the field that occurred up to a distance of 11 km from the release point (Mani & Wildbolz, 1977). In *Cydia pomonella*, the flight-mill data indicate that comparable flight distances could be expected for females as for males, thus male catches in pheromone traps could indeed indicate the simultaneous presence of females.
In contrast, the data presented here on *C. molesta* suggest that such extrapolations are more risky for *C. molesta*, where females outperform males in laboratory flight performance. This difference in flight behaviour between the sexes has also been shown for mated moths (Hughes & Dorn, unpublished). Moths that leave a peach orchard in search of a new habitat, e.g. after the harvest of peaches in summer, are likely to be well-fed since peaches contain extrafloral nectaries on which many insect species find their nutrition (Brown & Puterka, 1997). As a positive feeding status is likely to expand the radius of their maximal dispersal, females may land at significantly larger distances from the orchard of their origin than males. This renders monitoring of this *Cydia* species a particular challenge.

While pheromones are a well-established tool to attract male herbivores, host-plant derived volatiles offer promise for attraction of female herbivores (Dorn & Hern, 1999). The role of semiochemically mediated host location in *C. molesta* remains to be evaluated. Preliminary results on the response of female moths to plant-derived volatiles are encouraging (Natale et al., 1999).

Acknowledgements

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References


“Attract and kill”
A new IPM method in apple orchards against *Cydia pomonella* (L.)

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**Abstract:** Besides the use of trap-tests for monitoring adult flights, until now the employment of sex pheromones in IPM was limited to the mating disruption technique. This strategy can be successfully applied in orchards having a typography with well known technique parameters, like a 1 ha minimum surface, regular shape of the plot, etc. For this reason, the recent proposal of an innovative technique using a pheromone to control *Cydia pomonella* (L.) (Lepidoptera:Tortricidae), named “attract and kill”, was considered with interest. This method consists of the distribution, on trunk or woody branches of apple trees, of 1 or 2 drops of a flowable formulation with sex pheromone (Codlemone) mixed with a pesticide having a strong knock-down action by contact. The three years field experiments gave similar results and the damage at the harvest was lower than 1%, without statistically significant differences from that of the conventionally treated orchards.

**Key words:** Codlemone, small orchards, new strategy, codling moth

**Introduction**

The enemies of *Cydia pomonella* (L.) are known and investigated in all zones where apple is cultivated. Parasitoids of eggs, larvae and pupae were recently checked also in apple orchards of south-western Piedmont (Re et al., 1998a, 1998b). Unfortunately, until now so many enemies were not able to maintain the codling moth populations under the economic threshold nor were they usable in IPM programmes. The biotechnical method of mating disruption showed better results through the use of the sexual pheromone Codlemone. But this strategy, besides the expensiveness, can only be successfully applied in orchards having a typography with well known parameters, like a 1 ha minimum surface, regular shape and lay out of planting, same age, cultivar, and shape of tree, which hamper its employment in unfit Piedmontese areas.

For this reason, the recent proposal of an innovative technique using a pheromone to control *C. pomonella*, named “attract and kill” (AK), was considered with care. This technique consists of a flowable formulation containing Codlemone, a pesticide having a strong knock-down action by contact (Permethrin or Cypermethrin), and UV-absorbing substances, to be applied as drops directly on trunks or woody branches, or on suitable devices to hang on the protected plants. The males, being attracted by the pheromone, come into contact with the paste and die in few hours or are weakened and disoriented in searching the females and so the mating possibility in the field is drastically reduced, overcoming the difficulties of homogeneity and size of the cultivations (Charmillot et al., 1996).

Considering the undoubtedly positive results obtained in Switzerland (Hofer et al., 1996), a research was undertaken to assess the feasibility and the real efficacy of this technique, to evaluate the possible interaction of this compound with other apple phytophagous insects, to highlight the pros and cons of this method, and to consider its economic aspects.
Material and methods

The research was carried out in the triennium 1997-1999. During the two first years, blend quantity, doses per plant and per surface unit, time and number of plant applications were defined, and the side effects were analyzed. Here, only the data concerning the experimentation of the last year are reported.

The trials were carried out in 7 plots of farms in the fruit-growing area of south-western Piedmont: 5 in the Cuneo Province and 2 in the Torino Province, having size and typology representative of the Piedmontese area (Table 1). Such plots were oriented north-south and were chosen for their population level, which was ascertained by sex-traps in the previous years, among those that, owing to a conventional management, had shown such a population density to cause damage to fruits at the harvest not more than 1%.

Table 1. Typology of the 7 plots tested in 1999.

<table>
<thead>
<tr>
<th>plot</th>
<th>locality</th>
<th>cultivar</th>
<th>growth system</th>
<th>age (years)</th>
<th>lay out m</th>
<th>plants/ha</th>
<th>surface m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cuneo Prov.</td>
<td>Saluzzo</td>
<td>Golden D.</td>
<td>palmette</td>
<td>8</td>
<td>4.1x2.8</td>
<td>870</td>
</tr>
<tr>
<td>2</td>
<td>Saluzzo</td>
<td>Golden D.</td>
<td>irr. palmette</td>
<td>6</td>
<td>4.0x3.0</td>
<td>833</td>
<td>1,400</td>
</tr>
<tr>
<td>3</td>
<td>Saluzzo</td>
<td>Red Chief</td>
<td>Gala Renetta</td>
<td>canopy spindel</td>
<td>3</td>
<td>4.0x1.0</td>
<td>4.0x1.2</td>
</tr>
<tr>
<td>4</td>
<td>Castellar</td>
<td>Golden D.</td>
<td>palmette</td>
<td>7</td>
<td>4.5x2.0</td>
<td>1,111</td>
<td>3,900</td>
</tr>
<tr>
<td>5</td>
<td>Castellar</td>
<td>Golden D.</td>
<td>Gala Red Chief</td>
<td>spindel</td>
<td>4</td>
<td>4.5x1.5</td>
<td>4.5x1.5</td>
</tr>
<tr>
<td>6</td>
<td>Castellar</td>
<td>Golden D.</td>
<td>spindel</td>
<td>6</td>
<td>4.0x2.6</td>
<td>961</td>
<td>3,500</td>
</tr>
<tr>
<td>7</td>
<td>Cavour</td>
<td>Golden D.</td>
<td>irr. palmette</td>
<td>10</td>
<td>3.7x1.8</td>
<td>1,500</td>
<td>2,350</td>
</tr>
</tbody>
</table>

The control plots were chosen in the same farms, close to the investigated ones, and were subjected to a traditional chemical control, namely: 1 treatment with Triflumuron and 1 with Teflubenzuron in the control of plots 1, 2, 3; 1 treatment with Diflubenzuron, 1 with Lufenuron, and 1 with Chlorpyrifs-methyl in the control of plot 4; 1 treatment with Triflumuron, 1 with Phosalone, and 1 with Chlorpyrifs-methyl in the control of plot 5; 1 treatment with Triflumuron, 2 with Phosalone, 1 with Chlorpyrifs-ethyl, and 1 with Chlorpyrifs-methyl in the control of plot 6; 1 treatment with Lufenuron, 2 with Phosalone, 1 with Chlorpyrifs-ethyl, and 1 with Chlorpyrifs-methyl in the control of plot 7.

The commercial compound was a flowable paste with an oil base, containing 0.16% (1.6 g/L) of Codlemone and 6% (60 g/L) of Permethrin. It was contained in a plastic dispenser of 150 g net weight, having a pump disposal which allowed a distribution in drops. According
to the producer indications, each drop should have a volume of 50 µL and a weight of 0.05 g on average, so to contain 0.08 mg of Codlemone and 3 mg of Permethrin. Actually, with the aim to avoid operative mistakes and to establish correctly the quantities of compound distributed in the field, besides the count of the distributed drops, after each application the dispensers were weighed. So the compound quantities employed per surface unit reported in Table 2 were fixed weighing the dispensers before and after the application.

Table 2. Dates of application and quantity of applied compounds.

<table>
<thead>
<tr>
<th>plot</th>
<th>cultivar</th>
<th>treatments</th>
<th>spot/plant/treatment</th>
<th>spot/ha/treatment</th>
<th>compound amount/ha (g)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>no.</td>
<td>date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Golden D.</td>
<td>1</td>
<td></td>
<td>3 28/5; 6/7; 13/8</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Golden D.</td>
<td>2</td>
<td></td>
<td>3 28/5; 6/7; 13/8</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Red Chief Gala Renetta</td>
<td>3</td>
<td>29/5; 7/7; 13/8</td>
<td>1yes/1no</td>
<td>1yes/1no</td>
</tr>
<tr>
<td>4</td>
<td>Golden D.</td>
<td>4</td>
<td></td>
<td>2 28/5; 6/7</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Golden D. Gala Red Chief</td>
<td>5</td>
<td></td>
<td>3 27/5; 8/7; 9/8</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Golden D.</td>
<td>6</td>
<td></td>
<td>3 27/5; 3/7; 13/8</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Golden D. Golden D.</td>
<td>7</td>
<td></td>
<td>3 27/5</td>
<td>1</td>
</tr>
</tbody>
</table>

* c. f., commercial formulation; a. i., Permethrin; pher., Codlemone.

The drops were placed on trunks and on some years old branches, on the part less exposed to the light, avoiding positions in contact with fruits. Two drops/plant were applied in plantings with 800 plants/ha on average, and one drop/plant in dwarf plantings with about 1,000-1,500 plants/ha, alternating the application height in the latter plants, i.e. 1.70 m on the first plant, at the top on the second one, and so on. On the plants of the perimetral rows and on those next to smaller plants, one drop/plant was added. In total, about 1,500 drops/ha were distributed. The laboratory research in the previous years revealed that each drop has an attractive action until 1 m and so a protective diameter on the vegetation of 2 m, and that each application has a persistence of 35-40 days on average. Therefore it was stated to make 3 applications altogether, reduced to 2 in the areas where the codling moths had only 1 generation (Table 2).

Owing to a delay on the compound delivery, at the appearance of the adults of the 1st generation in the plots controlled with AK, a treatment with an ovicide was made, namely: 1 treatment with Triflumuron in plots 1, 2, 3, 5, 6; 1 treatment with Diflubenzuron in plot 4; 2 treatments (1 on the border only) with Lufenuron in plot 7.

The protocol foresaw that the experiment should be stopped when 2% of damaged fruits was reached in the 1st and 2nd generations. Starting in the second half of June, fortnight checks
were made on 1,000-1,500 fruits of the perimetral rows and in the middle of the plots to ascertain both the presence of probable penetrations and the larval instars. If leafroller moths would be present (in particular *Argyrotaenia pulchellana* Howard), treatments only with *Bacillus thuringiensis* Berliner were foreseen so not to affect the experiment.

At the harvest, to avoid the representativeness limits of sample checks, the real damage was evaluated on the whole production of each plot, analyzing the fruits considered commercial harvest wastes.

**Results and discussion**

Table 3. Results of the experimentation in 1999.

<table>
<thead>
<tr>
<th>plot</th>
<th>thesis</th>
<th>cultivar</th>
<th><em>Cydia pomonella</em></th>
<th>leafrollers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AK</td>
<td>Golden D.</td>
<td>0.47 a #</td>
<td>0.37</td>
</tr>
<tr>
<td>2</td>
<td>AK</td>
<td>Golden D.</td>
<td>0.54 a</td>
<td>0.00</td>
</tr>
<tr>
<td>3</td>
<td>AK control*</td>
<td>Red C.-Gala-Renetta</td>
<td>Golden D.</td>
<td>0.34 a</td>
</tr>
<tr>
<td>4</td>
<td>AK control</td>
<td>Golden D.</td>
<td>0.29 a</td>
<td>0.67</td>
</tr>
<tr>
<td>5</td>
<td>AK control</td>
<td>Golden D.-Gala-Red C.</td>
<td>Golden D.</td>
<td>0.24 a</td>
</tr>
<tr>
<td>6</td>
<td>AK control</td>
<td>Golden D.</td>
<td>0.26 a</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>AK control</td>
<td>Golden D.</td>
<td>2.03 ab</td>
<td>0.94</td>
</tr>
</tbody>
</table>

* for plots 1, 2, 3, the control was the same.
# values followed by the same letter are not significantly different (Duncan test, \( P \leq 0.05 \))

The results are reported in Table 3. The attack entity was lower than 1% in 6 plots, without statistically significant differences from the plots conventionally treated. Only plot 7 showed higher attacks, with a significant difference with respect to the control. This is an area with high population levels, where penetrations from nearby plots were checked so to make a border treatment necessary. The total quantity/ha of compound was homogeneous and comparable in the plots 1, 2, 3, 5, 6. Significant differences concerned plots 4 and 7: plot 4 because it had only 2 applications due to the low population of *C. pomonella*, plot 7 for the above mentioned reasons (Table 2). Insignificant were the attacks of *A. pulchellana* and the effects on the aphid enemies. Nothing can be anticipated on the economic aspects, because the compound is not yet registered and therefore it has no market price.

In the light of the results obtained in 3 years of experimental checks, it is possible to affirm that the AK method can be suitably applied in the field when the population level of *C. pomonella* is medium-low and the fruits damaged in the previous years were under 1%, following a correct application of conventional control strategies. Furthermore, after an adequate action of preventive information, the application does not present any particular difficulties and can be carried out by the growers themselves, only providing a help in the starting phase concerning the dose and the number of applications. Moreover, also orchards
having different characteristics, such as small surface or irregular shape, can be controlled. From this point of view, besides the traditional control method by mating disruption, another possibility of using sexual pheromones in IPM is given.

In any case, considering the phenomenon of the resistance to several active ingredients, phenomenon that in Italy is poorly investigated, but in several fruit-growing areas in the world is denounced (Ioriatti & Bouvier, 2000), it is necessary to keep in mind also other pathogenic enemies of *C. pomonella*, e.g. the granulosis virus, which has just been registered in Italy and has given interesting results both in the laboratory and in field applications.

**References**


Population numbers, harmfulness and control of pear psylla
(Cacopsylla pyri L.) in Serbia

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Abstract: Since the establishment of pear plantings on large areas, and especially over the last 10 years, pear psylla (Cacopsylla pyri L.) has been a pear pest of major economic importance in Serbia. In summer with its mass occurrence, pear tops are left defoliated, bearing only small, non-attractive and poor quality fruits. Such trees bear low yields in the following year, and usually die out in large numbers.

Over 1996-1999, the studies were conducted in the varietal pear plantings of the Fruit and Grape Research Centre in Cacak, as well as in the commercial orchards in some areas in Serbia. The largest number of commercial cultivars are suitable for C. pyri feeding, i.e. colonization. During more severe attacks on some cultivars (General Leclerc, Cure, Highland, Williams, Doyenne de Comice), honeydew, sooty mould and leaves falling off range from 15-75%. Of over 20 cultivars examined in the Fruit and Grape Research Centre, only standard cv Magness and cv Ping Guoli, from the Japanese pear group, were tolerant. Local genotypes Karamanka and Vidova-a showed moderate resistance.

Amitraz, amitraz + diflubenzuron, fenoxycarb + mineral oil, etofenprox and thiamethoxam proved to be most efficient in controlling C. pyri. Fenoxycarb is recommended at the end of C. pyri spring generation development, i.e. when nymphs are L 4-5. To improve contact and reduce the time of leaf exposure to C. pyri oviposition, mineral oil should be added to fenoxycarb. Since amitraz induces honeydew draining down the leaves, in case of excessive numbers, some IGR chemical from the benzoil urea group which improve efficacy (diflubenzuron, teflubenzuron or lufenuron), should be added. These insecticides are relatively selective for Chrisopa perla and predatory bugs.

Key words: Cacopsylla pyri, pear, control, cultivar resistance, insecticides

Introduction

Pear psylla (Cacopsylla pyri L.) is a permanent member of entomofauna in pear plantings in Serbia. Its numbers and harmfulness vary, and were especially high in 1989-1992 when defoliation and dying out of trees occurred (Stamenkovic et al., 1994).

The major aim of modern agriculture are high yields and adequate application of all cultural practices. Therefore, insect and disease control are necessary to achieve and maintain them. The intensive production involves mainly the cultivars with high productivity. The plants are grown as a single crop, with pesticides, fertilization and irrigation regularly applied.

In plantation orchards, which are unstable stands, pests with more generations and high potential of propagation, which usually do not have specific natural predators, propagate more intensively. pear psylla belongs to this group of insect pests (Injac, 1992).

The control of population numbers of Cacopsylla pyri L. implies reducing stand instability (pear plantings) by combined methods: reduced insecticide application, use of specific insecticides-psyllocides, monitoring population of natural predators and creating conditions favouring their development and maintainance, introduction of less susceptible and
resistant pear cultivars and optimal pruning and other cultural measures (Injac, 1992; Stamenkovic and Milenkovic, 1992).

In controlling pear psylla, the approach of repeated application of wide-spectrum insecticides was predominant, especially of pyrethroids, which substantially disturbed natural balance between pest and its predators. To control the pear psylla numbers more efficiently, it was necessary to test the efficacy of insecticides and their combinations, as well as susceptibility of pear genotypes to this pest.

**Material and methods**

The trials evaluating insecticides efficiency were set up in the collection pear orchard (Ljubinj locality) belonging to Fruit and Grape Research Centre in Cacak over 1996-1999. Treatments aimed at testing insecticides efficiency were carried out during hatching of the 2nd generation larvae of pear psylla. Evaluation of efficiency was done on marked shoots without sampling from day 1 to day 15 after treatments. The following insecticides were used: teflubenzuron (Nomolt SC 15), etofenprox (Trebon 10F), s-fenvalerate (Sumi-alfa 5 EC), mineral oil (Galmin) fenoxycarb (Insegar 25 WP), amitraz (Mitak 20), endosulphan (Thionex E 35), thiamethoxam (Aktara 25 WG), diflubenzuron (Dimilin WP 10), lufenuron (Match 50 EC) and diazinon (Basudin 600 EW). The evaluation was conducted using the formula of Abott.

The resistance of 10 pear genotypes was monitored under the conditions of natural attack by surveys at 15-day intervals from early April to late August (1996-1999). No pesticides were applied in experimental orchards during evaluation. Evaluation was done on the basis of pear psylla population numbers (numbers of imagos and larvae per infested shoot) and the intensity of damage to pear trees (% of shoots infested, intensity of honeydew) (Stamenkovic et al, 1994).

The appearance of predators was monitored by the method of branch brushing and that of parasitoids by collecting mumified *Cacopsylla pyri* larvae.

**Results and discussion**

In 1996-1999, during the hatching of the 2nd generation larvae, pear plantings were treated with insecticides to test the possibility of controlling pear psylla. The average efficacy of insecticides is presented in Table 1.

Most of the insecticides applied showed low initial toxicity to pear psylla larvae, except for amitraz and the combination of amitraz and diflubenzuron. At appropriate concentrations teflubenzuron and fenoxycarb reach a high level of toxicity 7 days following treatment, after which their efficacy decreases. Fenoxycarb can be also applied in the autumn to interrupt the diapause of the overwintering females which lay eggs at that time (Krysan, 1990).

The classic representative of pyrethroids, s-fenvalerate, reaches maximal efficacy of 91.5%, but it decreases due to the effect of high temperatures. Etofenprox, as a somewhat more stable non-ester pyrethroid, maintains the efficacy at the level of 91.2% fifteen days following treatments. However, pyrethroids should be avoided or the number of treatments limited because they adversely affect natural predators of pear psylla.

Application of amitraz or amitraz + diflubenzuron was shown to be highly efficient during the evaluation period (96.1, i.e. 98.2%). Also, high efficacy was obtained with the combination of fenoxycarb and mineral oil (94.1%). The representative of neonicotinoides (thiametoxam), which has not been applied under our conditions for pear psylla control, was shown to be highly efficient during evaluation. Organophosphorous insecticide Basudin, as
well as the growth regulators teflubenzuron and fenoxycarb, were not efficient enough when applied alone.

Table 1 Average efficacy of some insecticides in the control of Cacopsylla pyri L. larvae at the locality Ljubic-Cacak in 1996-1999

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Insecticide</th>
<th>Concentration applied (%)</th>
<th>Efficacy after (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>thiametoxam</td>
<td>Aktara 25 WG</td>
<td>0.015</td>
<td>90.1</td>
</tr>
<tr>
<td>teflubenzuron</td>
<td>Nomolt SC15</td>
<td>0.1</td>
<td>59.3</td>
</tr>
<tr>
<td>lufenuron</td>
<td>Match 50 EC</td>
<td>0.1</td>
<td>84.0</td>
</tr>
<tr>
<td>etofenproks</td>
<td>Trebon 10 F</td>
<td>0.1</td>
<td>83.3</td>
</tr>
<tr>
<td>s-fenvalerat</td>
<td>Sumi-alfa 5EC</td>
<td>0.05</td>
<td>78.9</td>
</tr>
<tr>
<td>fenoxycarb</td>
<td>Insegar 25 WP</td>
<td>0.1</td>
<td>77.6</td>
</tr>
<tr>
<td>fenoxycarb +</td>
<td>Insegar 25 WP</td>
<td>0.05</td>
<td>71.2</td>
</tr>
<tr>
<td>mineral oil</td>
<td>Insegar 25 WP</td>
<td>0.05 + 4</td>
<td>80.1</td>
</tr>
<tr>
<td>amitraz</td>
<td>Mitak 20</td>
<td>0.3</td>
<td>92.2</td>
</tr>
<tr>
<td>amitraz +</td>
<td>Mitak 20 +</td>
<td>0.3 + 0.15</td>
<td>90.2</td>
</tr>
<tr>
<td>diflubenzuron</td>
<td>Dimilin WP10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>endosulfan</td>
<td>Thionex E 35</td>
<td>0.25</td>
<td>93.8</td>
</tr>
<tr>
<td>basudin</td>
<td>Basudin 600 EW</td>
<td>0.15</td>
<td>86.0</td>
</tr>
</tbody>
</table>

Host plant plays an important role in pest control. It is noteworthy to point out that the resistance to pests is an inherited trait based on defined mechanisms and is a major resource in a so-called sustainable agriculture (Stoner, 1996). Since there are significant differences in liability of pear cultivars to pear psylla attack (Stamenkovic et al., 1994), its development on 10 pear cultivars was monitored. Evaluation of the criteria of pear resistance to pear psylla (parameters of population numbers and harmfulness) revealed significant differences (tab. 2). Table 2 clearly shows the differences in the intensity of pear psylla attack on the mentioned pear cultivars, especially in % of shoots infested and the number of larvae per shoot infested. Comparing the data from the table 2 led to classification of all the pear cultivars with respect to degree of resistance shown, into the following groups: highly susceptible, susceptible and moderately resistant (Table 3). With regard to the results of our earlier research (Stamenkovic et al, 1994), there has been no changes in terms of resistance groups by cultivars.

Magness, being a cultivar with good pomological properties, can be recommended for commercial growing, whereas Vidovaca and Karamanka are cultivars of local importance which can be grown on small holdings or used in pear breeding programmes for resistance to pear psylla.

To clarify the shown resistance in pear, resistance mechanisms should be investigated. During the trial it was noticed that pear psylla avoided oviposition on some cultivars, whereas
oviposition occurred on other cultivars but eggs or larvae died (Ping Guoli). Butt et al., 1989 reported similar observations.

Table 2. The intensity of *Cacopsylla pyri* L. attack on some pear cultivars (Ljubic-Cacak, 1996-1999)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>% shoots infested</th>
<th>imagos/shoot</th>
<th>larvae/shoot infested</th>
<th>honey dew (1-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Leclerc</td>
<td>69.4</td>
<td>8.0</td>
<td>60</td>
<td>4.4</td>
</tr>
<tr>
<td>Highland</td>
<td>62.0</td>
<td>4.8</td>
<td>50</td>
<td>4.1</td>
</tr>
<tr>
<td>Cure</td>
<td>52.6</td>
<td>2.7</td>
<td>30</td>
<td>4.5</td>
</tr>
<tr>
<td>Passe Crassane</td>
<td>24.0</td>
<td>2.2</td>
<td>15</td>
<td>3.0</td>
</tr>
<tr>
<td>Guyot</td>
<td>22.1</td>
<td>3.2</td>
<td>29</td>
<td>2.0</td>
</tr>
<tr>
<td>Williams</td>
<td>62.0</td>
<td>4.0</td>
<td>63.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Magness</td>
<td>8.0</td>
<td>1.2</td>
<td>6.8</td>
<td>1</td>
</tr>
<tr>
<td>Vidovaca</td>
<td>5.0</td>
<td>1.2</td>
<td>3.0</td>
<td>1</td>
</tr>
<tr>
<td>Karamanka</td>
<td>1.8</td>
<td>0.6</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Ping Guoli</td>
<td>10.0</td>
<td>1.0</td>
<td>2.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 3. Susceptibility of pear cultivars to *Cacopsylla pyri* L.

<table>
<thead>
<tr>
<th>Highly susceptible</th>
<th>Susceptible</th>
<th>Moderately resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Leclerc</td>
<td>Passe Crassane</td>
<td>Magness</td>
</tr>
<tr>
<td>Highland</td>
<td>Guyot</td>
<td>Vidovaca</td>
</tr>
<tr>
<td>Cure</td>
<td></td>
<td>Karamanka</td>
</tr>
<tr>
<td>Williams</td>
<td></td>
<td>Ping Guoli</td>
</tr>
</tbody>
</table>

Ping Guoli belongs to the group of Japanese (Nashi) pears with specific pomological properties (Kajiura, 1994).

Table 4 clearly shows that conventional method results in few hybrids having satisfactory resistance, mainly in the cross in which both parents are moderately resistant (Magness x Karamanka).

Magness is an American cultivar ripening at the end of the first decade of September. The tree is moderately vigorous with the crown well branched. Flowering time is short and medium late. Fruits are moderately large (about 150 g), russety, of regular pyriform shape. The flesh is cream white, juicy, melting, with a pronounced melon aroma, without grit cells. It has been reported as being resistant to the causal agent of bacterial fire blight *Erwinia amylovora* (Sansavini and Rosati, 1986).
Vidovaca is an old, domestic cultivar. Tree is vigorous. An excellent cropper. Fruits are small with long stalks, ripening in late June and early July (Niketić, 1951). Due to its resistance to pear psylla and diseases, it merits including in hybridization programmes, as well as in growing on small holdings.

Karamanka is also an old cultivar highly spread throughout the country. Tree is vigorous and crown has a specific shape. Fruit is medium sized and flesh sweet, refreshing, of excellent aroma. Ripens in the second half of August (Niketić, 1951). It is resistant to pear psylla and the type from the collection of the Fruit and Grape Research Centre also shows resistance to sooty mold.

In the pear planting ecosystem, in which relations between species have been disturbed, the numbers of natural predators of pear psylla are relatively low. Orchard survey revealed the presence of predatory bugs *Orius* spp. and *Anthocoris nemoralis* (F).

**Conclusions**

- Pear psylla *Cacopsylla pyri* L. is the major entomological problem in the control of the plantation pear orchards. To achieve efficient control, the use of selective insecticides is a must, coupled with growing more resistant cultivars and monitoring the development of *Cacopsylla pyri* population and its natural predators.

- The most efficient insecticides for controlling this pest proved to be: amitraz, amitraz + diflubenzuron, fenoxycarb + mineral oil, thiametoxam and etofenprox.

- Insecticides use should be timed with the hatching of the 1st and the 2nd generation larvae; later treatments should be avoided due to the development of the natural predators.

- The resistant cultivars are an indespensable factor in controlling *Cacopsylla pyri* L. Moderately resistant genotypes, such as Magness and Ping Guoli could be introduced into production, as well as local cultivars Karamanka and Vidovaca on small holdings. These cultivars are primarily valuable in the hybridization programmes and breeding of new resistant hybrids.

**References**


Monitoring resistance of pear psylla *Cacopsylla pyri* to amitraz

Lukas Schaub, Bernard Bloesch, Urs Aeschlimann and Géraldine Garnier

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**Abstract**: Pear psyllae sampled in different regions, months and years were submitted to bioassays measuring mortality due to amitraz (Acarac). Natural variation was large enough to produce statistically different response curves and LC₅₀ values. Variation did not depend on the season. LC₅₀ ratios and LC₉₀ to LC₁₀ comparisons were used to assess resistance. None of the orchards had psyllae with mortality low enough to indicate resistance.

**Key words**: bioassays, resistance monitoring, pear psylla, amitraz

**Introduction**

Worldwide, pear psyllae are prone to development of resistance and have done so in Switzerland (Schaub *et al*. 1996). Growers must find a difficult balance between adequate tree vigor to ensure fruit quality and excess vigor favoring psylla proliferation. In addition to cultural practices, since 1995, when pear psylla *Cacopsylla pyri* L. became resistant to teflubenzuron (Schaub *et al*. 1996), Swiss pear producers rely almost entirely on the insecticide amitraz to control psylla. Because this situation may again lead to resistance development, resistance monitoring studies were undertaken in the laboratory to provide reference data of amitraz against psylla.

**Materials and methods**

Adult pear psylla samples were collected from 1996 to 1999 in pear orchards in Western Switzerland. Orchards were all managed according to Swiss Integrated Fruit Production guidelines.

Bioassays estimated mortality of psyllae exposed to different insecticide concentrations. Psylla adults were collected in orchards and deposited on young pear rootstock seedlings. Adults were caged for one day on seedlings for oviposition. At 22°C and 14 days after oviposition when psyllae were at the stage L₂-L₃, seedlings were treated. Concentrations were between 0.001% and 1% of formulated product (Acarac). Two days after treatment the number of dead and live larvae were counted.

Two or three seedlings with about 100 psyllae per seedling were used per insecticide concentration. Often this corresponded to more than 1000 psyllae per bioassay. Concentrations were selected in order to produce data for 3-4 concentrations with mortality not close to 0% or 100%. Probit analysis statistics was calculated with POLO-PC (LeOra Software, 1987; Robertson & Preisler, 1992).
Results and discussion

Statistical comparisons indicated that probit functions and LC$_{50}$ values were usually significantly different. Even samples taken in the same orchard at weekly intervals produced different functions and LC$_{50}$ values. These statistical tests revealed a natural variation of pear psylla sensitivity to Acarac and therefore cannot be used to identify resistance.

A more useful, first criterion of resistance is the ratio between two LC$_{50}$ values. For groups of samples, ratios of all possible combinations of LC$_{50}$ values were computed (fig. 1).

![Fig. 1: Range of LC$_{50}$ ratios of groups of samples of pear psylla](image1)

The slope is the third proposed criterion to assess resistance development. A slope lower than the reference population slope indicates a high variability of sensitivity in the population and may indicate a mixture of sensitive and resistant individuals. The slopes of the probit functions of groups of samples ranged from 1 to 3 (fig. 3). Slopes lower than 1 are interpreted as a warning sign of a shift in the population toward resistance.

![Fig. 2. Range of LC10 and LC90 values of groups of samples of pear psylla](image2)
The three criteria in combination with the observed LC$_{50}$, LC$_{90}$ and slope values will be used to assess future bioassay data of pear psylla. For Western Switzerland, they are the best reference data available. Nevertheless, it is likely that resistance development began before data were acquired.

References

Ground dwelling predatory carabid beetles as biocontrol agents of pests in fruit production in UK

Jean Fitzgerald and Mike Solomon
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Abstract: Carabid beetles were collected from a newly-planted and an established apple orchard to determine the species composition. Numbers were generally higher in the newly-planted orchard, and higher close to windbreaks where diverse vegetation was present.

Low numbers of carabid beetles were found in the centre of a strawberry field within two weeks of planting, showing that these predators were able to colonise new areas quickly. However, numbers of beetles were higher throughout the first growing season in the grass boundary conservation areas, where cover and prey were more numerous, and at the edges of the planting, close to these boundaries.

In laboratory experiments with the strawberry aphid *Chaetosiphon fragaefolii*, presented on leaf discs, the carabid species *Calathus fuscipes* and *Pterostichus melanarius*, two of the most numerous in the strawberry sampling programme, were found to consume a mean of 12 and 9 *C. fragaefolii* respectively per day. When presented with aphids on single leaf ‘plants’ *C. fuscipes* and *Nebria brevicollis* were able to climb onto the leaf and consume the aphids.

Key words: carabids, predators, biocontrol, apple, strawberry, *Chaetosiphon fragaefolii*, conservation areas, refuges.

Introduction

Carabid beetles are polyphagous, ground dwelling predators. Their biology in agricultural systems has been reviewed by Luff (1987). In arable systems much work has been done on the usefulness of carabids as control agents for aphids, mainly when they have fallen off the plants and are accessible on the ground (e.g. Sunderland et al., 1987). Kromp (1999) reviewed the control efficacy of carabids on a range of pests in agricultural systems.

In fruit production, carabids have potential as biocontrol agents of pest species that have a life cycle stage either on, or at shallow depths within, the soil. In apple the major pests with these characteristics are the apple sawfly, *Hoplocampa testudinea*, the apple leaf midge *Dasineura mali*, and the codling moth, *Cydia pomonella*. Several species have been found to feed on the green apple aphid, *Aphis pomi*, in apple in Ontario (Hagley & Allen, 1990), and in experiments using tethered codling moth larvae, Riddick & Mills (1994) showed that carabids would consume these larvae on the soil surface.

In strawberry the major soil dwelling pest is the black vine weevil, *Otiorhynchus sulcatus*. Workers at Horticulture Research International-East Malling have developed a panel of vine weevil stage specific monoclonal antibodies (Crook & Solomon, 1996), and these have been used to determine which carabid species are consumers of the different developmental stages of vine weevils (Crook, 2000). Slugs are also a major pest in soft fruit, and in arable fields 84% of *Pterostichus melanarius* caught in pitfall traps and tested with slug antibodies had consumed slug species (Symondson et al., 1996). The strawberry aphid, *Chaetosiphon fragaefolii*, is found on the lower surfaces of strawberry leaves, and may be accessible to carabid beetles.
Experiments were undertaken to determine the species of carabids present in apple orchards and strawberry plantations in the UK, and their distribution within the plantings, and to determine whether these beetles are able to reduce strawberry aphid numbers on plants in the laboratory.

Materials and methods

**Apple**

Pitfall traps of 8cm diameter were placed in an organic orchard planted in 1999, and an established orchard planted in 1988, which had received only fungicide applications for the last five years. Both plantings were approximately 0.4 ha in area. On 12 August 1999 three or four traps were placed in the centre of the orchards, in the surrounding windbreaks, and in the first row of trees close to the windbreaks. Traps contained ethylene glycol as a preservative. Traps were emptied each week until March 2000, and species of carabids identified in the laboratory.

**Strawberry**

An organic strawberry plantation was planted in July 1999 in raised beds covered with black polythene. The strawberry plot was in rotation with seven other plots, each approximately 0.25 ha in area. Between the plots conservation borders of 3m width were sown with a mixture of grass and flowering plant species. The flowering species included cornflower (*Centaurea cyanus*) and corn chamomile (*Anthemis arvensis*), two species shown to be attractive to flying beneficial species in previous experiments (Solomon *et al.*, 1999). In July 1999 four pitfall traps were placed in the conservation borders and at 0.5, 5 and 20m from the boundary within the alleys of the strawberry plot. Four traps were also placed in one of the grass rotational plots. Traps were emptied every one to two weeks until 7 October, and species of carabids identified in the laboratory.

Laboratory feeding experiments with strawberry aphids

Carabids were collected from a strawberry plot in dry pitfall traps emptied each day, and maintained on cat food in boxes in the laboratory. Before feeding, individuals were starved for 48 hours. Thirty *Chaetosiphon fragaefolii* were transferred from culture plants onto a clean strawberry leaflet. The leaflet was placed on damp filter paper in a Petri dish, a carabid added, and left for 24 hours. Numbers of aphids missing from the leaflet were then recorded. There were five replicates for each experiment, and each species was tested from two to eight times. The control treatment consisted of leaflets with aphids and no carabids.

In a second experiment, carabids treated as above, were allowed to feed on aphids on a 'simplified plant’. Thirty aphids were added to a leaflet with a stem, and the stem was threaded through a small hole in the lid of a 4.5cm diameter plastic pot containing water. This pot was placed in a 10x10x10cm plastic box and sand added until it was level with the surface of the lid of the pot. A starved carabid was added, and numbers of aphids missing after 24 hours recorded. Control treatments consisted of aphids on leaves with no carabid added. There were five replicates per experiment, and the experiments were repeated eight times.

Results

**Apple**

Mean numbers of all carabid species caught in eight pitfall trap samples in the two orchards and at different positions in the orchard between 12 August and 7 October are shown in Table 1.
The most abundant species in the recently-planted orchard were *Nebria brevicollis*, *Pterostichus madidus* and *Harpalus rufipes*, and in the established orchard were *N. brevicollis* and *Calathus fuscipes*. Twelve species in total were identified from these orchards. Collections between 7 October and March 2000 caught few carabid adults, but did catch large numbers of carabid larvae, most of which were identified as *N. brevicollis*.

Table 1. Mean numbers of all carabid species caught in pitfall traps in apple orchards. Numbers of traps per sample occasion are given in parentheses.

<table>
<thead>
<tr>
<th>Orchard planted 1999</th>
<th>centre (4)</th>
<th>border (4)</th>
<th>alder windbreak (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchards planted 1988</td>
<td>3.6</td>
<td>4.0 (3)</td>
<td>4.9 (3)</td>
</tr>
</tbody>
</table>

**Strawberry**

Within two weeks of planting, low numbers of carabids were collected from traps in the centre of the strawberry plot, 20m from the edge. Mean numbers of all carabid species caught in eleven pitfall trap samples between 16 July and 7 October at different positions within an organic strawberry planting are shown in Table 2. The most abundant species were *C. fuscipes*, *P. melanarius* and *N. brevicollis*.

Table 2. Mean numbers of all carabid species caught in pitfall traps in an organic strawberry plantation.

<table>
<thead>
<tr>
<th>Traps in conservation border</th>
<th>Traps between strawberry beds, at different distances from the conservation border</th>
<th>Traps in grass rotation plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 m 4.3</td>
<td>5 m 0.6</td>
<td>20 m 0.6</td>
</tr>
<tr>
<td>6.2</td>
<td>4.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 3. Mean numbers of aphids missing from leaflets in Petri dishes in the presence of four carabid species.

<table>
<thead>
<tr>
<th>Species tested</th>
<th>Control</th>
<th>Nebria brevicollis</th>
<th>Calathus fuscipes</th>
<th>Trechus quadristrianus</th>
<th>Pterostichus melanarius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of aphids missing</td>
<td>2.8</td>
<td>5.1</td>
<td>12.1</td>
<td>11.6</td>
<td>8.9</td>
</tr>
</tbody>
</table>

**Laboratory feeding experiments**

Mean numbers of aphids missing from the detached leaflets are shown in Table 3, and from the ‘simplified plants’ in Table 4.
There was a significant difference in the number of aphids consumed by *C. fuscipes* and *T. quadrirstrianus* compared with *N. brevicollis* and *P. melanarius* (P<0.01) in the detached leaflet experiments. There was a significant difference in the number of aphids consumed by *C. fuscipes* compared with *N. brevicollis* (P<0.05) in the ‘simplified plant’ experiments.

Table 4. Mean numbers of aphids missing from ‘simplified plants’ in the presence of two carabid species.

<table>
<thead>
<tr>
<th>Species tested</th>
<th>Control</th>
<th>Calathus fuscipes</th>
<th>Nebria brevicollis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of aphids missing</td>
<td>3.7</td>
<td>11.7</td>
<td>9.2</td>
</tr>
</tbody>
</table>

**Discussion**

In the apple orchards higher numbers of carabids were found in the windbreak and areas close to the windbreak in the recently-planted compared with the established orchard. *Pterostichus melanarius* was one of the most abundant species in the recently-planted orchard, but was only found in high numbers in the established orchard in traps under the windbreak trees. This may be due to disturbance of the habitats surrounding the orchard planted in 1999. *Nebria brevicollis* was abundant in both orchards and at all locations. Work is now needed to determine whether any of the species found in the orchards are consumers of apple sawfly and apple leaf midge pupae in the soil.

In strawberry, carabids moved into the plantation very soon after its establishment, with low numbers of *P. melanarius* being caught in the centre of the plot (20m from the conservation border) two weeks after planting. Numbers of carabids were high in the conservation strips where ground cover was diverse and prey was abundant, and also around the edge of the plantation. They were also high in the grass rotational plot. Several researchers have reported that vegetation diversity and density affect the abundance of carabid beetles (e.g. Armstrong & McKinlay, 1996). The use of refuge strips to increase species diversity of carabids in field crops was investigated by Carmona & Landis (1999). In their experiments carabid activity was higher in the refuge strips, but the presence of refuges had no effect on numbers of carabids caught in the neighbouring cropping areas; they hypothesised that the refuges were acting as ‘sinks’ for the beetle populations. In other experiments a positive influence of flowering plants was detected on carabid numbers in cereal fields (e.g. Lys, 1994). In our experiments numbers of beetles were high in the conservation borders, and some movement into the strawberry plantation was detected. Several of the species found in our survey have been shown to be major consumers of vine weevil in strawberry and blackcurrant (Crook, 2000).

In a separate experiment to determine the distribution of carabids within a commercial strawberry plantation, similar numbers of beetles were caught in traps in the alleys, on top of the polythene covering the raised beds and also under the polythene (Crook & Solomon, unpublished). This indicates that carabids are able to climb onto the raised beds and come into contact with the strawberry plants.

In laboratory feeding tests several species of carabid were found to feed on strawberry aphids, and *Calathus fuscipes* and *Nebria brevicollis* were able to feed on aphids on ‘simplified plants’, indicating that they have some ability to climb the plants and gain access
to aphids. Several species are therefore likely to provide some measure of biocontrol of aphids in strawberry plantations.

Acknowledgements

We would like to thank Ellen Deleye (Hogeschool, Gent, Belgium) and Nicola Pepper for practical assistance. The apple orchard survey of carabid species was part of a project funded by the Ministry of Agriculture, Fisheries and Food, UK.

References


Exploiting the parasitoids *Lathrolestes ensator* and *Platygaster demades* for control of apple sawfly and apple leaf midge in IPM in apple orchards

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*Horticulture Research International, East Malling, West Malling, Kent ME19 6BJ, UK*

**Abstract:** The establishment of the *Lathrolestes ensator* and *Platygaster demades*, parasitoids respectively of apple sawfly (*Hoplocampa testudinea*) and apple leaf midge (*Dasineura mali*), in large plots subject to different pest and disease management was studied in a replicated experiment at East Malling over a 6 year period after planting. The different pest and disease management regimes were 1) disease-susceptible cultivars, routine insecticide treatments with fungicides and broad-spectrum insecticides 2) disease-susceptible cultivars, managed treatments with fungicides and broad-spectrum and selective insecticides 3) disease-resistant cultivars, minimal managed treatments with selective insecticides 4) disease-susceptible and disease resistant cultivars, no fungicides or insecticides. Pesticide treatment, especially treatments 1) and 2), reduced populations of *H. testudinea* but had little effect on *D. mali*. *Platygaster demades* appeared to be absent initially and was introduced in the fourth year. *Lathrolestes ensator* established naturally. The percentage parasitism by *L. ensator* varied greatly from year to year and on different apple cultivars with different flowering times. The parasitoid did not prevent significant crop losses by *H. testudinea*. Moderate levels of parasitism (10-42%) of second generation *D. mali* larvae by *P. demades* developed by the sixth year after planting, with greater parasitism for treatments 3) and 4). The exploitation of these parasitoids in IPM is discussed.

**Key words:** parasitoid, natural enemy, integrated pest management

**Introduction**

A long-term replicated orchard experiment at HRI-East Malling (planted Jan 1995) examined different Integrated Pest and Disease Management (IPDM) strategies for apple to find ways of greatly reducing insecticide and fungicide inputs and to examine the feasibility of pest control without anticholinesterase OP or carbamate insecticides. The experiment had four treatments, 1) ‘Routine’ – disease susceptible varieties Cox, Gala and Fiesta (plus the variety Discovery used as an experimental standard) + routine pesticide sprays, 2) ‘IPDM-S’ – disease susceptible varieties + IPDM, 3) ‘IPDM-R’ – disease resistant varieties Ahra, Discovery, Ecolette, Saturn and CPRO 80015-25 + IPDM (without OPs), 4) ‘Untreated control’ of all varieties. Over the 6 years of the study to date, the success of each treatment is being judged by the number of pesticide treatments, the control of pests and diseases and by economic analysis (see Berrie & Cross, 2000). During the experiment, records were taken of populations of apple sawfly (*Hoplocampa testudinea* (Klug)) and apple leaf midge (*Dasineura mali* (Keiffer)), of the damage they caused, and of the degree of parasitisation of each species by their main parasitoids, *Lathrolestes ensator* (Brauns) (Hymenoptera: Ichneumonidae) and *Platygaster demades* (Walker) (Hymenoptera: Platygasteridae) respectively. The biology of these parasitoids has recently been reviewed by Cross *et al.* (1999). *Lathrolestes ensator* is a univoltine larval koinobiont endoparasitoid whose only reported host is *H. testudinea*. Only late first and second instar *H. testudinea* larvae can be
parasitized successfully. Eggs are black and comma-shaped and can be seen through the host skin. The parasitoid eggs eclose 2-3 weeks after the host larva has entered the soil. *Platygaster demades* is a koinobiont egg/young larval parasitoid of *D. mali* and is probably bi- or possibly multi-voltine. Todd (1956, 1959) (cited in Cross et al., 1999) reports that in New Zealand the adult parasitoid emerges 2-3 days later than its host and that the egg, which is extremely tiny, can be located in the abdominal region of the host larva. He reports that the embryonic development of the host is prolonged and that free larvae are not found until the host larva has started spinning its cocoon. Multiparasitism occurs with both species.

One important aim of IPDM is to exploit natural enemies, including parasitoids, to the full, though study of the role of parasitoids in IPDM programmes has often been neglected. This paper reports the populations of *H. testudinea* and *D mali* and the degree of crop damage they caused in the IPDM experiment and the degree of parasitism by the two parasitoids. The benefits and limitations of the two parasitoids are discussed.

**Material and methods**

The IPDM strategies experiment is a randomised complete block design with three replicates of the four treatments (see above). Each of the 12 plots (c. 0.15 ha in area) contains 12 rows of 12 trees and is surrounded by Italian alder (*Alnus cordata*) windbreaks to minimise inter-plot spray drift contamination. Pesticides were applied in response to need as determined by assessments and pheromone trap catches (Table 1).

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Selectivity*</td>
<td>BS</td>
<td>S</td>
<td>BS</td>
<td>S</td>
<td>BS</td>
<td>S</td>
</tr>
<tr>
<td>Routine</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>IPDM-S</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
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</tr>
<tr>
<td>IPDM-R</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

*BS = broad-spectrum (mainly chlorpyrifos, fenitrothion), S = selective (pirimicarb, Bt, IGRs)

**Assessments**

Populations of apple sawfly larvae and damage to fruitlets were assessed in June each year by counting the number of damaged, infested and undamaged fruitlet trusses and fruitlets on each of 10 trees of each variety in each plot. Samples of mature larvae were removed from infested fruitlets and the number parasitised by *L. ensator* was counted. At harvest, all the fruits from 10 trees of each variety on each plot were examined individually for signs of damage by sawfly. Injury included egg puncture scars (usually near the calyx), corky scars (often in pairs) caused by young larvae penetrating the skin, and typical ribbon scars. The percentage of fruits of each variety on each plot injured by *H. testudinea* was determined.

Damage caused by leaf midge larvae was assessed by examining 5 leaves in the terminals of each of 2 shoots on each of 10 trees per variety per plot. No attempt was made to determine actual numbers of *D. mali* larvae present as this would have been very time-consuming. A sample of 100 mature second generation larvae (fully grown and characteristically pink in colour) were collected from leaf galls, 5 from each of 20 galls per plot, in June-July each year. They were dissected to determine whether they contained one or more larvae of *P. demades*. Each *D. mali* larva was placed in a watch glass immersed in water. Under a stereo
microscope, the larvae were torn apart at the anterior end with a pair of needles so that the parasitoid larvae erupted out into the water along with the body contents. As no description of the early larval stages of \textit{P. demades} occurred in the literature, photographs were sent to H. Vlug, Wageningen who confirmed that they were \textit{Platygaster} sp. Adults subsequently emerged from larvae and their identity as \textit{P. demades} was confirmed by H. Vlug.

\textbf{Artificial introduction of \textit{P. demades}}
\textit{Platygaster demades} appeared to be absent or at only very low levels in the untreated control plots initially, so attempts were made to introduce it artificially into each plot in 1998. On 22 June 1998, about 800 leaf galls containing mature \textit{D. mali} larvae were collected from an unprayed organic apple orchard (cv Worcester Pearmain) at Poultry farm, Marden, Kent. Dissections of the \textit{D. mali} larvae revealed that approximately 20\% were parasitised by \textit{P. demades}. An apple leaf gall containing mature \textit{D. mali} larvae, 20\% parasitised by \textit{P. demades}, was introduced into every other tree in each plot on two occasions, 24 June and 11 August 1998. The leaf galls were lodged in the foliage of the tree.

\textbf{Results}

\textit{H. testudinea and \textit{L. ensator}}
As the trees were de-blossomed in 1995, the first growing season after planting, no sawfly damage to fruitlets or fruits could occur that year. Very little fruit was harvested in 1996 because of severe frost damage during blossom. The percentage fruits attacked by sawfly was very small and there was little damage at harvest, particularly on the routinely treated plots which received a spray of HCH shortly after petal fall. In 1997, a greater percentage of fruits were damaged by sawfly but the damage was still within acceptable economic limits (< 1.0\%). Over half the fruits damaged by sawfly had only superficial blemishes, usually egg insertion marks without ribbon scars. Interestingly, no sawfly damage was recorded on cv Discovery, which proved in later years to be one of the most susceptible varieties. Damage on cv. Discovery increased in 1998, reached a peak in 1999 and abated in 2000 (Table 2). It was worst on the Untreated plots and least on the Routine and IPDM-S plots with intermediate damage on the IPDM-R plots. Considerably greater damage occurred on Discovery, Gala and Saturn than on the other varieties (Table 2).

No parasitism by \textit{L. ensator} was recorded in 1996 or 1997. It was first detected at very low levels on Discovery and Saturn in the untreated plots in 1998. Just two mature \textit{H. testudinea} larvae of 84 examined each contained a single \textit{L. ensator} egg. A much higher percentage parasitism developed in 1999, but only on the later flowering varieties cv Gala and Saturn where 30\% of larvae were parasitised. No parasites were recorded on the early flowering variety Discovery, though > 500 larvae were examined. In 2000, the occurrence of the parasitoid decreased dramatically. Only 4 larvae were parasitised by \textit{L. ensator} out of 143 examined on the Untreated control plots. None were recorded in the insecticide-treated plots.

\textit{D. mali and \textit{P. demades}}
Populations of \textit{D. mali} larvae and damage to apple shoots were high throughout the duration of the study. In the first 5 years, virtually 100\% of shoots of every variety in every plot were damaged by each of the three or more generations that occurred each year. Almost all the young leaves in every shoot were damaged, each leaf containing several to many larvae. \textit{Platygaster demades} appeared absent in 1997 and was first detected at very low levels (1\% larvae parasitised) in the Untreated control plots in 1998 (Table 4). The parasite larvae had a round globular body, 0.3-0.5 mm in diameter and were found in the anterior end of the larvae.
near the mouthparts. The percentage parasitism of the second generation increased in 1999 to 18 % on the Untreated control plots, 10% on the IPDM-R plots but remained low on the Routine and the IPDM-S plots. A further increase occurred in 2000, but levels remained greatest on the Untreated control and IPDM-R plots. The mean percentage parasitism of third generation *P. demades* larvae in 2000 was lower (6-12%) and varied greatly between replicates.

Table 2. Mean % of trusses of cv Discovery infested by *H. testudinea* in June and mean % fruits of all varieties damaged on the untreated control plots at harvest in 1998-2000.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Variety</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% trusses infested in June</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine</td>
<td>Discovery</td>
<td>2.4</td>
<td>1.5</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>IPDM-S</td>
<td>Discovery</td>
<td>0.6</td>
<td>1.4</td>
<td>0</td>
<td>0.7</td>
</tr>
<tr>
<td>IPDM-R</td>
<td>Discovery</td>
<td>5.6</td>
<td>8.9</td>
<td>2.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Untreated</td>
<td>Discovery</td>
<td>6.3</td>
<td>33.1</td>
<td>15.4</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td>% fruits damaged at harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>Ahra</td>
<td>0</td>
<td>5.6</td>
<td>5.4</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Cox</td>
<td>0.7</td>
<td>4.2</td>
<td>3.0</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Discovery</td>
<td>1.4</td>
<td>15.1</td>
<td>7.2</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Ecolette</td>
<td>1.0</td>
<td>3.3</td>
<td>4.3</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Fiesta</td>
<td>1.4</td>
<td>9.2</td>
<td>2.5</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Gala</td>
<td>1.9</td>
<td>16.5</td>
<td>16.4</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td>Saturn</td>
<td>1.8</td>
<td>21.2</td>
<td>9.0</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>CPRO 80015-25</td>
<td>0.8</td>
<td>7.5</td>
<td>3.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Table 3. Percentage leaf midge larvae parasitised by *P. demades*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage parasitism by <em>P. demades</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1998*</td>
</tr>
<tr>
<td>Date</td>
<td>29 June – 3 July</td>
</tr>
<tr>
<td>Generation</td>
<td>2</td>
</tr>
<tr>
<td>Routine</td>
<td>0</td>
</tr>
<tr>
<td>IPDM-S</td>
<td>0</td>
</tr>
<tr>
<td>IPDM-R</td>
<td>0</td>
</tr>
<tr>
<td>Untreated</td>
<td>1</td>
</tr>
</tbody>
</table>

* *D. mali* larvae parasitised by *P. demades* were introduced artificially on 24 June and 11 August 1998

**Discussion**

Parasitism by *L. ensator* developed naturally in the plots. The limited data show that the percentage parasitism varied greatly from year to year and greatly between varieties with different flowering times. As the parasite can only parasitise late first or second instar *H. testudinea* larvae whose development is synchronised, there is only a narrow window of opportunity for the adult parasite. The results point to the importance, both to the host and the
parasitoid, of suitable weather conditions at the times that adults are active. Although the parasitoid has some beneficial influence in regulating *H. testudinea* populations, it is unreliable and unlikely to be adequate to prevent serious losses due to *H. testudinea* in some, perhaps most, seasons. It is not possible to determine whether the establishment and increase in *P. demades* populations in the plots was due to natural or artificially-introduced populations, or a combination of both. Greater % parasitism developed on the untreated and IPDM-R plots, suggesting populations on the Routine and IPDM-S plots were adversely affected by the multiple sprays of broad-spectrum pesticides. *Platygaster demades* appears to have potential to be exploited as a natural regulator of *D. mali* populations as has previously been reported by Trapman (1988) (cited in Cross *et al.*, 1999). More careful study of the biology of *P. demades* is needed.

**Acknowledgements**

We thank Jeremy Brind, Damon Crook, Heather Faulkner and Adrian Harris for their assistance and also Henk Vlug for the identifications of *P. demades*.

**References**


Mass trapping of *Synanthedon myopaeformis* (Borkhausen) in Lleida (Spain) with pheromone traps

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**Abstract:** *Synanthedon myopaeformis* (Borkhausen) (Lepidoptera: Sesiidae), is a xylophagous species what attacks pome and stone fruit trees. The control of its populations is not easy, because the larvae develop inside the tree branches and trunks. Male mass trapping with pheromone traps may be a good control alternative, compatible with an integrated pest management program.

Field trials of *S. myopaeformis* mass trapping with pheromone traps have been conducted in two apple orchards at Lleida (NE Spain) from 1998 to 2000. The weekly or quarterly number of male catches in funnel pheromone traps, the weekly or quarterly number of pupal exuviae, the number of larvae per m², and the number of mated female catches in juicy traps were recorded each year.

The total number of catches has decreased by a 93.6% and a 51.9%. However, the number of pupal exuviae has decreased by a 44.0% in the orchard which had a very high initial population, but has increased by a 67.0% (only last year) in the other.

The trial will be conducted again in 2001 in the same orchards.

**Key words:** *Synanthedon myopaeformis*, mass trapping, apple tress

**Introduction**

*Synanthedon myopaeformis* (Borkhausen) (Lepidoptera: Sesiidae), is a xylophagous species which attacks pome and stone fruit trees. The control of its populations is not easy, because the adults show a long emergence period and the larvae develop inside the tree branches and trunks. An indirect control method for this pest it may be keeping the tree in a good vegetative stage, avoiding wounds and injuries. Its control with locally applied chemical insecticides has given good results, but it is impracticable due to his high economic costs in great and heavily infested areas. Its control with general chemical treatments may also give good results, with the application of broad spectrum insecticide treatments, but these products are not recommended in integrated pest management programs (Trematerra, 1993; Blaser & Charmillot, 1984).

Mass trapping can be an alternative for *S. myopaeformis* control. Mass trapping is based on the use of a highly specific insect attractant (preferably of both sexes) what captures a number of individuals of the target insect species enough to reduce its population below the economic thresholds (Trematerra, 1993). The difficulty is to know what proportion of the wild population needs to be trapped. Knipling & McGuire (1966) assumed that trapping only one sex (which is the case when using pheromone traps) the efficiency should be as high as 80-95%.

The knowledge of the phenology of *S. myopaeformis*, and the possibility of its control by male mass trapping with pheromone traps, as a control alternative compatible with an integrated pest management program, was studied in Lleida from 1998 to 2000.
Material and methods

The assays were carried on in two commercial orchards at Lleida (NE Spain). The first orchard, identified as "Els Arcs", was a 7.6 ha orchard planted in 1980 with two apple varieties, Golden and Granny Smith. Broad spectrum insecticides were used for pest control. The second orchard, identified as Gimenells, was a 1.1 ha orchard planted in 1994 with three apple varieties, Golden Smoothee, Top Red and Early Red One, and two pear varieties, Conference and Blanquilla. Integrated Pest Management was applied in the apple trees since its plantation, while pear were untreated. There was a great difference in tree canopy between the trees of the two orchards; in Els Arcs the trees were vigorous, 4 m high and they suffered from an important attack of Zeuzera pyrina L.) several years before, what caused them an important number of cankers. In Gimenells, the tree height ranged between 2.5 and 3.5 m, depending on the variety.

Male mass trapping was carried out in 1998, 1999 and 2000 by placing 9 (Gimenells) and 40 (Els Arcs) funnel traps from the beginning of April to the end of September. The traps were hanged at about 1.60 m from the ground. Each trap was provided with a 1-mg pheromone dispenser from Russell Fine Chemicals Ltd and a with vapone. The pheromone dispensers were replaced each 4 weeks.

The variables measured were:
1. The number of S. myopaeformis males caught in the mass-trapping pheromone traps. The traps were weekly or quarterly checked.
2. The number of pupal exuviae and their sex. All the cankers (up to a height of 2 m) of ninety-five trees were weekly or quarterly sampled in Els Arcs. The grafting area (where the attack was located in this case) of eighty-six trees were sampled in Gimenells. The pupal exuviae were removed and sexed in the lab.
3. The number of larvae per m² of canker. Samplings were carried out at the beginning of the spring and at the end of the year. This sampling was done only in 2000 in Els Arcs.
4. The percentage of mated females during the year. It was done in July - August, 2000 in Gimenells using 7 juicy traps. The traps were provided with a mixture of water, black wine, sugar, vinegar and terpenyl acetate.

Results and discussion

The total number of males caught decreased by a 93.6% in Els Arcs and by a 51.9% in Gimenells from 1998 to 2000. (Table 1). In Els Arcs, the more important decrease was observed between the second and the third year of the assay.

Table 1. Number of Synanthedon myopaeformis males caught in 40 (Els Arcs) and 9 (Gimenells) mass-trapping funnel pheromone in Lleida in 1998, 1999 and 2000.

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Year 1998</th>
<th>Year 1999</th>
<th>Year 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Els Arcs</td>
<td>45,646</td>
<td>30,255</td>
<td>2,923</td>
</tr>
<tr>
<td>Gimenells</td>
<td>424</td>
<td>280</td>
<td>204</td>
</tr>
</tbody>
</table>
Figure 1. Quarterly evolution of the number of catches and of the number of pupal exuviae in Els Arcs from 1998 until 2000. Data from 40 pheromone-baited funnel traps.

Figure 2. Quarterly evolution of the number of catches and of the number of pupal exuviae in Gimenells from 1998 until 2000. Data from 9 pheromone-baited funnel traps.

Figures 1 and 2 show the number of catches and the number pupal exuviae found in Els Arcs (Figure 1) and in Gimenells (Figure 2) from 1998 to 2000. Male adult flight began at the end of April - beginning of May, reached a maximum at the end of May - beginning of June and ended at the end of August.
The number of pupal exuviae in Els Arcs decreased by a 44.0 % from 1998 to 2000. In Gimenells, the number of pupal exuviae was similar in 1998 and 1999, but increased in 2000. However, the population density of \textit{S. myopaeformis} was low. The percentage of pupal exuviae that could be successfully sexed in the laboratory ranged from 72 to 92%. The sex ratio was roughly 50:50% (Table 2).

Table 2. Total number sampled of exuviae, sexed percentage of them and males (M) and females (F) percentage of those exuviae found in Els Arcs and Gimenells during the years 1998, 1999 and 2000

<table>
<thead>
<tr>
<th></th>
<th>Els Arcs</th>
<th></th>
<th></th>
<th>Gimenells</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. exuviae</td>
<td>728</td>
<td>611</td>
<td>408</td>
<td>55</td>
<td>52</td>
<td>93</td>
</tr>
<tr>
<td>Sexed exuviae (%)</td>
<td>92.6</td>
<td>66.6</td>
<td>84.3</td>
<td>89.1</td>
<td>78.9</td>
<td>72.0</td>
</tr>
<tr>
<td>Males (%)</td>
<td>51.8</td>
<td>45.9</td>
<td>54.9</td>
<td>51.0</td>
<td>65.9</td>
<td>52.2</td>
</tr>
<tr>
<td>Females (%)</td>
<td>48.2</td>
<td>54.1</td>
<td>45.1</td>
<td>49.0</td>
<td>34.1</td>
<td>47.8</td>
</tr>
</tbody>
</table>

The results on the larval density are preliminary, as they have been obtained only for one orchard (Els Arcs) and for one year (2000). In February, 2000, 17.7 m$^2$ of canker were sampled, and 5.3 larvae per m$^2$ were observed. In October, 2000, 19.8 m$^2$ of canker were sampled, and 5.2 larvae per m$^2$ were observed, showing that larval population did not vary. Samplings will be carried out again in 2001.

Also as preliminary results, we observed that the percentage of females caught in the juicy traps in Gimenells, 2000, that were mated reached 95%. Stüber & Dickler (1988) stated that in commercial orchards up to a 10% of unmated females may be observed. The percentage of mated females is an important variable that will be sampled again in 2001.

In conclusion, the application of male mass trapping using pheromone traps as a control method for \textit{S. myopaeformis} caused a decrease of the adult population and in one orchard also a decrease of the larval population, showing that it may be an useful method to control this pest.

Acknowledgements

This work has been supported by the Spanish INIA (project no. SC97-048) and by La Paeria (project no. P97-127). We also thank he firm Agro. Llobera (Mollerusa, Spain) for providing the pheromone dispensers and the traps and for the collaboration of A. Burballa.

References


Control of leopard moth, Zeuzera pyrina L., in apple orchards in NE Spain: mating disruption technique

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Abstract: The leopard moth, Zeuzera pyrina Linnaeus, is a cossid whose larvae bore into the twigs, branches and trunks of several trees and shrubs, weakening and sometimes killing them. Control of this pest using the so-called mating disruption technique, which uses the female sex pheromone to confuse males so that sexes can not – or have great difficulty to – find each other, has been tested experimentally in apple orchards in Girona (Spain) since 1996. Experimental dispensers were loaded initially with 123 mg of ZP sex pheromone (only the main component); they were set on the upper third of the trees around mid-april of each year and stayed there until mid-october, at the rate of 500 dispensers per hectare. Serbios monitoring traps loaded with conventional ZP dispensers were used (5 traps/plot) only to monitor the ongoing mating disruption within the experimental plots. Four experimental plots were used (two mating disruption plots and two control plots). In order to assess the efficacy of the technique, two thorough checks were carried out: that of infested shoots (in September) and that of gallery plugs (in January). Larval density – measured in winter – in the mating disruption plots decreased 89-97% after three or four years of consecutively applying the technique; however fluctuating larval densities were observed in the control plots from year to year, either increasing or decreasing, following an erratic pattern. Therefore, results clearly indicate the mating disruption technique used is working very well and effectively protects the orchards against Z. pyrina.

Key words: pest control, Lepidoptera, Zeuzera pyrina, apple orchards, mating disruption technique

Introduction

The leopard moth, Zeuzera pyrina L., is a lepidopteran of the Cossidae family. It occurs all over the Palearctic excluding its coldest areas. It can also be found in some USA and Canada areas where it was introduced and became a minor pest (CIE, 1973). Its larvae are wood borers affecting a wide variety of trees and shrubs -up to 20 taxonomic genera have been quoted so far- (Carter, 1984; Gatwick, 1992). Comprehensive data on its biology can be found in Feron & Audemard (1966), Audemard (1967) and Sarto i Monteys (2000).

In Catalonia (NE Spain) there are three species seriously affected by this pest, apple and pear trees in Girona and Lleida areas and hazelnut trees in Tarragona. Concerning apple and pear, the number of hectares dedicated to them in the mediterranean region is quite important. So, in Spain figures are 40,000 ha for apple and 31,000 for pear; in Greece, 18,500 ha and 6,800 ha respectively; in Italy, 79,000 ha and 41,000 Ha respectively. In Spain, an important piece of the whole area dedicated to those orchards is located in Catalonia, figuring 17,128 ha to apple (14,234 ha in Lleida and 2,160 in Girona) and 18,287 ha to pear (17,021 ha in Lleida and 583 in Girona) (Sarto i Monteys, 2000).

It is estimated that market value for apple and pear in the three above-mentioned mediterranean countries is over 1000 million euros. And despite the fact that total costs for controlling the several pests that affect apple and pear orchards in these three countries, are at least 35 million euros/year, crop loss is still estimated at 5-15%. In the whole European
Union, costs to protect apple, pear, peach and olive plantations are estimated at over 100 million euros. Obviously, the pest we are dealing with, *Z. pyrina*, accounts for a piece of such remarkable losses.

**Materials and methods**

Due to the fact that *Z. pyrina* larvae are endophytic, conventional insecticides do not reach them properly and so are quite ineffective. Control of this pest using the so-called mating disruption technique, which uses the female sex pheromone to confuse males so that sexes can not -or have great difficulty to - find each other, has been tested experimentally in apple orchards in Girona (Spain) since 1996 (Sarto i Monteys, 1996, 2000).

Experimental control-release mating disruption dispensers were made and provided by DENKA International based on TNO Institute technology. These are produced through a gamma radiation curing of a mixture containing poliuretane and poliachrilate prepolimers, the main component of the sex pheromone and proper stabilizers (den Braber, 1998). Each dispenser weighs 4.1 g and is loaded initially with 123 mg (3%) of pheromone; they are designed to overlast the moth flying period (from may to september in Girona). They were set on the upper third of the trees around mid-april of each year and stayed there until mid-october, at the rate of 500 dispensers per hectare, i.e. 62 g of pheromone per Ha; plot borders were reinforced so that dispensers density on them doubled that of the centre.

Four experimental plots were used. Two of them, Camp del Frare (2.68 Ha - 6,064 trees) and Palau Sator-S (2.10 Ha - 4,652 trees), underwent mating disruption. The other two, Camp Major (1.53 Ha - 3,565 trees) and Palau Sator-C (1 Ha - 2,262 trees), were used as control plots for the corresponding mating disruption plots; needless to say the technique was not applied on them. However, all plots underwent conventional chemical sprays against usual apple orchards pests, including *Zeuzera pyrina*.

In order to closely follow the ongoing of the mating disruption technique being used, five conventional monitoring pheromone traps were set on each experimental plot. These traps were SERBIOS made, specifically for *Zeuzera pyrina*, each holding a monitoring dispenser (Novapher ZP15807) which was replaced by a new one at mid-season (Sarto i Monteys, 2000). Traps were placed on top of long adjustable telescopic javalins stuck on the ground (Sarto i Monteys, 1996; 1998), in such a way that the dispenser they held stayed always about 1-1.5 m above apple trees canopies; according to Pasqualini *et al.*, (1996), this position was the best for maximizing male catches. These traps were set on the plots at mid april and checked weekly for male catches until mid october, when the trials stopped. By doing that, a good indication of the efficacy of the mating disruption technique being used was obtained. Expectations were that traps placed in mating disruption plots should ideally record null catches of males; on the other hand, those placed in non-mating disruption plots should record some male catches, according to the flight curve of the lepidopteran in our area.

However, conclusive results of the efficacy of the technique used were obtained by undertaking two thorough and time-consuming counts: that of shoots attacked by first or second instar larvae (carried out in early september) and that of gallery plugs -seen on trunks and branches- produced by grown larvae (carried out in january). Both counts estimate quite precisely larval population densities of the pest in a particular plot. The first count gives an indication of the pressure the plot bears because of very young *Zeuzera pyrina* larvae; an unknown percentage of the latter will perish for several causes (parasitism, microbial or fungical diseases, contact with insecticides) before reaching winter time. The second count gives an indication of the pressure the plot bears because of overwintering grown larvae; such larval winter population – undoubtedly with less expected mortality than that of the summer
and from which it comes – will become the moth population next spring, so resuming the cycle.

The first count looks for shoots showing dead (brown) or withered leaves on their terminal tips; these symptoms appear as a result of the boring activity of the young larva. The second count looks for holes on trunks and branches which indicate the presence of a gallery where the grown larva inhabits and overwinters. Thorough descriptions and photographs are provided by Sarto i Monteys (1996, 2000).

In the first count, much more time-consuming than the second one because of the large quantities of shoots present on the trees (around 400 shoots/tree), 17% of trees in the plots were checked, i.e. one in six trees was checked. In the second count, 33% of trees were checked, i.e. one in three trees was checked. Both counts were carried out visually and simultaneously by pairs of observers, in such a way that one half of the tree was scanned by one observer at the same time that the other half was scanned by his/her pair. Counts began by the first tree row – they all had been previously numbered –, continued by the second one, third one and so on, following a zig-zag route, until reaching the last row. By doing this, each and all plot rows – their corresponding trees – had been checked, securing an homogeneously distributed count over it.

Results

*Population-larval-density in winter: gallery plugs /100 trees*

Table 1 shows figures obtained since 1996; in order to ease comparisons, they are presented as total gallery plugs (in general terms one gallery plug is equivalent to one larva) found per 100 trees checked. In Camp del Frare mating disruption (MD) plot, larval density went down from the starting figure of 30.70 larvae/100 trees to that of 3.29 after four consecutive years of applying the technique (i.e. a 89.28% decrease). In Palau Sator-S MD plot, similar figures go from 34.05 to 1.03 after only three consecutive years (i.e. a 96.98% decrease). In the control plots (Camp Major and Palau Sator-C), figures fluctuated considerably from year to year, either increasing or decreasing, following an erratic pattern, in accordance with what must be the species’ natural fluctuations. Such natural fluctuations of *Zeuzera pyrina* larval populations within non-mating disruption plots were also observed in other plots in the area (Sarto i Monteys, 2000).

Table 1. Gallery plugs/100 trees in experimental plots

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Camp del Frare</td>
<td>30.70</td>
<td>18.25</td>
<td>12.41</td>
<td>4.51</td>
<td>3.29</td>
</tr>
<tr>
<td>Camp Major</td>
<td>13.37</td>
<td>7.56</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Palau Sator-S</td>
<td>–</td>
<td>34.05</td>
<td>21.06</td>
<td>0.32</td>
<td>1.03</td>
</tr>
<tr>
<td>Palau Sator-C</td>
<td>–</td>
<td>19.62</td>
<td>8.32</td>
<td>21.12</td>
<td>13.06</td>
</tr>
</tbody>
</table>

1) Camp del Frare and Palau Sator-S are the two mating disruption plots. Camp Major and Palau Sator-C are the two control plots.
2) Unfortunately, control plot Camp Major was unexpectedly -and without warning- pulled up by its owner in november 1997.
3) Palau Sator-S and Palau Sator-C begun to be checked in january 1997.
Population larval-density in summer: shoots attacked /100 trees

Table 2 shows figures obtained since 1996; in order to ease comparisons, they are presented as total shoots attacked (again, one shoot attacked is equivalent to one larva) per 100 trees checked. In Camp del Frare MD plot, larval density went down from the starting figure of 56.72 larvae/100 trees detected in September 1996 (just after having applied mating disruption to the plot for the first time) to that of 6.93 in September 1999, i.e. three consecutive years later (representing a 87.78% decrease). On its control plot, Camp Major, figures remained high and stable around 46 larvae/100 trees in 1996 and 1997 (as it has been said, this plot was pulled up without warning by its owner in November 1997).

In the other MD plot, Palau Sator-S, similar figures go from 47.74 larvae/100 trees detected in September 1997 (just after having applied mating disruption to the plot for the first time) to 4.84 in September 2000, i.e. three consecutive years later (representing a 89.86% decrease). However in this plot, figures do not follow a nicely homogeneous descending line as the one seen at Camp del Frare; instead they form a plateau in the middle years (1998 and 1999) to abruptly fall down again in 2000. On its control plot, Palau Sator-C, larval population drops were also detected year after year despite the mating disruption technique was not applied there. This might be explained by the fact of its proximity to the MD plot – only 70 meters away –, so some mating disruption could also be experienced in the control plot; also, natural population fluctuations could account for part of that. In any case, Control plot figures after the first year are clearly much higher than the corresponding ones at the MD plot, which indicates the technique used is working.

It must be said here that year-to-year value-fluctuation power is much stronger in the variable for shoots attacked than in that for gallery plugs; this accounts for the latter being more reliable to assess the efficacy of the technique used. Such strong year-to-year fluctuations of the variable shoots attacked have also been observed in other non-mating disruption plots in the area (Sartor i Monterey, 2000).

Table 2. Shoots attacked/100 trees in experimental plots

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Camp del Frare</td>
<td>56.72</td>
<td>38.73</td>
<td>12.75</td>
<td>6.93</td>
<td>–</td>
</tr>
<tr>
<td>Camp Major</td>
<td>46.55</td>
<td>45.86</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Palau Sator-S</td>
<td>–</td>
<td>47.74</td>
<td>11.49</td>
<td>13.58</td>
<td>4.84</td>
</tr>
<tr>
<td>Palau Sator-C</td>
<td>–</td>
<td>38.56</td>
<td>20.95</td>
<td>19.58</td>
<td>12.53</td>
</tr>
</tbody>
</table>

Conventional sex pheromone monitoring traps: their contribution to assess the efficacy of the mating disruption technique used.

Aside data presented so far, a good indication that the mating disruption technique being used was efficiently working was that provided by catches of Zeuzera pyrina males in conventional monitoring traps (five per plot) as mentioned above. So, in 1998, during the moth flying period, not a single male was caught in both MD plots (Camp del Frare and Palau Sator-S), while the traps placed within the control plots caught 86 males (at Camp La Basa – the plot that replaced Camp Major due to its unexpected pulling-up) and 76 males (at Palau Sator-C). Likewise, in 1999, only one male was caught at Camp del Frare and none at Palau Sator-S; however 33 and 17 males were caught in the two control plots as before. Obviously, the fact that only one male was collected in all the monitoring traps placed within the mating
disruption plots during the five months covered and during two consecutive years is highly significant and supports the efficacy of the technique.

**Discussion**

According to the combined results presented above it is concluded that the mating disruption technique used works very well in our area and effectively protects apple orchards against *Zeuzera pyrina*. In Emilia Romagna (Italy), the technique also worked satisfactorily (Pasqualini, pers.com.); however it did not work in Greece where *Zeuzera pyrina* standing larval population levels within the plots are very high (Haniotakis pers.com.). According to our experience, protection of apple orchards seems to be achieved progressively, after three to four years of consecutively applying the technique, provided that the former larval population in the plot was not too high (values not higher than 35-70 overwintering larvae/100 trees). When former standing populations in plots show figures much higher than these, the mating disruption technique does not seem to work.

**Acknowledgements**

I’m indebted to Lluis Batllori, Josep Blay, Alex Creixell and Quim Punsola for helping me finding the experimental plots in the area. To all farmers involved for giving me permissions to work in their properties. To all students hired to carry out the never-ending checks. To my colleagues in the EU-AIR Project, Jan de Vlieger, Janusz Moskal, Edison Pasqualini, George Haniotakis and Joan Isart, for the long and profitable talks we had while the project was on.

**References**


Selective insecticides in control of fruit moths and leaf rollers

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Abstract: During last few years a study was conducted to evaluate under field conditions the usefulness of some modern insecticides such as indoxacarb (Steward 30 WG), methoxyfenozide (Runner 240 SC), spinosyn A+D (Spinosad 480 SC), Bacillus thuringiensis (Biobit WP 32000), codling moth granulosis virus (Granupom) and codlemone+cyfluthrin (Appeal 04 PA) in controlling codling moth, plum fruit moth, and leaf rollers in different parts of Poland. All the compounds tested were found to be effective or even highly effective in reducing damage caused by the above listed pests. Their efficacy was, however, more or less influenced by such factors as weather conditions, timing of the treatment and density of the pest population. Nevertheless, all these preparations seem to be very promising as to their usefulness in the programme of integrated pest management.

Key words: Tortricidae, control, selective insecticides, codling moth, plum fruit moth, leaf rollers

Introduction

Crop protection is an indispensable and integral part of the production of high quality fruits. This is especially important in the case of pests directly damaging fruitlets or fruits. From the other hand, according to IFP rules such fruits should be produced with minimum of undesirable side effects that are caused by the agrochemicals used.

Among pests attacking fruits, three groups of small moths are noticed as important pests as well in Poland as in the majority of european countries. They are: codling moth (Laspeyresia pomonella (L.)), plum fruit moth (Laspeyresia funebrana Tr.) and the complex of leaf rollers (Tortricidae). We found that 8-9 species of tortricides occure in Polish orchards and from among them especially important are: Pandemis heparana Den. et Schiff., Spilonota ocellana F., Adoxophyes reticulana Hbn. and during last years Archips rosanus L. and locally Acleris rhombana Den. et Schiff.

Among insecticides generally used for controlling codling moth, plum fruit moth and tortricids, only a few are both selective and effective enough to be useful for integrated control programs. As the concept of integrated fruit production is more and more often accepted by growers and consumers all over the world, new groups of selective insecticides are still needed. During last several years new compounds have been synthetised by some chemical companies. On the base of data reported by producers they can be classified as a safe for beneficial fauna. According to some authors, beneficial fauna and especially parasitoids can be treated as potential population suppressors of some species of tortricids and even of codling moth (Miczulski & Kościńska, 1976; Gall, 1984; Reede et al., 1985; Helsen & Blommers, 1989; Zerova et al., 1989; Harzer, 1990). Thus products harmless for natural enemies are very desirable.
Material and methods

Depending on the pest and preparation, research was carried out from one to three years in the period 1995-2000. It was conducted in commercial apple orchards located in various regions of Poland. Pheromone traps were used for determining the beginning and dynamics of flights of codling and plum fruit moth, while timing of treatments was based on trap catches according to the procedure of Koślińska et al. (1987) and Kozłowski (1994). Depending on the orchard area or number of cultivars, 1-2 traps were used. Traps were inspected every 2 or 3 days and specimens were counted and removed on each occasion. In the case of tortricids, the timing of treatment was based on visual evaluation of larval development and species composition. The experimental plot area varied from 0.3 ha to 3 ha, depending on the orchard. Against these pests we tested such preparations as: indoxacarb (Steward 30 WG), methoxyfenozide (Runner 240 SC), spinosyn A+D (Spinosad 480 SC), codlemone+cyfluthrin (Appeal 04 PA) and microbial preparations such as Bacillus thuringiensis (Biobit WP 32000) and Cydia pomonella granulosis virus (Granupom). As standard compounds fenoxycarb (Insegar 25 WP), diflubenzuron (Dimilin 25 WP), triflumuron (Alsystin 480 SC) and fenitrothion (Owadofos 540 EC or Sumithion 500 EC) were applied. The treatment efficacy was assessed during harvest time by inspecting 800 or 1000 fruit (10 items from each of 8 or 10 randomly selected trees) collected within the central part of each section, for the purpose of recording the level of damage. The efficacy of treatments was calculated by Abbott's formula (Abbott, 1925).

Results

Codling moth control

In orchards under study the population of codling moth exceeded the economic damage threshold. An especially high level of infestation was observed in some orchards in 1998-2000 (Table 1 - Results 1 and 2).

The efficacy of methoxyfenozide varied from 84.1 to 100%, whereas that of indoxacarb - from 71.5 to 100%, depending on the dose rate and infestation level. Diflubenzuron, applied as standard preparation showed an efficacy from 72.6 to 96.9%.

A quite new compound, such as Spinosad was tested in orchards as well. The efficacy of these chemicals varied from 74.2 to 83.3% and was comparable to that of fenitrothion, which reached 77.3 to 79.0% (Table 1 - Results 2).

Taking into consideration the results from all the tested orchards and years we can state that also Bacillus thuringiensis (Biobite WP 32000) has given results equal or similar to those obtained with standard preparations (Table 1 - Results 3). Among other things we tested the product based on CpGV (Granupom) that was used in a special manner, described in Table 1 - Results 4. Granupom significantly reduced the percentage of fruits damaged by codling moth caterpillars and its efficacy varied from 71.4 to 92.9%.

During three years, Appeal 04 PA was tested in a commercial orchard, too (Table 1 - Results 5). Depending on the number of drops per hectare its efficacy varied from 60.0 to 92.1% and was comparable with that of an acylurea preparation (Alsystin 480 SC).
Table 1. Effectiveness of insecticides in reducing codling moth damage.

### Results (1). 1998 and 1999

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>% control of codling moth in orchard no.</th>
<th>1*</th>
<th>2**</th>
<th>3*</th>
<th>4*</th>
</tr>
</thead>
<tbody>
<tr>
<td>methoxyfenozide</td>
<td>0.4</td>
<td>92.6</td>
<td>100.0</td>
<td>85.5</td>
<td>84.1</td>
<td></td>
</tr>
<tr>
<td>indoxacarb</td>
<td>0.17</td>
<td>71.8</td>
<td>96.9</td>
<td>71.5</td>
<td>82.4</td>
<td></td>
</tr>
<tr>
<td>indoxacarb</td>
<td>0.2</td>
<td>85.2</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diflubenzuron</td>
<td>0.6</td>
<td>89.3</td>
<td>96.9</td>
<td>72.6</td>
<td>75.6</td>
<td></td>
</tr>
</tbody>
</table>

**Damaged fruits in unsprayed plot (%)**

- picked fruits/fallen fruits

|                  | 6.8/47.5 | 2.3/7.0  | 6.8/66.0 | 6.1/63.5 |

* one treatment per season; ** two treatments per season

### Results (2). 1999 and 2000

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>% control of codling moth in orchard no.</th>
<th>1*</th>
<th>2*</th>
<th>3*</th>
</tr>
</thead>
<tbody>
<tr>
<td>spinosyn A+D</td>
<td>0.42</td>
<td>74.2</td>
<td>80.3</td>
<td>83.3</td>
<td></td>
</tr>
<tr>
<td>fenitrothion</td>
<td>2.25</td>
<td>79.0</td>
<td>77.3</td>
<td>77.8</td>
<td></td>
</tr>
</tbody>
</table>

**Damaged fruits in unsprayed plot (%)**

- picked fruits/fallen fruits

|                  | 6.8/66.0 | 4.0/17.0 | 5.0/16.0 |

* see Table 1 - results 1

### Results (3). 1995, 1996 and 1998

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>% control of codling moth in orchard no.</th>
<th>1*</th>
<th>2*</th>
<th>3**</th>
<th>4*</th>
<th>5**</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>B. thuringiensis</em></td>
<td>0.75</td>
<td>98.4</td>
<td>89.7</td>
<td>92.5</td>
<td>53.1</td>
<td>45.0</td>
<td></td>
</tr>
<tr>
<td>fenitrothion</td>
<td>2.25</td>
<td>70.5</td>
<td>93.1</td>
<td>95.0</td>
<td>87.5</td>
<td>83.9</td>
<td></td>
</tr>
</tbody>
</table>

**Damaged fruits in unsprayed plot (%)**

- picked fruits/fallen fruits

|                  | 3.6/8.0 | 3.6/-   | 2.9/6.3 | 2.3/7.0 | 6.8/47.5 |

*; ** see Table 1 - results 1

### Results (4). - from one orchard during two years, 1998 and 1999

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% control of codling moth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granupom</td>
<td>71.4</td>
</tr>
<tr>
<td>Standard preparation (triflumuron)</td>
<td>82.9</td>
</tr>
</tbody>
</table>

**Damaged fruits in unsprayed plot (%)**

- picked fruits/fallen fruits

|                  | 3.5/-          | 3.2/26.5 |

Granupom – five treatments per season, with differentiated dosage:

1st year – twice complete (300 ml/ha) and three times 1/10 of the complete dose
2nd year – once complete and four times one 1/10 of the complete dose

Triflumuron – once in the season (0.4 l/ha)

### Results (5). - from one orchard during three years, 1998-2000
<table>
<thead>
<tr>
<th>Treatment</th>
<th>% control of codling moth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appeal 04 PA - 2 x* (6000 drops per ha and treatment)</td>
<td>82.9 88.7 92.1</td>
</tr>
<tr>
<td>Appeal 04 PA - 2 x (4000 drops per ha and treatment)</td>
<td>60.0** 74.2 75.2</td>
</tr>
<tr>
<td>Alsystin 480 SC - 1x</td>
<td>88.6 83.9 91.1</td>
</tr>
<tr>
<td>Damaged fruits in unsprayed plot (%) - picked fruits/fallen fruits</td>
<td>1.4/14.0 2.8/17.0 3.7/32.0</td>
</tr>
</tbody>
</table>

* number of treatments; ** one drop per tree was used (2000 drops per ha and treatment)

**Plum fruit moth control**

Only metoxyfenozide, indoxacarb and spinosyn A+D were tested against this pest. Depending on the rate of treatment (in the case of indoxacarb) and location of the experiment (orchard), the efficacy of these compounds varied from 51.0 to 93.9% and in the majority was comparable to that of the standard preparation (diflubenzuron), whose efficacy varied from 74.0 to 84.8% (Table 2 - Results 1). In all these orchards spinosyn A+D showed also a very high efficacy (90.6%-94.5%), comparable or even higher than that of the standard preparation (fenitrothion).

Table 2. Effectiveness of insecticides in reducing plum fruit moth damage.
Results (1). 1999 and 2000

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>% control of plum fruit moth in orchard no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1*</td>
</tr>
<tr>
<td>metoxyfenozide</td>
<td>0.4</td>
<td>49.4</td>
</tr>
<tr>
<td>metoxyfenozide</td>
<td>0.5</td>
<td>83.1</td>
</tr>
<tr>
<td>indoxacarb</td>
<td>0.17</td>
<td>62.7</td>
</tr>
<tr>
<td>indoxacarb</td>
<td>0.2</td>
<td>83.9</td>
</tr>
<tr>
<td>diflubenzuron</td>
<td>0.6</td>
<td>80.0</td>
</tr>
<tr>
<td>spinosyn A+D</td>
<td>0.42</td>
<td>94.5</td>
</tr>
<tr>
<td>fenitrothion</td>
<td>0.6</td>
<td>91.8</td>
</tr>
<tr>
<td>Damaged fruits in unsprayed plot (%) - picked fruits/fallen fruits</td>
<td>19.8/48.5</td>
<td>2.5/11.5</td>
</tr>
</tbody>
</table>

* two treatments per season were done

**Leaf roller control**
The efficacy of methoxyfenozide and indoxacarb was tested in six commercial apple orchards with reasonably high populations of tortricids. Especially in orchard 1, 2 and 6 they were very numerous and the level of fruit damage on unsprayed plots was very high. Depending on the number of treatments and place of experiment (orchard), the efficacy of both compounds was more or less similar and varied from 53% to 100%, whereas that of the standard preparations (fenitrothion and fenoxycarb) - from 52% to 93% (Table 3 - Results 1). Also spinosyn A+D,
applied against these pests in two orchards proved a very good control of the pest and its efficacy has exceeded the level of 88% (Table 3 - Results 2).

Table 3. Effectiveness of insecticides in reducing leaf rollers damage
Results (1). 1998 and 1999

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>% control of leaf rollers in orchard no.</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1*</td>
<td>2*</td>
<td>3**</td>
<td>4**</td>
<td>5**</td>
</tr>
<tr>
<td>methoxyfenozide</td>
<td>0.4</td>
<td>81.6</td>
<td>69.5</td>
<td>86.4</td>
<td>88.9</td>
<td>100.0</td>
</tr>
<tr>
<td>indoxacarb</td>
<td>0.17</td>
<td>52.9</td>
<td>67.1</td>
<td>97.0</td>
<td>88.9</td>
<td>87.0</td>
</tr>
<tr>
<td>fenitrothion</td>
<td>2.25</td>
<td>51.7</td>
<td>56.1</td>
<td>71.2</td>
<td>77.8</td>
<td>91.3</td>
</tr>
<tr>
<td>fenoxy carb</td>
<td>0.6</td>
<td>66.7</td>
<td>84.8</td>
<td>96.8</td>
<td>78.6</td>
<td>87.0</td>
</tr>
</tbody>
</table>

Damaged fruits in unsprayed plot (%) 8.7 8.2 6.6 5.4 2.3 10.4

* one treatment per season; ** two treatments per season

Table 3. Results (2). 2000

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose rate (l or kg/ha)</th>
<th>Number of treatments</th>
<th>% control of leaf rollers in orchard no.</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>spinosyn A+D</td>
<td>0.42</td>
<td>2</td>
<td>88.9</td>
<td>88.2</td>
<td></td>
</tr>
<tr>
<td>fenitrothion</td>
<td>2.25</td>
<td>2</td>
<td>81.0</td>
<td>76.5</td>
<td></td>
</tr>
</tbody>
</table>

Damaged fruits in unsprayed plot (%) 6.3 3.4

Discussion

A field study conducted in different commercial orchards showed that all tested compounds gave promising results in control of such important pests as codling moth, plum fruit moth and leaf rollers. All the compounds reduced the number of damaged fruits to an extent comparable with that of the standard insecticides at the dose rates used. As far as methoxyfenozide, indoxacarb, spinosyn A+D and codlemone+cyfluthrine are concerned, investigations presented here are continuation and confirmation of those presented earlier (Olszak & Płuciennik, 1998; 1999).

Taking into consideration different factors influencing the efficacy of the compounds tested, one can say that the best control of codling moth was obtained with two treatments of methoxyfenozide or indoxacarb at doses of 0.4 and 0.2 kg/ha, respectively. Also spinosyn A+D applied at the dose of 0.42 l/ha gave very promising results in controlling this pest (80.3-83.3%), better than the standard preparation (fenitrothion). A quite new concept is the use of synthetic pyrethroid (cyfluthrine), joining it in a very safe manner with codlemone. Applying this composition twice a season at the rate of 6 thousands of drops per hectare has given results comparable to or even better than those obtained with triflumuron.

In the case of plum fruit moth, both methoxyfenozide and indoxacarb at the rates of 0.5 l/ha and 0.2 kg/ha have given results similar to those obtained with diflubenzuron. We would also like to underline very good results obtained with Spinosad 480SC. This compound applied twice against such important pest of plums as *C. funebrana* gave better results then the standard preparation fenitrothion.
Three compounds (methoxyfenozide, indoxacarb and spinosad) also provided very good control of the tortricid complex. Especially good results were obtained when these preparations were applied twice a season.

So, in our opinion all the tested compounds could be recommended for control of pests mentioned in this paper. Considering their selectivity towards beneficial insects they will be especially useful in integrated pest management.

Acknowledgements

We wish to thank very much Dr. R.Z. Zajac for his critical reading the manuscript and Mrs. U. Tworkowska for her technical assistance.

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The use of geostatistics to study the spatial distribution of Cydia pomonella and Pandemis heparana in Lleida (Spain)

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Abstract: The study of the spatial distribution of insects can be carry out by means of the dispersion indices, and, more recently, by means of geographic information systems (GIS) and geostatistics. Geostatistics permits to describe correlations through space and/or time and to interpolate between and to extrapolate beyond sample points, allowing the drawing of maps of isolines. A project to explore the possibilities of applying geostatistical techniques to the study of the spatial distribution of two important pome and stone fruit pests (Cydia pomonella and Pandemis heparana, both Lepidoptera: Tortricidae), by means of the catches in pheromone traps, was begun in 1997. The number of catches in pheromone traps can be used to describe the spatial population of both species by means of geoestatistics and to identify the zones of maximal pest attack risks. Geostatistics can also be used to determine the optimum number and location of traps to study population dynamics.

Keywords: Geostatistics, spatial distribution, Cydia pomonella, Pandemis heparana

Introduction

The pattern of the distribution in space of the individuals of a population has a high ecological significance and affects the design of the sampling program and the method of statistical analyses of the data (Southwood, 1978). In agricultural ecosystems, the spatial distribution of pests and natural enemies can be envisaged at the plot level (an orchard, for example) or at a wide area level (a county, for example). The knowledge of the spatial distribution at a plot level allows to optimise the decision making on the control measures to be applied; at an area level, it facilitates the planning of monitoring, for example.

The study of the spatial distribution of insects has been carry out traditionally by means of the dispersion indices, such as the indices of Taylor, Morisita, Lloyd and Iwao (Taylor, 1984). More recently, the development of two new tools that permit the management and analysis of big data sets has open new possibilities to describe and analyse the spatial distribution on populations: geographic information systems (GIS) and geostatistics (Liebhold, Rossi & Kemp, 1993). While the GIS only permits to compile and to manipulate spatially referenced data, geostatistics permits to describe correlations through space and/or time and to interpolate between and to extrapolate beyond sample points (Liebhold, Rossi & Kemp, 1993). The geostatistical description of the spatial distribution of a population leads to a map of isolines.

The variable used to study the spatial distribution of a population (number of individuals per unit of surface, number of individuals per unit of habitat, number of individuals per trap ...) must be a regionalised variable (Matheron, 1971). The existence of good data sets of the number of males caught in pheromone traps across more or less big areas and over a series of years, is very common in the case of lepidopterous pests of pome and stone fruits. For this
reason, we began in 1997 to explore the possibilities of applying geostatistical techniques to
the study of the spatial distribution of two important pome and stone fruit pests (*Cydia pomonella* (codling moth) and *Pandemis heparana*, both Lepidoptera: Tortricidae), by means
of the catches in pheromone traps. Part of the results of this study has been already published
(Ribes-Dasi *et al.*, 1998), and other part is in preparation. We present here a brief summary of
all the work carried out.

The aims of the study have been:
1. To describe the spatial distribution of *C. pomonella* and *P. heparana* in the area of
   Torregrossa (Lleida) in 1996 and 1997 by means of geostatistical techniques.
2. To identify the zones of maximal pest attack risks by the two species
3. To determine the optimum number and location of traps for studying the population
dynamics of both pests.

**Material and methods**

The analysed variable was the total number of *C. pomonella* and *P. heparana* males caught in
pheromone traps from May, 13 to July, 15, 1996 and 1997. Fifty-five Delta traps provided
with pheromone dispensers from the University of Wageningen were placed in Torregrossa
(Lleida). The U.T.M. co-ordinates of each trap were calculated. The geostatistical analysis
was carried out using the program GEO-EAS (Englund & Sparks, 1988), which computes the
parameters of the semio-variogram (nugget and range) and states whether a variable can be
regionalised. The maps showing the each year distribution of both populations were drawn
using the isocatches: lines what join points where the total catches were equal. Five traps
were removed at random and used as controls, comparing the actual number of catches with
the estimated number of catches made by interpolation.

To explore whether geostatistical techniques can be useful to determine the optimum
number of traps to be placed in an area, a series of traps where eliminated taking into account
the lowest range computed. The procedure to eliminate the traps was the following: a trap was
chosen in one of the four corners of the map (at random) and all the traps within its range
were eliminated. The procedure was repeated as many times as necessary. Then, the
distribution maps were redrawn and compared to those obtained with the whole data set.

**Results and discussion**

The results of the geoestatistical analysis showed that the number of catches in pheromone
traps was a regionalised variables, susceptible then to be treated by geostatics. The
estimates were more accurate in the case of *P. heparana* than in the case of *C. pomonella*,
probably because the catches of codling moth are more influenced by factors other than
population density, such as the vicinity of packing houses or nut tress, for example (see
Ribes-Dasi *et al.*, 1998 for a more detailed explanation not given here due to the lack of
space).

Figures 1 and 2 show the spatial distribution of codling moth in 1996 and *P. heparana* in
1997 (the rest of the figures are not shown due to the lack of space), computed using the
whole data set (left part of each figure) and after removing some traps (right part). When the
distribution maps of each species are visually compared, there is a quite high coincidence of
areas with maximal and minimal captures, showing that the number of traps could be reduced.
On the contrary, there was no coincidence of areas of maximal infestation between species.
Whereas maximal *P. heparana* catches located in the NW quadrant in both 1996 and 1997,
maximal *C. pomonella* catches concentrated in the central area of the region in both years.
In conclusion, the number of catches in pheromone traps can be used to describe the spatial population of a species by means of geostatistics and to identify the zones of maximal pest attack risks. Geostatistics can also be used to determine the optimum number and location of traps to study population dynamics.

**Acknowledgements**

This project was partially supported by La Paeria (Lleida, Spain), project No. P97-115. We are grateful to Ms. Montserrat Bascuñana (ADV, Torregrossa, Lleida) for providing the pheromone catches database.
References


Fish-liver oil as repellent in IPM

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Abstract: In our experiments lasting several years, we have found repellent activity of fish-liver oil on wildlife and some insects. The specific smell of fish-liver oil is not similar to the smell of plants which are attractive for phytophaga, vertebrates, or insects. Sulphatised fish-liver oil applied on plants changes the plant's natural smell which disappears, and the smell of fish-liver oil acts as a repellent on some kinds of pests. The sequence of attacks (attractant, deterrent, incitant, phagostimulant) is interrupted already in the search phase. The plant smelling of fish-liver oil is not attractive and becomes repellent to pests and wildlife.

The repellence of fish-liver oil for wildlife in our experiments was 90-100%. The duration of repellence depended on the weather conditions, temperature and precipitation. As much as 30% of sulphatised fish-liver oil has been found on the treated fruit-seedlings after a considerable time (100 days) during the winter.

There was a smaller intensity of eggs laid by pear psylla (Psyllidae: Homoptera) on pear trees treated with fish-liver oil. The repellence of fish-liver oil on pear trees at vegetation time lasted for a short time. The psylla females did not lay eggs on treated parts of the trees for only 8 - 10 days.

There was no significant repellence in experiments with codling moth Cydia pomonella (L.) (Tortricidae: Lepidoptera). The difference in the number of eggs laid on treated and untreated trees was not significant.

Key words: repellent, wildlife, fish liver oil, Cacopsylla pyri, Cydia pomonella

Introduction

Repellents, substances which repel plant pests, have been known for a long time, in the same way as insecticides and other plant protection substances (Wegler, 1970).

In the continental part of Croatia and in the neighbouring countries, in the Pannonian plain and other parts of Croatia, there is a abundant wildlife. In the winter time, especially when there is snow, animals attack many kinds of trees, especially young seedlings of apples, pears, and other kinds of fruit, even stone fruit. The animals manage to enter even fenced orchards.

Many repellents are used for the protection of fruit seedlings from the animals, but the problem is that the repellent action depends on the climatic conditions, precipitation, etc. Investigations of fish liver oil as a wildlife repellent have been carried out.

The influence of fish liver oil on laying eggs of the pear psylla and codling moth has been investigated also, because a great problem in the IPM is caused by these pests, for which many non-pesticide methods are studied (Westigard, 1979; Neumann, 1996.).

The strange smell of the fish liver oil can influence the change of the natural smell of the plant organs, and the pear psylla female or the codling moth female does not recognise the host plant (Ciglar & Baric, 1993.).
Knowing the influence of different oils on the insecticide penetration, we investigated the influence of fish liver oil on the insecticide efficacy.

**Material and methods**

In order to achieve the fish liver oil application, it was sulphatised to enable its dilution with water.

Investigation of the repellent fish liver oil on wildlife was carried out on young apple seedlings. Trial treatment was done before winter, i.e. before snow by spraying or coating in the concentration of 10 per cent.

The evaluation of damage on seedlings was done 28, 50 and 80 days after treatment.

Investigation of repellence on pear psylla was done by spraying the trees with fish liver oil in the concentration of 0.3 per cent when adults appeared, i.e. before eggs were laid. The estimate of the egg number on the pear branches was done 10 days after the application.

The activity of fish liver oil on the codling moth attack was investigated by treating the apple trees in the concentration of 0.3 per cent when butterflies appeared.

The influence of fish liver oil on egg laying was estimated by calculating the percentage or damaged fruit.

A mixture of fish liver oil with insecticides for better insecticide penetration was tested in fighting the pear psylla *Cacopsylla pyri*.

The persistence of fish liver oil was tested by oil extraction with petroleum ether from the surface of the treated plant.

**Results and discussion**

*Repellence activity on wildlife*

Results of repellent action for wildlife on young apple seedlings are presented graphically for each year of investigation (Figures 1 and 2).

![Graph showing percentage of protected seedlings by fish liver oil (first year of investigation)](image)

Figure 1. Percentage of protected seedlings by fish liver oil (first year of investigation)

Fish liver oil had a repellent activity on wildlife (rabbits) 28 and 50 days after treatment, but the activity was slightly weaker after 80 days.
Influence of fish liver oil on egg laying of pear psylla (Cacopsylla pyri)
As shown in figure 3, the number of eggs laid on a pear shoot treated with fish liver oil was very small.

The repellent activity on the pear psylla female lasted only 10 days. After ten days, the females resumed laying eggs, partly due to the loss of smell and partly due to new shoots.

Influence of fish liver oil on codling moth Cydia pomonella attack
The repellence of fish liver oil on codling moth female was not markedly pronounced, which can be due to various influences (fast growth, high temperatures, etc), but the results indicate the possibility of using fish liver oil as one of the measures to decrease the population of this dangerous pest.
Results of tests mixing diflubenzuron insecticide with fish liver oil

![Graph showing percentage of attacked pear shoots by pear psylla](image)

Figure 5. Percentage of attacked pear shoots by pear psylla

As shown in the figure, sulfated fish liver oil considerably increased the activity of diflubenzuron.

Investigation of fish liver oil persistence

Since the repellency of fish liver oil depends on its persistence, investigation of fish liver oil residue on seedlings was made in different conditions. The investigation was made 80 days after the application with 10 per cent fish liver oil, on seedlings samples which were not exposed to precipitation and seedlings in natural conditions.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Percentage of fish liver oil residue</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not subjected to precipitation</td>
<td>42.44</td>
<td></td>
</tr>
<tr>
<td>In natural conditions</td>
<td>32.02</td>
<td></td>
</tr>
</tbody>
</table>

The analysis results show that about 30 per cent of fish liver oil deposits remained in natural conditions after three months.

Deficiencies of fish liver oil repellent:

Extreme climatic conditions, such as very low temperatures (below minus 25°C), lasting snow, sudden thawing or heavy rainfall in a short time can badly influence the repellence of fish liver oil. The repellence of fish liver oil on pear psylla and codling moth greatly depends on the growth of the new shoots, and in these cases the repellence is very short.

Conclusions

Investigations on the application of sulphated fish liver oil, made over several years, have provided the following results:

1. Sulphated fish liver oil applied on the bark of young fruit seedlings or branches subjected to wildlife attack has a repellent activity on the animals. After the treatment with fish
liver oil in the 10 per cent concentration, the seedlings were not damaged by rabbits or deer for some time (30 to 60 days).

2. Sulphated fish liver oil has a repellent activity on pear psylla females *Cacopsylla pyri*. After treatment with 0.3 per cent fish liver oil, psylla females laid considerably fewer eggs.

3. Repellent activity of fish liver oil on egg laying by codling moth was less pronounced in our investigation. The females of codling moth butterflies laid fewer eggs on the treated trees than on the untreated trees.

4. Fish liver oil mixed with insecticides showed better efficacy in fighting pear psylla *Cacopsylla pyri*.

5. The persistence of fish liver oil applied on a plant, was found to depend on the climatic conditions (precipitation). In continental Croatia, a considerable residue (30%) of the preparation was found even after 80 days.

References


Phenology of San José Scale, *Quadraspidiotus perniciosus* (Comstock) on apple in Guarda region (central eastern Portugal)

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Abstract: San José Scale, *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae), phenology was studied in an unsprayed apple orchard of the cultivar Golden Delicious, near Guarda (central eastern region of Portugal), during 1997. Three major periods of male flight activity were shown by pheromone traps in this study, for two periods of crawler emergence, which suggest that the insect developed two generations and a partial third one. Spring flight began by the end of March, at ca. 116 degree-days (base 10º C from 1 March) and occurred till mid April, during bloom in the apple variety studied. Emergence of first male generation started in the beginning of July at ca. 656 degree-days and continued through mid September, while that of second generation males, began in mid September, at ca. 1535 degree-days and ended by mid October. First generation crawlers emerged in mid May, at ca. 326 degree-days and continued to appear through the end of July. Second generation crawlers emerged in mid August, at ca. 1161 degree-days and were active throughout November. Approximately 210 degree-days elapsed between first caught of spring males in pheromone traps and the release of first generation crawlers. The use of these data in pest management programs is discussed.

Keywords: seasonal flight; crawlers phenology; pheromone traps; sticky-tape traps; degree-days

Introduction

San José Scale (SJS), *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae), is one of the world's most severe pests of deciduous fruits and nuts. Although several parasites and predators attack this phytophagous, its economic control depends on the use of insecticides. Chemical control of SJS in deciduous fruit orchards is usually achieved with dormant oil sprays, or spring and summer applications of organophosphates to control crawlers. Also crawlers are broadly distributed in time and may require multiple applications to protect the fruit. The effectiveness of spring and summer control programs depends upon appropriate timing of sprays based on adult male flight and subsequent periods of crawler activity. The objective of this study was to determine the seasonal flight activity of male SJS and to describe crawler phenology in Guarda region (central eastern Portugal), to assist key management timing decisions for this pest in the region.

Material and methods

The experimental work was carried on from 17 March until 30 November 1997 in an 70-year-old unsprayed apple orchard, from the Golden Delicious cultivar, located near Guarda. Temperature data were collected from a weather station located near the orchard. Stages of apple tree development were recorded according to Fleckinger (Acta, 1979). Male flight activity was monitored using two standard SJS pheromone traps, placed 1.5 m above the
ground, within the canopies of two randomly selected trees that were at least 100 m apart. Trap catch of males was recorded three times each a week during the main male flight period activity and one time per week in the other periods. Crawlers were sampled using sticky tape traps wrapped tightly around the circumference of a tree branch. Four traps were placed in each of four random selected trees and the tapes were replaced weekly from 2 May to 30 November. Crawlers on the tapes were counted under a dissecting microscope in the laboratory. Mean adult and crawlers trap catches were plotted over seasonal day-degree (DD) accumulations (Baskerville & Emin, 1969) above a base of 10ºC from 1 March (Mague & Reissig, 1983).

Results and discussion

Male flight activity of overwintered SJS began abruptly in the end of March, at ca. 116 degree-days (base 10ºC from 1 March) and continued for about four weeks, with the greatest number of individuals being trapped during the first two weeks of collections (Fig. 1). These data agree with those of Mague and Reissig (1983), from western New York, who reported that the onset of the spring flight ranged from 94 to 140 degree-days. Also, as reported by authors such as Mague and Reissig (1983), Reissig et al. (1985), Beers et al. (1993), and Schaub et al. (1999), it was found that male spring flights coincided with apple bloom. The early flights were followed by a period of about eleven weeks with little or no male activity. The emergence of first generation males during the second flight started in the beginning of July at ca. 656 degree-days and continued through mid September. Two periods of little or no male activity occurred, one at the beginning of August and the other at the end of August/beginning of September, when temperature was below 17ºC, which is considered to be the flight threshold temperature (Kyparissoudas, 1987). About 540 degree-days elapsed between first emergence of the first and the second flight, which compared favourably with results from Mague & Reissig (1983), of approximately 527 to 573 degree-days. A third major period of scale flight activity, began in mid September, at ca. 1535 degree-days, and ended by mid October. This agree in part with data from Mague & Reissig (1983), according to which in western New York a partial third male flight contributed to trap catch beyond 1215 degree-days.

First crawlers were found in mid May at ca. 326 degree-days, and continued to appear until the middle of November, with two well-marked periods of emergence: mid May/mid July and mid August/end of October (Fig. 2). Peak populations of this stage were recorded, the first in mid June and the second in the beginning of September. Approximately 210 degree-days elapsed between first caught of spring males in pheromone traps and the release of first generation crawlers. Two periods of crawler activity were also reported in western New York, by Mague & Reissig (1983). However, while in western New York emergence of first generation crawlers began at ca. 360 degree-days and second generation emergence occurred at ca. 890 degree-days, in Guarda the appearance of these generations required respectively about 326 and 1161 degree-days. Notwithstanding, the 210 degree-days elapsed between first caught of spring males in pheromone traps and the release of first generation crawlers, in Guarda, compared favourably with the 230 degree-days recorded in western New York.

Three major periods of male flight activity were shown by pheromone traps in this study, end of March/mid April, beginning of July/mid September and mid September/mid October, for two periods of crawler emergence, mid May/mid July and mid August/end of October, which suggest that the insect developed two generations and a partial third one, such as reported by Mague & Reissig (1983), in western New York. In contrast, Paloukis (1979) and
Katsoyannos & Argyriou (1985) in Greece, and Stoetzel (1975) in eastern United States reported three periods of adult male activity for three generations of the species, while Rice & Jones (1977), in California, reported four periods.

![Graph showing seasonal flight of San José Scale](image1.png)

Fig. 1. Seasonal flight of San José Scale in an unsprayed orchard of apple variety Golden Delicious. Numbers of male scale are weekly averages from two pheromone traps. Guarda, 1997.

![Graph showing seasonal crawler emergence of San José Scale](image2.png)

Fig. 2. Seasonal crawler emergence of San José Scale in an unsprayed orchard of apple variety Golden Delicious. Numbers of crawler scale are weekly averages from four sticky tape traps. Guarda, 1997.

According to Kyparissoudas (1987), who studied the seasonal flight of SJS males under two different climatic conditions in Central Macedonia (Northern Greece), the field development of SJS crawlers as well as the number of generations per year depend mainly on weather conditions especially temperature (November-December). Hence in cool years the insect might complete three generations while in milder years in some regions a partial fourth one might also appear.
On the basis of the data obtained in the present study, once an emergence of adult males has been detected, the crawler stage can be predicted to appear about 210 degree-days (base 10°C) later, for the spring generation. For the summer generation, crawlers are expected to appear about 505 degree-days (base 10°C) after a new flush of males appear in the traps (Table 1). It is difficult to compare the degree-days accumulations associated with phenological events of SJS in this area with other areas as the developmental thresholds differ. Furthermore, as suggested by Angerilli & Logan (1986), strain differences between scale insect populations in degree-days requirements are possible.

Table 1. Degree days for San José Scale phenological events essential to management decisions. Guarda, 1997.

<table>
<thead>
<tr>
<th>Phenological events</th>
<th>Degree days</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring generation</strong></td>
<td></td>
</tr>
<tr>
<td>March 1- 1st male</td>
<td>116</td>
</tr>
<tr>
<td>March 1- 1st crawler</td>
<td>326</td>
</tr>
<tr>
<td>1st male-1st crawler</td>
<td>210</td>
</tr>
<tr>
<td><strong>Summer generation</strong></td>
<td></td>
</tr>
<tr>
<td>March 1- 1st male</td>
<td>656</td>
</tr>
<tr>
<td>March 1- 1st crawler</td>
<td>1161</td>
</tr>
<tr>
<td>1st male-1st crawler</td>
<td>505</td>
</tr>
</tbody>
</table>

In considering how the data from this study can be used in pest management programs, it must be referred that recommendations for timing sprays against SJS crawlers vary considerably in different areas. In California, Rice et al. (1982), reported that a spray at the beginning of crawler appearance probably would not be optimal, and that it is better to delay it for several days after the appearance of the first crawler. Reissig et al. (1985), in New York, demonstrated that the most effective control was obtained by applying two sprays against each crawler generation, one at the beginning and another 10 to 14 days later. In Northern Greece, Paloukis (1986), suggested that a spray should be applied when 65% of the crawlers have emerged, while Kyparissoudas (1990) believed that the initial treatment against crawlers of the first generation should be applied 2-3 days after the beginning of their emergence, when only about 5% of he crawlers have emerged. During this period, according to the author’s observations as well as those of other studies that were made in the region (Paloukis & Kyparoussidas, 1990), there are only immatures present, which are considered to be the most sensitive to insecticides (Rice et al. 1982; Paloukis, 1983). Otherwise, according to Schaub et al. (1999) the efficacy of a spray is optimal when 10% of the crawlers have emerged.

References


Overwintering of the San José Scale on stone fruit in Northern Italy

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Abstract: A monitoring programme was carried out in Emilia-Romagna during winter 1998-99 to establish the developmental stage of overwintering Quadrascidiotus perniciosus (Comstock) (Homoptera: Diaspididae) specimens in Northern Italy, mainly on stone fruit. Some stone fruit orchards and one pear orchard (used for comparison) were sampled. Samples were collected at the end of the autumn and three times during winter. Alive San José scale specimens were removed and slide mounted. Microscopic observations were conducted to assess developmental stage and stylet development. According to data collected, the most of specimens spend the greatest part of the winter in the first stage. Only at the end of the winter specimens begins to develop, quite quickly towards the second and adult stage. No significant differences have been observed between the different crops. Data on the phenology of this pest are very useful in choosing control strategies mainly based on IGR application during winter.

Key words: development, Quadrascidiotus perniciosus, peach

Introduction

The San José Scale (SJS), Quadrascidiotus perniciosus (Comstock), and the White Peach Scale (WPS), Pseudaulacaspis pentagona (Targioni-Tozzetti), are the major scale insects in Northern Italy stone fruit orchards. Historically P. pentagona was the most worrying species on peach but, during the last years the economic importance of Q. perniciosus has increased, leading the San José Scale to be the most concerning scale insect on stone fruit in Northern Italy.

Several reasons can be adduced to explain this. Climatic changes are taking place mainly producing milder winters that reduce natural mortality. In many orchards, control strategies applied against moth (Cydia molest and Anarsia lineatella) are now based on pheromone applications like mating disruption method. This reduces the number of sprays with organophosphates against moth’s larvae but some of these treatments were at least partially active against scale crawlers. There is also a reduced attitude in farmers to spray in winter with polysulphides and last but not least, there are also difficulties for many farmers and technicians to recognise and to evaluate the severity of early infestations of the SJS, certainly less evident than those of WPS.

The most effective strategies to control scale insects in stone fruit orchards in Northern Italy are based on winter treatments (Cravedi, 2000). As new products (e.g. IGRs) have been or will be introduced, it is necessary to consider that their efficacy can be substantially affected by a correct timing in application much more than polysulphides or winter oils. In fact, to be effective these new insecticides need, to be used against young developing instars of Q. perniciosus. Moreover, there are still many doubts among technicians and farmers about the overwintering stage of Q. perniciosus in Northern Italy on stone fruit. The only recent available data about the overwintering of Q. perniciosus in Italy were collected in Southern
Italy, where all the instars were found during winter (Russo, 1986; Longo et al., 1989).

**Materials and methods**

During winter 1998-1999, near Faenza, an important fruit growing district of Emilia Romagna (Northern Italy), 5 untreated orchards with significant *Q. perniciosus* infestation were selected (Tab. 1). There were 3 peach, 1 plum and 1 pear orchards. The least one was used for comparison between stone and pome fruit.

To determine the developmental stage of SJS, alive specimens were collected in 4 different periods: November-December; mid January; mid February and March (Tab. 1). Each time, in each orchard, 20-30 young and small twigs were cut.

Twigs, soon after cutting, were delivered to the laboratory and inspected under binocular microscope. Scale covers were gently removed with a pin. Between 100 and 130 alive specimens/sample were collected and directly slide mounted with Hoyer’s medium (McClain et al., 1990). Slides were observed with a Leika DMRB light microscope equipped with “interferential differential contrast”. Specimens were scored according to the following developmental stage: first instar; second instar and adult female. No attempt was done to differentiate in young instars between males and females. First and second instar specimens were recorded also according to stylet formation and to detachment between the old and the new cuticle in pygidium area. Specimens were subdivided in 4 classes according to the stylet development and in 2 classes of cuticle detachment (PA=no detachment; PS=clear separation in pygidium area). The classes for stylet development were the following: NS=new stylets not yet developed; ST=new stylets start to develop; SC=new stylets fully developed; SU: new stylets into the crumena. The analysis of scale cover development was not carried out due to the difficulty to separate accurately the different instars using this character.

Table 1. Orchards selected to monitor the overwintering stage of *Q. perniciosus* in Northern Italy and the corresponding sampling date.

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Cultivar</th>
<th>1st sampling (November ’98)</th>
<th>2nd sampling (January ’99)</th>
<th>3rd sampling (February ’99)</th>
<th>4th sampling (March ’99)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peach 1</td>
<td>Sweet Red</td>
<td>25.11.1998</td>
<td>19.01.1999</td>
<td>13.02.1999</td>
<td>4.03.1999</td>
</tr>
<tr>
<td>Peach 2</td>
<td>Sweet Lady</td>
<td>1.12.1998</td>
<td>15.01.1999</td>
<td>11.02.1999</td>
<td>17.03.1999</td>
</tr>
</tbody>
</table>

**Results and discussion**

The number of SJS specimens collected and checked during the study ranged from 104 to 128. In the plum orchard the natural mortality was so high that no alive specimens were found in February and March samples.

The average stage-structure of populations observed is reported in figure 1. It can be seen that in November a few adult females were still present. In general, they were depositing crawlers but the most of them were at the end of their life-cycle. In January a few 2nd instar
specimens were found but more than 99% of alive scale insects collected were 1st instar specimens. The same situation was observed in February. Only in March there was a substantial change as at this time about 25% of collected specimens were in 2nd instar.

The analysis of data of each orchard (Tab. 2) shows that no important differences can be seen among plots till March; at this time there is a sudden change in the population structure as shown by data of peach orchards no. 2 whose twigs were collected about two weeks later. In this case, more than 92% of alive scale insects were in 2nd instar.

![Developmental stage diagram](image)

Figure 1. Instar distribution (average - percentage) of alive *Q. perniciosus* specimens during winter 1998-1999 in Northern Italy.

Table 2. Instar distribution (percentage) of *Q. perniciosus* alive specimens collected during winter 1998-1999 in each sample, in Northern Italy. No alive specimens were found in plum orchard in February and March.

<table>
<thead>
<tr>
<th>Date</th>
<th>Instar</th>
<th>Peach #1</th>
<th>Peach #2</th>
<th>Peach #3</th>
<th>Plum</th>
<th>Pear</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>1st instar</td>
<td>92.4</td>
<td>97.6</td>
<td>98.3</td>
<td>99.1</td>
<td>92.1</td>
</tr>
<tr>
<td></td>
<td>2nd instar</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>adult female</td>
<td>7.6</td>
<td>2.4</td>
<td>1.7</td>
<td>0.9</td>
<td>2.4</td>
</tr>
<tr>
<td>January</td>
<td>1st instar</td>
<td>98.3</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>99.2</td>
</tr>
<tr>
<td></td>
<td>2nd instar</td>
<td>1.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>adult female</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>February</td>
<td>1st instar</td>
<td>99.1</td>
<td>100.0</td>
<td>100.0</td>
<td>97.3</td>
<td>97.3</td>
</tr>
<tr>
<td></td>
<td>2nd instar</td>
<td>0.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>adult female</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>March</td>
<td>1st instar</td>
<td>98.1</td>
<td>7.7</td>
<td>99.2</td>
<td>98.3</td>
<td>98.3</td>
</tr>
<tr>
<td></td>
<td>2nd instar</td>
<td>1.9</td>
<td>92.3</td>
<td>0.8</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>adult female</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

To get a clearer view of *Q. perniciosus* development and to differentiate more accurately between first and second instar, stylet renewal and detachment of the old cuticle were considered. Average data for 1st instars are shown in figure 2. A progressive increase in the
percentage of specimens included in classes of developed stylets is clearly visible. In January, stylet development starts significantly and in February, the percentage of 1\textsuperscript{st} instar specimens, which show clearly the development of new stylets, is more than 25%. Between February and March there is the most significant increase of activity as in the last sampling only less than 14\% of specimens have no sign of metamorphosis. On the other side, more than 75\% of specimens show fully developed stylets and are ready to moult.

![Figure 2](image-url)  

In January, the cuticle detachment was observed for the first time in a quite low number of specimens (1.2\%). In general, the percentage of specimens, registered in the class “PS”, was slightly lower than the percentage of specimens showing stylet renewal in progress. Little differences were present among the 5 orchards but these differences seem to be linked with the particular orchard situation and not linked with crop influence (Fig. 3). The greatest differences in stylet development were recorded only in February: in peach orchards no. 1 and no. 3 the percentage of specimens without any evidence of new stylet formation was about 30\% lower. Before and after no important differences were detected.

In general, the number of second instar specimens was quite low, with the only exception of the sample collected in March in peach orchard no. 2. In this case, more than 92\% of specimens were at 2\textsuperscript{nd} instar but all of them probably moulted recently as no sign of new stylet formation could be detected.
Figure 3. Distribution (percentage) of 1st instar alive *Q. perniciosus* specimens collected in winter 1998-1999 in Northern Italy without any evidence of stylet renewal.

**Conclusions**

In Emilia Romagna SJS development appears to stop during the middle part of the winter. In this period the only alive specimens present are 1st instar larvae but, these specimens are probably non fully inactive as the more detailed analysis of the renewal of their stylets shows that at least 10% of specimens is producing new mouthparts. The pest increases its activity before the end of winter and there is a more significant increase between February and March. Moreover, no important differences have been detected in development between specimens collected on peach and those collected on pear. So at least two important conclusion can drawn: the 1st instar is the completely predominant overwintering stage of SJS in Northern Italy and there is time enough to spray with IGRs or other similar products against the more susceptible stages.

**References**

Chemical control of *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae) in apples and side effects on phytoseiid mites (Acari: Phytoseiidae)

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Abstract: Investigations on the effectiveness of several insecticides, in pre-bloom and post-bloom sprays, on San José Scale, *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae), and on the toxicity of these products against naturally occurring populations of phytoseiid mites (Acari: Phytoseiidae), were carried out on apple orchards, in Guarda region (central eastern region of Portugal), during 1997. A single spray was applied, in a pre-bloom treatment, during the green stage, using mineral oil alone and mineral oil in combination either with methidathion or with chlorpyrifos. Two sprays were applied, in post-bloom treatments, the first, one week after the beginning of first generation crawler emergence, and the other 19 days latter. The following insecticides were chosen: sodium silicate, fenoxicarb, piriproxyfen, methidathion and chlorpyrifos. In the untreated check near 65 % of the fruits were damaged by SJS in the orchard where pre-bloom sprays were tested, while the figure for the orchard where post-bloom sprays were tested was of 100%. Pre-bloom sprays reduced this damage to between 19% and 29%, while with post-bloom sprays, the lower level of infestation obtained was of 61%. Oil alone was as effective in controlling SJS as any of the oil-organophosphorous mixtures tried, with the advantage of being less toxic to phytoseiid mites. Chlorpyrifos was the most effective product against the 1st generation of SJS crawlers. However, this material was also the most toxic to phytoseiid mites in the first seven days after spraying. It is concluded that in the severely infested orchards studied, none of the compounds applied in pre-bloom sprays or in post-bloom sprays, provided commercially acceptable control of SJS.

Keywords: San José Scale, pre-bloom sprays, post-bloom sprays, *Typhlodromus pyri* (Scheuten)

Introduction

The San José Scale (SJS), *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae), is a key pest in most deciduous fruit orchards in several regions of the world. In recent years, outbreaks of this species in many apple-growing regions of Portugal, have resulted in an increased need to incorporate controls for this pest into orchard management programs. In absence of demonstrably effective biological controls, SJS has routinely been controlled with pesticides applied as pre-bloom (dormant) sprays or as sprays directed against crawler stages of the spring or summer generations (Stafford & Summers, 1963; Reissing *et al.* 1985; Costa-Comelles *et al.*, 1989; Costa-Comelles *et al.*, 1996). The purpose of this study was to evaluate the performance of different insecticides both in pre-bloom and post-bloom sprays against SJS. Furthermore the side effects of these treatments on naturally occurring populations of phytoseiid mites (Acari: Phytoseiidae), were also analysed as these mites are recognised as important and effective agents for biological control of spider mites (Acari: Tetranychidae) in fruit orchards.
Material and methods

Trials were carried out in apple orchards, near Guarda (central eastern region of Portugal), that were infested with SJS. Treatments were applied to two-tree plots arranged in a fully randomised design and replicated four times. Plots were separated by at least one unsprayed buffer tree. Sprays were applied to runoff with a hand sprayer. The control plot was not treated.

Pre-bloom sprays
The experiment was carried out in a commercial orchard, which included 15-yr-old trees planted at a spacing of 4.0 × 2.5 m, from several varieties. A single treatment was applied on 11 March, during the green stage, using the following insecticides: mineral oil (200 ml/hl of 80% a.i.), mineral oil (200 ml/hl of 80% a.i.) + methidathion (150 g/hl of 40% a.i.) and mineral oil (200 ml/hl of 80% a.i.) + chlorpyrifos (200 ml/hl of 480g/l a.i.). Insecticidal and fungicidal sprays were performed in this orchard to control pests and diseases, namely one spray with each of the following products: hexythiazox, propargite, phosalone and pirimicarb; three sprays with diflubenzuron and six sprays with captan + penconazol.

Post-bloom sprays
This experiment was conducted in an unsprayed orchard, which included 22-yr-old trees planted in a spacing of 4.0 × 2.5 m, mainly of the Starking variety. Two treatments were applied, the first on 19 May, one week after the beginning of first generation crawler emergence, and the other 19 days later. Crawler activity was evaluated with sticky tapes placed around tree limbs and checked weekly. The following insecticides were chosen: sodsilicate (1.5 kg/hl of 90% a.i.), fenoxicarb (100g/hl of 25% a.i.), piriproxyfen (100g/l of 75 cc/hl a.i.), methidathion (150 g/hl of 40% a.i.) and chlorpyrifos (200ml/hl of 480g/l a.i.).

To evaluate the performance of the different insecticides against SJS, in mid-September, 100 fruits were picked at random from each replicate (400 per treatment), and both the percentage of infested fruit and the mean number of SJS per fruit were determined. The effects of the treatments on phytoseiid mites was studied by counting the number of mobile forms on leaf samples. Each sample consisted of 120 leaves per treatment (30 per replication), randomly selected from the inner and the outer region of the tree canopy and from all quadrants. Observations were carried out 21 and 47 days after the treatment, for pre-bloom sprays. For post-bloom sprays they were done, one just before the first treatment and then, seven days after the first treatment, seven days after the second treatment, 21 days after the second treatment and 47 days after the second treatment. Mites were removed from the leaves and identified with a microscope, after preparation. Results were expressed as "per cent reduction" of live scales or infested fruits (Abbot, 1925). One-way of variance was used to estimate significance (P < 0.05) of treatments. The percentage of fruit with insect injury was transformed to arcsine, sine^{-1} ((x /100) ^{0.5}) and the scale and mite counts were transformed to log (x+1) prior to analysis (Steel & Torrie, 1980). Separation of means was done with Tukey’s studentized range test. Furthermore, the side effects of the treatments on phytoseiids were calculated with the Henderson-Tilton formula and divided into four categories corresponding to the set standard for field methods of the IOBC Working group "Pesticides and Beneficial Organisms".
**Results and discussion**

**Pre-bloom sprays**
Both the number of SJS per fruit and the percentage of infested fruits were significantly lower in the sprayed plots than in the unsprayed check plot (Table 1). Also, the number of SJS per fruit was significantly lower on both the trees sprayed with oil and with the combination of oil+methidation than in those sprayed with the combination of oil+chlorpyrifos. However no significant differences were seen, between sprayed plots, in the percentage of SJS infested fruits. The percent reduction in the number of SJS per fruit ranged from 55 in the plots sprayed with the combination of oil+chlorpyrifos, and 94 in those sprayed with the combination of oil+methidation, while the observed values for the percent reduction in the percentage of infested fruits ranged from 55 in the plots sprayed with the combination of oil+chlorpyrifos and 71, in the plots sprayed with the combination of oil+methidation.

### Table 1. Effectiveness of a single application of different insecticides before blooming, against overwintering San José Scale. Guarda, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (a.i./hl)</th>
<th>San José Scale per fruit</th>
<th>San José Scale infested fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avg. nº</td>
<td>Percent reduction</td>
</tr>
<tr>
<td>check (untreated)</td>
<td>–</td>
<td>8.5</td>
<td>a</td>
</tr>
<tr>
<td>oil+chlorpyrifos</td>
<td>160 ml + 96 ml</td>
<td>3.4</td>
<td>b</td>
</tr>
<tr>
<td>oil</td>
<td>160 ml</td>
<td>1.1</td>
<td>c</td>
</tr>
<tr>
<td>oil+methidation</td>
<td>160 ml + 60 g</td>
<td>0.5</td>
<td>c</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter are not significantly different (P > 0.05; Tukey’s studentized range test). Percent infested apples transformed to arcsin, and number of live scales transformed to log (x+1), for analysis.

### Table 2. Side effects on phytoseiid mites of a single application of various insecticides before blooming, against overwintering San José Scale. Guarda, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (a.i./hl)</th>
<th>Avg. number of mites per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>21&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>check (untreated)</td>
<td>–</td>
<td>0.2 a</td>
</tr>
<tr>
<td>oil</td>
<td>160 ml</td>
<td>0.1 b</td>
</tr>
<tr>
<td>oil+metidation</td>
<td>160 ml + 60 ml</td>
<td>0.0 b</td>
</tr>
<tr>
<td>oil+chlorpyrifos</td>
<td>160 ml + 96 ml</td>
<td>0.0 b</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter are not significantly different (P > 0.05; Tukey’s studentized range test). Counts of phytoseiid mites transformed to log (x+1) for analysis.

<sup>1</sup> Days after spraying

*Typhlodromus pyri* (Scheuten) composed more than 75 % of the phytoseiid mites identified in this study. Either in the 21<sup>th</sup> or in the 47<sup>th</sup> days after spraying, the average number of motile forms of these mites per leaf was significantly lower in the sprayed plots than in the
unsprayed check plot (Table 2). No significant differences were seen between treatments in the 21\textsuperscript{th} after spraying. However, in the 47\textsuperscript{th} days after spraying, the plots sprayed with oil alone showed significantly more phytoseiids than those sprayed with both the combination of oil+metidathion and oil+chlorpyrifos.

**Post-bloom sprays**

The first crawlers were found on 12 May and continued to appear until the middle of July. Peak population of this stage were recorded on 16 June.

Except for the plots sprayed with sod silicate, all the other had a significantly lower average number of SJS per fruit than the unsprayed check (Table 3). Significant differences were also seen between the sprayed plots, with the lower average number of SJS per fruit in the plots sprayed with chlorpyrifos. The latter plots showed also a significantly lower percentage of SJS infested fruits than the unsprayed check, while no differences were seen between the other plots and the unsprayed check. The percent reduction in the number of SJS per fruit ranged from 0 in the plots sprayed with sod silicate, and 89 in those sprayed with chlorpyrifos, while the observed values for the percent reduction in the percentage of infested fruits ranged from 0 in the plots sprayed with sod silicate and 39, in those sprayed with chlorpyrifos.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (a.i./hl)</th>
<th>San José Scale per fruit</th>
<th>San José Scale infested fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avg. nº</td>
<td>Percent reduction</td>
</tr>
<tr>
<td>check (untreated)</td>
<td>–</td>
<td>65.2 a</td>
<td>–</td>
</tr>
<tr>
<td>sod silicate</td>
<td>1.35 kg</td>
<td>79.3 a</td>
<td>0</td>
</tr>
<tr>
<td>fenoxicarb</td>
<td>25 g</td>
<td>37.5 c</td>
<td>43</td>
</tr>
<tr>
<td>piriproxyfen</td>
<td>7.5 cc</td>
<td>18.0 d</td>
<td>72</td>
</tr>
<tr>
<td>methidathion</td>
<td>60 ml</td>
<td>13.2 e</td>
<td>79</td>
</tr>
<tr>
<td>chlorpyrifos</td>
<td>96 ml</td>
<td>7.2 f</td>
<td>89</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter are not significantly different (P > 0.05; Tukey’s studentized range test). Percent infested apples transformed to arcsin, and number of live scales transformed to log (x+1) for analysis.

In this study, about 95% of the identified phytoseiid mites were from the species *T. pyri* (Scheuten). The number of motile forms of these mites in samples collected prior to the first application of pesticides averaged 1.35, and was not significantly different among the six treatments (P>0.05). That number was reduced significantly in the seventh day following either the 1st or the 2nd spraying in the plots were chlorpyrifos and methidathion were applied, to recover in the 21\textsuperscript{th} day after the second spraying (Table 4). These observations were confirmed by the IOBC results, as chlorpyrifos was harmful (category 4) to moderately harmful (category 3) to these mites, in the seventh days after spraying and methidathion was moderately harmful (category 3) (Table 4). According to these results, sod silicate was slightly harmful (category 2) to harmless (category 1), while both fenoxicarb and piriproxyfen were harmless (category 1).
Table 4. Effects on phytoseiid mites of different insecticides applied against San José Scale crawlers, after blooming. Guarda, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (a.i./hl)</th>
<th>Avg. number of motile mites per leaf</th>
<th>IOBC category 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7²</td>
<td>7³</td>
</tr>
<tr>
<td>check (untreated)</td>
<td>–</td>
<td>1.3 a</td>
<td>1.3 a</td>
</tr>
<tr>
<td>chlorpyrifos</td>
<td>96 ml</td>
<td>0.3 b</td>
<td>0.4 b</td>
</tr>
<tr>
<td>fenoxicarb</td>
<td>25 g</td>
<td>1.5 a</td>
<td>2.1 c</td>
</tr>
<tr>
<td>methidathion</td>
<td>60 ml</td>
<td>0.6 bc</td>
<td>0.4 b</td>
</tr>
<tr>
<td>piriproxyfen</td>
<td>7.5 cc</td>
<td>1.3 a</td>
<td>1.9 c</td>
</tr>
<tr>
<td>sod silicate</td>
<td>1.35 kg</td>
<td>1.0 ac</td>
<td>0.9 a</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter are not significantly different (P > 0.05; Tukey’s studentized range test). Counts of phytoseiid mites transformed to log (x+1) for analysis.

1 1 = harmless (< 25%), 2 = slightly harmful (25-50%), 3 = moderately harmful (51-75%), 4 = harmful (> 75%); ² Days after 1st spraying; ³ Days after 2nd spraying.

Near 65 % of the fruits were damaged by SJS in the orchard where pre-bloom sprays were tested, while the figure for the orchard where post-bloom sprays were tested was of 100%. Pre-bloom sprays reduced this damage to between 19% and 29%, while with post-bloom sprays, the lower level of infestation obtained was of 61%, values considered commercially unacceptable. As reported in other studies (Reissig et al., 1985; Bower, 1987), oil alone was as effective in controlling SJS as any of the oil-organophosphorous mixtures tried, with the advantage of being less toxic to phytoseiid mites. Chlorpyrifos was the most effective product against the 1st generation of SJS crawlers. However, this material was also the most toxic to phytoseiid mites in the first seven days after spraying. It is concluded that none of the compounds applied in pre-bloom sprays or in post-bloom sprays, provided commercially acceptable control of SJS. Similar results were reported in other studies who have shown that in severely infested orchards, both prebloom spray and postbloom applications against crawlers are necessary to protect fruits adequately (Ker & Sears, 1986; Hull, 1979; Costa-Comelles et al., 1989). According to Downing & Logan (1977) several applications of insecticides are often necessary during the first generation of crawler activity to reduce damage, in Canada; in this study, the most effective control was obtained by applying two sprays against each crawler generation, one at the beginning and another 10 to 14 days latter.

References


Effects of several pesticides on the predacious mite
Agistemus fleschneri (Summers) (Acari: Stigmaeiidae)
in Quebec apple orchards

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Hortic. Res. and Dev. Centre, Agriculture and Agri-Food Canada, 430 Gouin Blvd.,
St-Jean-sur-Richelieu, Quebec, Canada J3B 3E6

The need to understand the effects of pesticides on non-target arthropods, especially natural
enemies, dates back to the availability of commercial pesticides. In commercial apple
orchards it was recognized by Pickett et al. (1946) following the wide spread use of DDT. In
order to manage arthropod pests by biological control programs, it is essential that pesticides
that are effective against target species, are at the same time relatively innocuous to non-target
parasitic and predatory arthropods. In this respect, Gambaro (1991) showed how in Verona,
Italy, the lack of knowledge on the toxicity of mancozeb and metiram to Amblyseius
andersoni led to Panonychus ulmi outbreaks in 5 out of 6 apple orchards that were being
monitored. Our study reports base line toxicity data for four fungicides (kresoxim-methyl,
Sovran 59WG; tryfloxystobine, Flint 50WG; flusilazole, Nustar 50DF; myclobutanil, Nova
40WP) and two insecticides (lambda-cyhalothrin, Warrior T 12%; and imidacloprid, Admire
240g/l) on field collected Agistemus fleschneri (Summers). Agistemus fleschneri females were
collected from a commercial orchard in August. The slide dip method was used to determine
adult mortality. On each slide 30 females were stuck with double sided tape. For egg viability,
adult females were sprayed and allowed to lay eggs on apple foliage for 48 hours and then
they were removed. Female mortality and egg viability was determined by probits. For the
probit analysis the dosages were 4X, 2X, X, 1/2X, 1/4X, 1/8X where X represented the
recommended dose in the field. For kresoxim-methyl the recommended dose was 0.035g
a.i./l; for tryfloxystobine it was 0.044g a.i./l; for flusilazole it was 0.035g a.i./l; for
myclobutanil it was 0.060g a.i./l; for lambda-cyhalothrin it was 0.0034g a.i./l; and for
imidacloprid it was 0.031g a.i./l.

The results indicated that none of the six pesticides evaluated had any adverse effects on
A. fleschneri even when these compounds were applied 4 folds the recommended dose. No
effects of myclobutanil on Amblyseius fallacis adults and eggs have also been reported by
Bostanian et al. (1998). Elsewhere, flusilazole had been reported to be slightly to non-toxic
to the aphid endoparasite Aphidius rhopalosiphi on wheat (Jansen 1999). The low residual
toxicity of lambda-cyhalothrin to A. fallacis had already been established as an asset to be
used in IPM programs in Quebec apple orchards (Bostanian and Racette 1997). As for
imidacloprid, its innocuousness to phytoseiids had been shown in peach orchards in Piedmont
Italy (Galliano et al. 1997). Therefore, these fungicides may be incorporated into existing IPM
programs for Quebec apple orchards without any restrictions. On the other hand, lambda-
cyhalothrin may be used throughout the season if A. fleschneri is the principal predator and
only pre-bloom if substantial numbers of A. fallacis occur after petal fall (Bostanian and
Racette 1997). Imidacloprid may be used any time if the principal predator is A. fleschneri,
its effects on A. fallacis have not yet been studied. Therefore, it is essential that before any
pesticides are applied, the predators are identified to the species and their response to the
pesticides to be used is well understand.
Acknowledgment

The authors thank BASF, Bayer, Dupont, Novartis, Rohm and Haas and Zeneca Canada for providing samples of their products for evaluation. Reference to trade names and proprietary products does not imply that such names are unprotected. No endorsement of named products or companies is made or implied, nor is any criticism intended of similar products or companies which are not mentioned.

References

Ground dwelling Coleoptera fauna of commercial apple orchards

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Abstract: First results are reported of a wide faunistic study of epigeic Coleoptera assemblages occurring in apple orchards in different fruit-growing regions of Hungary. The investigation took place in eleven apple orchards in Hungary. Pitfall traps were used to collect beetles from April until October. During the study 13 583 Coleoptera individuals were collected. On the basis of the cumulated samples we can state, that the dominant family was Carabidae (37%), followed by Silphidae (26%), and Staphylinidae (18%). The families Curculionidae (5%), Dermestidae (2.5%), Histeridae (2%) and Coccinellidae (1.5%) also occurred with a relatively high abundance. Within the family Carabidae the most common species were *Pseudoophonus rufipes* De Geer, *Harpalus tardus* Panzer, *Harpalus distinguendus* Duft., *Harpalus serripes* Quensel, *Calathus erratus* Sahlberg and *Anisodactylus binotatus* Fabricius. Within the family Staphylinidae the species of the subfamilies Omaliinae, Aleocharinae and Xantholininae were abundant. The dominant species were *Omalium caesum*, *Aleochara bipustulata* and *Tachyporus hypnorum*.

Key words: Apple, orchard, epigeic, Coleoptera, Carabidae, Staphylinidae

Introduction

The reduction of the impact of pesticides on the environment of orchards, as well as the possible conservation of beneficial and other non target organisms, are among the basis aims of IPM. Among these non-target organisms epigeic Arthropods are the most abundant, indifferent or often useful group in the in orchards. The species richness and composition of Arthropods in the canopy level were studied widely in Hungary (Mészáros 1984, Markó et al. 1995, Bogya et al. 1999, Jenser et al. 1999). However, the structure of ground dwelling beetles, their family diversity and abundance in apple orchards are still little known (Kádár & Szél 1989, Kádár & Lövei 1992). During the development of different environmentally friendly and integrated plant protection methods the apple orchards were placed in the main focus. Our aims were to investigate the composition of ground dwelling Coleoptera assemblages in these orchards in Hungary. In the present paper we focused our attention on two predator groups, on Carabidae (Holliday & Hagley 1978, Gilgenbegr 1990, Fazekas & Kádár & Lövei 1992, Heyer 1994, Riddick & Mills 1995), and Staphylinidae families (Gilgenberg 1990, Andersen 1995), as their rule in apple orchards are still little know.

Material and methods

The investigations were carried out in nine apple orchards in different geographical regions of Hungary. Samples were collected in the following localities: Bakonygyirót, Győrgytarló, Szeblőrinc, Újfehértó, Szigetcsép, Tura, Vámosmikola and Kecskemét (Table 1). The pest management of the orchards based on wide spectrum, mainly organophosphorus insecticides. However, three orchards were investigated in Újfehértó: a conventional, treated with wide
spectrum insecticides, another, where integrated pest management (I.P.M) was applied and an abandoned orchard. The orchard situated in Kecskemét was also abandoned (Table 1). Covered pitfall traps (300 cm³ in size, 8 cm in diameter, half-filled with ethylene glycol in water) were used to collect beetles from April until October in 1998 - 1999. Ten pitfall traps were used per orchards, except the ones in Újfehértó and Vámosmikola where only six traps were placed. Five traps were placed in the centre of the orchards, and five near the inner edges. Samples were collected only for one year in Újfehértó and Vámosmikola, spring and autumn samples were studied in Szentlőrinc and Szigetcsép.

Table 1. The characteristics of the investigated orchards and samples

<table>
<thead>
<tr>
<th>Apple orchards</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5.1</th>
<th>5.2</th>
<th>5.3</th>
<th>6</th>
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</thead>
<tbody>
<tr>
<td>Trap number used</td>
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<td>6</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Treatments</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>CT</td>
<td>A</td>
<td>CT</td>
<td>IPM</td>
<td>A</td>
</tr>
<tr>
<td>Age of plantation</td>
<td>40</td>
<td>13</td>
<td>36</td>
<td>50</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>Size of plantation</td>
<td>10 ha</td>
<td>10ha</td>
<td>118 ha</td>
<td>20 ha</td>
<td>1 ha</td>
<td>5 ha</td>
<td>7 ha</td>
<td>20 ha</td>
</tr>
<tr>
<td>Soil</td>
<td>sandy-loam</td>
<td>clay</td>
<td>sandy-loam</td>
<td>clay</td>
<td>sandy</td>
<td>sandy</td>
<td>sandy</td>
<td>sandy</td>
</tr>
</tbody>
</table>


Results and discussions

During the study 13,103 Coleoptera individuals were collected. On the basis of the cumulated samples we can state, that the dominant family was Carabidae (39.4%), which was followed by Silphidae (26.5%), and Staphylinidae (17.3%). The families Curculionidae (5.3%), Dermestidae (2.6%), Histeridae (2.3%), Coccinellidae (1.5%) and Leiodidae (1.5%) also occurred with relatively high abundance. The members of additional 26 Coleoptera families occurred in the samples only occasionally. The dominance levels mentioned above show significant differences if we separate the samples by orchards.

The dominant families were Carabidae (85%) in Vámosmikola, Staphylinidae (48%) in Tura and Silphidae (62%) and Dermestidae (5%) in Kecskemét. The family Histeridae (9%) was relatively abundant in Bakonygyirót and Curculionidae (32%) in Györgytarló.

The dominance of the family Carabidae takes values between 22.2% and 85.1%. A highest abundance was found in the conventionally treated orchard in Vámosmikola, and the lowest abundance in Tura and Györgytarló. Altogether 109 species of Carabidae were identified from the investigated 11 plantations. The species richness of Carabidae was between 14 and 53 in the investigated orchards. The most abundant ground beetle species and their abundance are given in table 2.

Within the family Carabidae the most common species was Pseudoophonus rufipes, found in all orchards with abundance of at least 5%, and was the dominant species in 5 orchards.

The other dominant species was Harpalus tarsus, found to be dominant in one orchards and subdominant in 5 orchards. The species of Calathus erratus was found with abundance of
46% and 60% in two plantations. Other common species were Calathus fuscipes, Harpalus serripes, Amara aulica and Amara bifrons found with greater than 5% abundance only in abandoned orchards. In conventionally treated plots the dominant species were Anisodactylus binotatus, Amara aulica and Amara aenea. However, in the I.P.M. plot the Bembidion propeans, Agonum dorsale, and Nebria brevicollis were found as dominant species.

Table 2. List of the most common Carabidae species and their dominance (%) in apple orchards in Hungary. (Pitfall trapping, 1998 – 1999). Data are shown only in case of the dominance higher than 5%.

<table>
<thead>
<tr>
<th>Species</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5.1</th>
<th>5.2</th>
<th>5.3</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudoophonus rufipes</td>
<td>6</td>
<td>50</td>
<td>52</td>
<td>27</td>
<td>9</td>
<td>32</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>Harpalus tardus</td>
<td>30</td>
<td>24</td>
<td>17</td>
<td>54</td>
<td>13</td>
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<td>Calathus erratus</td>
<td>46</td>
<td></td>
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<td></td>
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<tr>
<td>Harpalus distinguendus</td>
<td>27</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Anisodactylus binotatus</td>
<td>14</td>
<td>5</td>
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<td></td>
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<td>Amara aenea</td>
<td>5</td>
<td>7</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Harpalus serripes</td>
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<td>Amara bifrons</td>
<td>11</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Calathus fuscipes</td>
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<tr>
<td>Amara aulica</td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>Bembidion properans</td>
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<tr>
<td>Nebria brevicollis</td>
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<td></td>
<td></td>
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<tr>
<td>Agonum dorsale</td>
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<td></td>
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<tr>
<td><strong>specimens</strong></td>
<td>1559</td>
<td>758</td>
<td>553</td>
<td>207</td>
<td>141</td>
<td>162</td>
<td>106</td>
<td>97</td>
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<tr>
<td><strong>species</strong></td>
<td>53</td>
<td>36</td>
<td>31</td>
<td>27</td>
<td>26</td>
<td>16</td>
<td>14</td>
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</tbody>
</table>


The other important predatory group is the family Staphylinidae. Their abundance in orchards varied between the 6 and 49%. The higher abundance was found in Újfehértó in abandoned plot, the lesser abundance in Vámosmikola in conventionally treated plot.

Altogether 107 species were captured in the investigated 11 plantations, the species richness varied between the 11 and 50. The most dominant Staphylinid species and their abundance are given in table 3.

Within the family Staphylinidae the species of the subfamilies Omaliinae, Xantholyphiniae, Staphylininae, Tachyporinae and Aleocharinae were abundant. The most widespread species was Omalium caesium Gravenhorst, found in five plots with abundance of 7% and 27%. The most abundant species was Platydracus stercorarius (Olivier) found in two orchards with 54% and 67%. The dominant species in the studied orchards were as follows: Omalium caesium in Györgygyarló, Paraphalus linearis (Olivier) in Tura, Platydracus stercorarius in Vámosmikola, Tachyporus hypnorum (Fabritius) in Újfehértó, and Aleochara bipustulata (Linnaeus) in Bakonygyirót. We can also conclude on the basis of this study, that the role of the Staphylinidae in some apple orchards may be important.

We can conclude that the species of the families Carabidae and Staphylinidae are the most abundant in conventionally treated apple orchards. The most abundant ground beetle species, we found in the orchards, are typical for disturbed ecosystems. However, in case of
Staphylinid assemblages there were great differences in species composition and especially in dominance order. We found nearly 110 species from both families and only 14 species were more abundant than 5%. The most dominant species were the carabid *Pseudoophonus rufipes* and the row beetle *Omalium caesum*. Both families could play a certain role in biological control in Hungarian apple orchards.

Table 3. List of the most common Staphylinidae species and their dominance (%) in apple orchards in Hungary. (Pitfall trapping, 1998 - 1999). Data are shown only in case of the dominance higher than 5%.

<table>
<thead>
<tr>
<th>Specie</th>
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<th>5.1</th>
<th>5.2</th>
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</tr>
</thead>
<tbody>
<tr>
<td><em>Omalium caesum</em></td>
<td>7</td>
<td>27</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Aleochara bipustulata</em></td>
<td>26</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>Tachyporus hypnorum</em></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td><em>Platydracus stercorarius</em></td>
<td>54</td>
<td>67</td>
<td></td>
<td></td>
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<tr>
<td><em>Sphenoma abdominale</em></td>
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<tr>
<td><em>Pseudocypus mus</em></td>
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<td>13</td>
<td></td>
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<td><em>Mocya orbata</em></td>
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<td>7</td>
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<tr>
<td><em>Paraphalus linearis</em></td>
<td>45</td>
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<tr>
<td><em>Purrolinus laeticeps</em></td>
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<tr>
<td><em>Styloxys rugifrons</em></td>
<td>8</td>
<td></td>
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<tr>
<td><em>Hyponigrus angustatus</em></td>
<td>6</td>
<td></td>
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<tr>
<td><em>Hemitropsa sordida</em></td>
<td>6</td>
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<tr>
<td><em>Philonthus debilis</em></td>
<td>5</td>
<td></td>
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<tr>
<td><em>Meneidopalpus roubali</em></td>
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<td>5</td>
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</tbody>
</table>


Acknowledgements

The authors are grateful to Mr. László Ádám for his help in identification some Staphylinidae species, and Mr. Gyöző Szél for identification some “difficult” Carabidae taxa. The work was funded by Hungarian Research Fund (OTKA No. 023885).

References

Heyer, W. 1994: Präsenz epigäischer Raubarthropoden in Apfelanlage – Ansatz zu einer
Pear tree responses to psyllid infestation: intercultivar variation in emission of volatiles

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Abstract
Previous experiments have shown that feeding by Cacopsylla on leaves of pear cultivar ‘Conference’ induces the emission of volatile compounds and subsequent attraction of anthocorid predators. Here we show that, compared to ‘Conference’, there are qualitative and quantitative differences in blend composition and amplified emission of volatiles among three other pear cultivars – ‘Bartlett’, NY10355’ and ‘Beurre Hardy’ – infested by Cacopsylla. Methyl salicylate, attractive to anthocorid predators, is constitutively expressed in all pear cultivars and its emission increases after increased infestation, especially in infested leaves of partially and completely infested trees. However, (E,E)-α-farnesene, a specific compound induced by Cacopsylla infestation, also found to attract anthocorid predators, is constitutively expressed in uninfested leaves of ‘Bartlett’, NY10355’ and ‘Beurre Hardy’, whereas in ‘Conference’ it is induced only in Cacopsylla-infested leaves.

Key words: induced response, Cacopsylla, pear cultivar, methyl salicylate, (E,E)-α-farnesene

Introduction
Responses induced by pathogens, herbivores or environmental stress may be expressed systemically throughout a plant or locally in damaged tissue only (Karban & Baldwin, 1997). Previous field and laboratory experiments demonstrated the induction of volatile compounds in Cacopsylla-infested pear trees of cultivar ‘Conference’, and the subsequent attraction of anthocorid predators (Drukker et al., 1995; Scutareanu et al., 1997). Recently, we also identified a phenolic compound which is constitutively expressed in pear cultivars 'Bartlett' and ‘NY10355’, and only locally induced in ‘Conference’ (Scutareanu et al., 1999, 2000). Using the same three cultivars plus ‘Beurre Hardy’, we show here that intercultivar variation also exists in emission of volatiles induced by partial or complete infestation by pear psyllids. We also demonstrate intercultivar differences in volatile-blend composition in samples of both uninfested and Cacopsylla-infested leaves.

Material and methods

Location
A greenhouse under controlled climatic conditions (22-24°C, c. 65% RH, 16/8 L/D) at the University of Amsterdam.
**Insects**

Pear leaf suckers, *Cacopsylla pyricola* (Foester) and *C. pyri* L. (Homoptera, Psyllidae), reared on potted pear trees in the greenhouse for 3 years before use in the experiment.

**Plants**

Two-year-old potted pear trees of 4 cultivars: Bartlett, a susceptible *Pyrus communis* cv. (syn. Williams Bon Chretien); NY10355, a resistant hybrid of *P. communis* x *P. ussuriensis* (75% of parental genes in common with Bartlett; Bell & Stuart, 1990); Conference and Beurre Hardy, both *P. communis* cvs. Bartlett and NY10355 were provided by the National Clonal Germplasm Repository (Corvallis, OR, USA) as scions. They were grafted on quince Kwee MC rootstocks in Amsterdam. Conference and Beurre Hardy were obtained from a nursery (Boomkwekerij C. van Diepen, The Netherlands).

**Treatments**

(1) Partially infested tree – 4 open trees, each with 1 branch enclosed in a bag of fine-mesh gauze and initially infested with 15-20 adult psyllids; (2) Completely infested trees – 5 encaged trees initially infested by 30 adult psyllids; (3) Control trees – 3 open, uninfested trees, 2 Conference and 1 Beurre Hardy.

**Assessment of infestation level**

Right after volatile trapping, psyllid nymphs were counted on infested leaves (Table 1).

**Collection and identification of leaf volatiles**

Headspace sampling and GC-MS analyses were performed on samples of 6-10 fresh leaves (blade + petiole) collected just before infestation (start) and after 32-42 days (end of experiment). For details on analyses see Scutareanu et al. (1997). Compounds in gas chromatograms were counted when 3 criteria were met: potential plant origin, present in 2 or more samples, and damage-related (i.e. potentially mediating plant-predator communication). A compound was considered damage-related if the difference in mean abundance between infested and uninfested leaf samples exceeded 25 ng (Scutareanu et al., 1997).

**Table 1. Mean number of psyllid nymphs on infested leaves of 4 pear cultivars. Bartlett and NY10355 were sampled after 38-42 days infestation, Conference and Beurre Hardy after 32-42 days.**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Partially infested tree</th>
<th>Completely infested tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartlett</td>
<td>12.7 (n=1)</td>
<td>10.6 (n=1)</td>
</tr>
<tr>
<td>NY10355</td>
<td>1.8 (n=1)</td>
<td>8.1 (n=1)</td>
</tr>
<tr>
<td>Conference</td>
<td>23.6 (n=1)</td>
<td>14.3 (n=1)</td>
</tr>
<tr>
<td>Beurre Hardy</td>
<td>31.3 (n=1)</td>
<td>20.0 (n=2)</td>
</tr>
</tbody>
</table>

**Results and discussion**

The full blends of volatiles and characteristic chromatograms per cultivar and treatment will be presented elsewhere. Here we focus on qualitative (number) and quantitative (total amounts) differences among cultivars, and the quantitative variation of methyl salicylate and (E,E)-α-farnesene in response to *Cacopsylla* infestation. These 2 compounds have been demonstrated to attract predatory bugs (Scutareanu et al., 1997).
**Qualitative and quantitative differences in volatile blends**

The blends of volatiles, both from uninfested and *Cacopsylla*-infested leaves, show qualitative and quantitative differences among the 4 pear cultivars. The diversity of compounds is greatest in Conference and Beurre Hardy (Table 2). Uninfested leaves of partially infested Bartlett and NY10355 trees release fewer compounds than Conference and Beurre Hardy. At the end of the experiment – 40 days after the nymphs started to feed – uninfested leaves of partially infested Bartlett and NY10355 trees release fewer compounds than before infestation, or than infested leaves of partially or completely infested trees. In these cultivars the highest amounts are detected in infested leaves of the completely infested trees. In Conference and Beurre Hardy this trend is reversed due to large amounts of (Z)-3-hexen-1-yl-acetate, previously shown to be non-attractive to anthocorid predators (Scutareanu et al., 1997). At the end of the experiment, uninfested leaves of control trees of Conference and Beurre Hardy release less than treated trees or than at the start. This suggest that, at least in Conference aging of undamaged leaves is associated with decreased emission of volatiles.

Although the present experiment was shorter, the results confirm findings of a previous experiment with Conference (Scutareanu et al., 1997). In that paper we showed that number and total amount of compounds from young Conference leaves were higher than from uninfested and infested old Conference leaves. Interestingly, the present results indicate that this is not the case with the leaves of cultivar Beurre Hardy.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trees: partial infestation</td>
<td>complete inf. control</td>
</tr>
<tr>
<td></td>
<td>Leaves: uninfested</td>
<td>uninfested</td>
</tr>
<tr>
<td>Bartlett</td>
<td>No. ng</td>
<td>No. ng</td>
</tr>
<tr>
<td>NY10355</td>
<td>14 570</td>
<td>8 91</td>
</tr>
<tr>
<td>Conference</td>
<td>29 1071</td>
<td>13 8108</td>
</tr>
<tr>
<td>Beurre Hardy</td>
<td>35 349</td>
<td>22 2709</td>
</tr>
</tbody>
</table>

**Variation in induction of some volatile compounds**

Figure 1 shows the quantitative variation in emission of methyl salicylate and (E,E)-α-farnesene, expressed as peaks extracted from normalized chromatograms. These volatiles were previously shown to mediate attraction of anthocorid bugs to *Cacopsylla*-infested pear trees (Scutareanu et al., 1997).
Fig. 1. Amounts of (A) methyl salicylate and (B) (E,E)-α-farnesene in uninfested and *Cacopsylla*-infested leaves of 4 pear cultivars under treatments: 1 = partially infested; 2 = completely infested; c = control trees. Start = before infestation, end = after 32-42 days.
Methyl salicylate is constitutively expressed in all pear cultivars, but the emission increased in infested leaves of partially and completely infested trees, especially of cultivars Conference and NY10355 (Fig. 1A). In control trees, at the end of experiment, this compound was detected in trace amounts in Conference, while in Beurre Hardy the emission was much higher than at the start of the experiment, or than in Conference control trees (Fig. 1A).

(E,E)-α-farnesene is constitutively expressed in uninfested leaves of pear cultivars Bartlett, NY10355 and Beurre Hardy, but its emission increased in infested leaves of these cultivars, especially in completely infested trees of NY10355 and Beurre Hardy (Fig. 1B). In Conference this compound is induced only in Cacopsylla-infested leaves of partially and completely infested trees – it was never detected in uninfested leaves of this cultivar (Fig. 2B). These results suggest that the release of (E,E)-α-farnesene in Conference is induced by herbivory, whereas it is constitutively expressed – and amplified by herbivory – in Bartlett, NY10355 and Beurre Hardy. Similar intercultivar variation was found for the phenolic 3-o-trans-p-coumaroyl tormentic acid, which is constitutively expressed in Bartlett and NY10355 but only locally induced in Conference (Scutareanu et al., 2000).

We reported the induction of (E,E)-α-farnesene in infested Conference trees before (Scutareanu et al., 1997). Landolt et al. (2000) reported that also apple fruits produced increased amounts of (E,E)-α-farnesene, upon infestation by codling-moth larvae or oblique-banded leafrollers or upon mechanically injury. Our present results and those obtained for phenoic compounds indicate that pear cultivar Conference responds locally to herbivory, both by emitting volatiles and by synthesis of a specific phenolic. The elucidation of signaling pathway in the pear trees remains. These results may enhance our insight in direct and indirect defences of pear trees against pear psyllids, and may have important implications for integrated pest management in the field.

Acknowledgements

We thank L. Tikovsky for grafting the scions of pears, and B. Bartlett (Natl Clonal Germplasm Repository, Corvalis, OR, USA) for providing the grafts of pear varieties ‘Bartlett’ and ‘NY10355’.

References


Systemic and non-systemic responses induced by herbivory: variation among pear cultivars

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Abstract: Previous experiments have shown that in response to feeding by pear psyllids (Cacopsylla spp.) a phenolic compound, identified as 3-O-trans-p-coumaroyl tormentic acid, is induced in the leaves of 'Conference', a European cultivar of pear. Here we present evidence from two experiments that the response is non-systemic in this cultivar. The phenolic compound is constitutively expressed and increases in the whole plant after Cacopsylla feeding in two other pear cultivars – ‘Bartlett’ and 'NY10355' – which originate from North America. This demonstrates the existence of between-cultivar variability in pear trees with respect to their response to Cacopsylla feeding.

Key words: induced response, pear cultivar, phenolics, Cacopsylla, systemic, local

Introduction

Responses induced by pathogens, herbivores or environmental stress may enhance a plant’s ability to defend itself directly or indirectly against its attacker (Bernays, 1994, Hartmann, 1996; Agrawal et al., 1999; Baldwin & Preston, 1999). These responses may be expressed systemically throughout the plant or locally, in the damaged tissue only (Karban & Baldwin, 1997). Genetic and phenotypic variation in these responses may also render the plant unpredictable to the herbivore and this may confer a selective advantage to the individual plant (Agrawal & Karban, 1999).

Previous experiments have shown that infestation by Pear Psylla (Cacopsylla pyricola Foerster and C. pyri L., Homoptera, Psyllidae), as well as mechanical damage inflicted upon leaves of pear trees (cultivar 'Conference') induces de novo synthesis of a phenolic compound, identified as 3-β-trans-p-coumaroyloxy-2α,19α-dihydroxyurs-12-en-28-oic acid (=3-O-trans-p-coumaroyl tormentic acid) (Scutareanu et al., 1996, 1999). In this study we used three pear cultivars to investigate whether the induced response is systemic or local, and whether there is variation between cultivars.

Material and methods

Location
A greenhouse under controlled climatic conditions (22-24°C, c. 65% RH, 16/8 L/D) at the University of Amsterdam.

Insects
The pear leaf suckers, C. pyricola Foerster and C. pyri L. were collected in an orchard in the Watergraafsmeer near Amsterdam, and have been reared on potted pear trees in the greenhouse for 3 years before use in the experiments.
Plants
Two-year-old potted pear trees of three cultivars: ‘Conference’, a *Pyrus communis* L. cv. obtained from a commercial nursery (Boomkwekerijen C. van Diepen, The Netherlands); Bartlett, a susceptible *Pyrus communis* cv. (syn. Williams Bon Chretien); NY10355, a resistant hybrid of *P. communis x P. ussuriensis* (75% of parental genes in common with Bartlett; Bell & Stuart, 1990). The latter two cultivars were provided as scions by the National Clonal Germplasm Repository (Corvalis, Oregon, USA). The scions were grafted on quince Kwee MC rootstocks in Amsterdam.

Treatments
Two kinds of experiments were performed. In the first, there were three trees per cultivar and each tree received a different treatment: (1) Partially infested tree – open tree with 1 branch enclosed in a bag of fine-mesh gauze and initially infested with 15-20 adult psyllids; (2) Completely infested tree – encaged tree initially infested by 30 adult psyllids; (3) Control tree – open, uninfested tree. Because this first experiment showed differences among the cultivars in induced responses, a second experiment was carried out to test whether the cultivar with the non-systemic response (Conference) can respond systemically when treated with extract of a cultivar with the systemic response (NY10355). In this experiment, two pear trees of Conference were put together in one cage and treated as follows: leaves of one branch were rubbed by hand to facilitate the infiltration, and the rubbed portion of each leaf was provided with 2 ml extract (200 mg dried powder/20 ml water) from infested leaves that had been collected from partially infested trees in the first experiment on day 40 since the first nymphs started feeding. The leaf extract (dried powder) was kept at -20°C until use. Thus, one of the two trees (Conference 1) received an extract of cv. NY10355 from the first experiment, and the other tree (Conference 2) an extract of cv. Conference from the first experiment, too. To make sure that any effect observed was due to the extract and not to the rubbing, leaves of another branch of each tree were rubbed and then treated with tap water instead of leaf extract.

Assessment of infestation level
In the first experiment, the number of psyllid nymphs was counted directly (using a magnifying-glass) on the trees on day 0, 9, 12-18 and 26, to monitor the increase of infestation level. On the last date (40 to 42 days after emergence) the nymphs were counted on 10-20 leaves collected randomly from the treated branches and trees using a binocular microscope, to assess the level of infestation at the time of HPLC analyses (Table 1).

Table 1. Mean number of psyllid nymphs on infested leaves of 3 pear cultivars: Bartlett, NY10355 and Conference. Samples were collected after 38-42 days infestation,

<table>
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<td>14.3 (n=1)</td>
</tr>
</tbody>
</table>

HPLC analyses
Freeze-dried powder of 6 fresh leaves from each homogenised, pooled sample collected in the first experiment, and from the samples collected on day 0, 3 and 5 in the second experiment were analysed. Of this powder, 10 mg was again homogenized in 200 µl ethanol, and
sinapinic acid (Aldrich) (2 mg sinapinic acid/200ml 96% alcohol) was added as an internal standard. This mixture was centrifuged and stored at -20°C until use. The HPLC equipment consisted of a solvent delivery system (LDC/Milton Roy Model CM 4000), a 20 µl valve loop sample injection system (LDC/Milton Roy Model auto Injector A1000) connected to a reverse phase C18 column (Merck: Lichrospher 100 RP-18, 5 µm, 250 x 4 mm i.d) and a photodiode array UV/VIS detector (Waters Model 996) operating in the wavelength range of 190-300 nm. Chromatographic data were processed using the Millenium 2010 Chromatography Manager (version 2.10, Waters, Milford, UK). Separation was achieved using a linear gradient from eluent A to eluent B in 50 min applying a flow rate of 0.8ml/min. Eluent A consisted of a mixture of 95% phosphate buffer at pH 2 and eluent B consisted of a mixture of 75% acetonitril and 25% phosphate buffer at pH 2.

Results

Variation in induction of the phenolic compound
In the first experiment, the characteristic HPLC chromatograms of leaf extracts revealed two isomer peaks (cis- and trans-) of an induced phenolic compound that elutes between 41 and 55 minutes and that was previously identified as 3-0-trans-p-coumaroyl tormentic acid (Scutareanu et al., 1999). Its presence in HPLC chromatograms at the same interval of time, as well as its identity was confirmed by its absorption spectrum with the multichannel array UV-VIS detector. The top of the trans-isomer peaks have values of 309.2 to 311.6/280 nm wavelength, which are very close to 306.9 to 310.4/280 nm of the previously identified, induced phenolic compound. A detailed structural elucidation and identification of the 3-0-trans-p-coumaroyl tormentic acid was presented in a previous paper published in Journal of Chemical Ecology (Scutareanu et al., 1999).

The intensity of these peaks was compared by measuring their area (Fig. 1). In all control and treated trees before infestation, the doublet of the identified phenolic did not appear in the HPLC's of leaf extracts of Conference, but it was present, at low peak intensity in leaves from Bartlett and higher in NY10355 (Fig. 1, all, start, open bars, Bartlett, NY10355). After a period of 40 to 42 days, the doublet was detected in a variable but higher peak intensity in extracts of leaves collected from infested branches of the partially infested trees in all three cultivars (Fig. 1, tree 1, black bars, end). In samples of leaves from uninfested branches of the same partially infested trees, the doublet also increased to a higher peak intensity on day 40 to 42 but only in Bartlett and NY10355 (Fig. 1, tree 1, open bars, end). In Conference however, the doublet was not detected on day 40 in leaves of the uninfested branch of the partially infested tree (Fig. 1, tree 1, Conference, end). The chromatograms of the samples collected from completely infested trees showed the doublet, indicating that the induced phenolic compound was present after 40 to 42 days in all varieties and reached its highest peak intensity in Conference (Fig. 1, tree 2, black bars, end). In the chromatograms obtained from extracts of leaves from uninfested control trees the chromatograms of day 38 showed higher peak intensity in Bartlett, but in NY10355 of a magnitude close to the initial level. However, the chromatogram from Conference showed the doublet only at the last date and at very low peak intensity (Fig. 1, tree c, open bars, end). It could be attributed to ageing of the leaves in that tree, differently to uninfested branch of the partially infested tree. The presence of this doublet in Conference only at the end of the experiment at very low peak intensity confirms the results obtained in the previous published paper (Scutareanu et al., 1999). It is worth to point out that this phenolic was previously detected in more than 24 leaf samples of cv. Conference, either infested by Cacopsylla or mechanically damaged, or both.
Fig. 1. Normalized total peak area (µV sec) of the late-eluting, previously identified, induced triterpenoid phenolic ester from leaf extracts of uninfested (open bars) or *Cacopsylla*-infested (black bars) leaves collected from partially infested (1) completely infested (2) and control (c) trees of three pear cultivars: Bartlett, NY10355, and Conference. ‘Start’ indicates sample collected just before infestation (mean value of all trees) whereas ‘end’ denotes samples collected 38 to 42 days after the appearance of nymphs on infested leaves.

Here we were interested only in differences in the intensity of elution of the previously identified phenolic ester, but not in its concentration in the plant tissue. Also, it was not our aim here to assess the phenolic concentration needed to provide protection against herbivore.
The most striking result is that the variety Conference shows a locally induced response to *Cacopsylla* feeding: the induced phenolic compound was virtually absent in the control trees and on day 0 in the treated trees, whereas on day 40 it was present in infested leaves of the partially infested tree but not in uninfested leaves from the same tree. This is in sharp contrast to the responses of the other two cultivars, Bartlett and NY10355, because these cultivars show constitutive expression of the phenolic compound in uninfested leaves of control and treated trees (prior to infestation). However, these trees also show great variability in expression. In the cultivar Bartlett there was a consistent increase in peak intensity from day 0 to day 40 in control and treated trees. This also applies to NY10355 in the treated trees, but not in the control trees. This variability in expression of the phenolic compound suggests plant-wide changes in two cultivars -Bartlett and NY10355- and exclusively local changes in another -Conference. This phenomenon prompted us to do a second experiment to test whether such plant-wide changes can be induced systemically by applying extracts from infested leaves of NY10355, where the response was systemic, to leaves of Conference where the response was non-systemic.

In this second experiment, we compared HPLC chromatograms obtained from leaves collected at day 3 and 5 after treating leaves of pest-free, two trees of cultivar Conference with the solution of leaf extract from the infested branches of either NY10355 (the treatment) or 'Conference' (the control) that originated from the trees used in the first experiment. These chromatograms show the presence of a late-eluting peak in the extract-treated leaves of the two Conference trees under test, but at a different retention time (Fig. 2, dark and dashed bars). However, in the water-treated leaves this peak appears only after 5 days in Conference tree 1 where another branch was treated with solution of 'NY10355' leaf extract (Fig. 2, open bar). This phenomenon is not observed in Conference tree 2, where leaves of a branch were treated with the solution from Conference (Fig. 2, Conference 2). Thus, we conclude that extracts from infested leaves of NY10355 induced a systemic response in the pest-free Conference trees, whereas such extracts from Conference only induced a local response in a pest-free Conference, again.

The late-eluting peaks in chromatograms obtained from leaves sampled in both trees in the second experiment were further analysed by comparison of their UV-VIS spectra. In the case of Conference tree 1, the absorption spectra at all peaks observed in extract-treated and water-treated leaves (elution time 41.4 to 45.3 min) had a maxima of 289 to 296/280 nm wavelength. This is close to the absorption spectrum (306.9 to 310.4/280nm) of the trans-isomer of the previously identified phenolic compound in the first experiment (Fig. 2, Conference 1, day 3 black bar, day 5 black and white bars). However, in the case of Conference tree 2 (Fig. 2, dashed bars), treated with extract solution of Conference tree from the first experiment, the absorption spectra at the top of the peaks observed exclusively in the extract-treated leaves show a lower value (266/280 nm wavelength) and a later retention time (46 to 55 min). Therefore, that peak was not assigned to the previously identified trans-isomer of the phenolic compound. The structural elucidation and identification of this presumably different phenolic compound was not within the scope of this paper.

**Discussion**

This paper reports on two preliminary experiments showing (1) insect-induced change in a phytochemical and (2) variation among cultivars in local versus systemic response, therefore its spatial and temporal spread. Reports on genetic variation in systemic vs localised responses in plants are scarce (Karban & Baldwin, 1997; English-Loeb et al., 1998; Baldwin et al., 1999). Recently, McAuslane & Alborn (1998) showed that isogenic lines of cotton differed not only in glandedness, but also in whether their response to fungi and herbivores...
Fig. 2. Normalized total peak area (µV sec) of the late-eluting, induced phenolic compounds in two trees of pear cultivar ‘Conference’: tree 1 with leaves of one branch rubbed by hand and treated with a solution of leaf extract collected from the Cacopsylla infested NY10355 tree and leaves of another branch treated with tap water, and tree 2 with leaves of one branch rubbed by hand and treated with solution of leaf extract collected from the Cacopsylla infested ‘Conference’ tree and leaves of another branch treated with tap water. The leaf extracts were collected from the infested leaves of the partially infested trees in the first experiment presented (Fig. 1). The dark bars indicate total peak area of a previously identified phenolic ester in the leaves of ‘Conference’ tree treated with extract of NY10355 and dashed bars peak area of a not yet identified phenolic compound in the leaves of ‘Conference’ treated with extract of ‘Conference’. The open bars indicate the total peak area of the identified phenolic ester in the leaves of the tree ‘Conference’ 1 treated with tap water.

systemic or localized. Our results show similar evidence for between-cultivar differences in pear trees. Phenotypic plasticity in systemic and localised production of secondary plant metabolites has also been found (Wold & Marquis, 1997). In response to early season feeding by caterpillars, white oak trees showed a systemic response whereas late season feeding induced only a localised response. One would expect systemic responses in plants when the attacker is mobile, and localised responses when the attacker has little or no means to move. In this respect, one may wonder why the plant’s response to mobile herbivores is so variable both between genotypically different plants and within individual plants. With respect to Cacopsylla on pear trees the first nymphs have a pronounced restriction in mobility, but this gradually disappears in the course of development and is virtually absent from the fourth
nymphal stage onward. Intraspecific (e.g., ontogenetic) and interspecific differences in herbivore mobility may well be an important factor in understanding why a plant responds systemically in one case and localised in another. An additional point to make is that the plant may profit from systemic responses to a mobile herbivore because this will cause the herbivore to move to its neighbour and potential competitor (van Dam et al., 2000).

The pear cultivar with a localised response to herbivory (Conference) shows more spaced-out distributions of *Cacopsylla*, compared to the clumped distributions observed on the susceptible cultivar with a constitutive, but weak expression of phenolics (‘Bartlett’) (Bell & Stuart, 1990; this paper). We suggest that Conference acquires its apparent ‘tolerance’ to *Cacopsylla* due to the localised production of phenolic compounds which will tend to harm the young, immobile nymphs and to trigger leaf-to-leaf movement of the older, more mobile nymphs. Because the cultivar NY10355 is resistant (Bell & Stuart, 1990), it exhibits a constitutive and induced expression of phenolics (this paper), and because sprayed phenolics can prevent oviposition and reduce nymphal survival (Scutareanu, unpublished data), we would expect spacing-out to become manifest in the egg distributions and the oviposition behaviour of the adults, rather than in the leaf-to-leaf movement of the nymphs. Moreover, we hypothesise that the leaf extract obtained from infested leaves of NY10355 contained a signal (sensu Pearce et al., 1991; Schaller & Ryan, 1996) that not only induces the production of the phenolic compound in the extract-treated leaves of Conference trees but also in the water-treated leaves from the same tree. Such a signal is apparently lacking in the extracts obtained from infested leaves of Conference. Hence, the signal is unlikely to be part of the insect saliva, because this must have been present in the extracts of infested leaves of both NY10355 and Conference. The identification of such a conveyer signal in pear trees will be the subject of a future paper (work in progress).

As a final point, it should be stressed that herbivore survival and behaviour do not only arise in response to direct plant defences. In an earlier paper, we have demonstrated that apart from induction of the triterpenoid-phenolic ester, attack by *Cacopsylla* also simultaneously induces the production of leaf volatiles in the pear cultivar ‘Conference’ (Scutareanu et al., 1996; see also this volume). Further insight into how direct and indirect defences together affect the survival and behaviour of herbivores is of crucial importance to the development of integrated crop protection.

**Acknowledgements**

We are grateful to Gisella v.d.Doelen, Mark Duursma and Leo Spetter from the Institute for Atomic and Molecular Physics (FOM), Amsterdam for help with HPLC analyses. We thank Leo v.d. Geest, Sam Elliot and Anurag Agrawal for comments on the manuscript, and Ludek Tikovsky for help with grafting the scions of pears. Special thanks are addressed to Richard Bell from Appalachian Fruit Research Station and to Bruce Bartlett from the National Clonal Germplasm Repository, Corvalis, Oregon, USA for their kindness in providing the budwood of ‘Bartlett’ and NY10355.

**References**


Efficiency and timing of some active ingredients to control
Hoplocampa brevis Klug in Emilia-Romagna (Italy)

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Bologna, Italy
² CRPV (Centro Ricerche Produzioni Vegetali - Cesena, Italy)

Abstract: A field trial was carried out to evaluate the efficacy of some insecticides to control
Hoplocampa brevis Klug (Hymenoptera Tenthredinidae). The a.i. evaluated were imidacloprid
(0,05%), vamidothion (0,125%), rotenone (0,25%), Quassio (0,5%) and mineral oil NR (20%) sprayed
before and after blossom on cv. William. The results showed the very good efficiency of imidacloprid
at any distribution timing and the good results obtained by vamidothion when distributed after
blossom. Rotenone, Quassio and mineral oil (Narrow Range) gave moderate results mainly when
applied before blossom.

Keywords: Hoplocampa brevis, control, pear orchards, timing

Introduction

Hoplocampa brevis Klug (Hymenoptera Tenthredinidae) has become a source of not always
negligible damages in Emilia-Romagna as well as in some other countries of the
mediterranean basin apart from Italy (Spain, Cyprus, Iran). It can cause subsequent
production losses of up to 80% (Davoudi, 1987). In this species males are extremely rare or
absent. (Davoudi, 1987; Pollini, 1998). The larvae of this insect pass the diapause as pupae
and hibernate in the soil at a depth of 5-10 cm (Pollini, 1998).

The adults appear at the beginning of spring in periods differing from region to region,
year to year, in function of different factors closely correlated to the weather condition.
Considering the fact that the appearance of the insect and flowering of pear do not coincide
very well, H. brevis can appear on the plant before, during or after blossom. In the case in
which the appearance of the adults coincides with the blossom one can expect highest
damages.

The risk of an attack by the pest increases as a function of the interaction of various risk
factors. It is, thus, depending on the i) potential population, ii) the situation in the preceding
year, iii) the correspondence of the flight of adults and flowering, iv) the level of flowering
induction and v) the fruit setting. (Oro et al., 1998). The adult emergence takes about 10-12
days. However, it might last up to 25 days if the mean temperatures are low. After little more
than one week of incubation time out of the eggs (each female lays about 100 of them), which
are located closely to the thalamus (Arias Giralda et al., 1973; Davoudi, 1987; Huberdeau
1995; Pollini 1998), emerge the tiny larvae that penetrate into the small fruits. Each larva can
attack several fruits (2-3) and passes through four moults, which are completed within a range
of 20-25 days. When maturity is achieved the larva leaves the fruit, falls to the soil where it
remains in diapause until the subsequent spring.
**H. brevis** as well as the closely related species (the Tenthredinidae of the apple *H. testudinea* Klug and the Tenthredinidae of the plum *H. flava* L.), undergo utterly intensive variations during their development. As a result there are years, one or several in a sequence, where high insect populations can appear resulting in up to 80% of affected fruits. Vice versa in other years, one or several succeeding ones the damage is practically negligible. Moreover, the heavy invasions are generally rather localised, as a result one orchard may suffer from massive infestations, while adjacent ones are almost unaffected. Finally, it is possible that within one orchard only determined varieties are attacked.

In the past, plant protection consisted in the use of parathion (0.06-0.18%) and trichlorphon (0.1%), applied at 70-90% of fallen petals (Szekely, 1977). Other authors suggested an chemical treatment at 50% of fallen petals, considering it the best moment to hit the newly hatched larvae (Davoudi, 1987). Thus, it is advantageous to control the presence of adults in the orchard and to monitor their flight-activity by the means of white coloured cromatotropic traps (type Rebell), for which exists a correlation between captured adults and the succeeding larval infestation.

A chemical application is justified if the number of captured adults exceeds the threshold of 20 adults per trap (Antropoli et al., 1994). At present, the guide lines of the Region Emilia-Romagna Integrated production programme foresee only oxydemeton-methyl after blossom.

The aim of the present research was to evaluate the activity of some p.a. on the control of *H. brevis* at two different periods of application by different a. i. (3-4 days before blossom and at 70% of petal fall).

**Materials and methods**

*Farm characteristics* are reported in Tab. 1.

Tab. 1. Farm characteristics

<table>
<thead>
<tr>
<th>Farm characteristics</th>
<th>Lenzi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm</td>
<td>Lenzi</td>
</tr>
<tr>
<td>Locality</td>
<td>Cento (Fe)</td>
</tr>
<tr>
<td>Species</td>
<td>Pear</td>
</tr>
<tr>
<td>Variety</td>
<td>William</td>
</tr>
<tr>
<td>Year of establishment</td>
<td>1964</td>
</tr>
<tr>
<td>Training system</td>
<td>Palmette</td>
</tr>
<tr>
<td>Orientation</td>
<td>N&gt;S</td>
</tr>
<tr>
<td>Planting distance</td>
<td>4 x 3 m</td>
</tr>
<tr>
<td>High</td>
<td>3 m</td>
</tr>
<tr>
<td>Water pH</td>
<td>8</td>
</tr>
</tbody>
</table>

**Experimental layout**

<table>
<thead>
<tr>
<th>Nº Randomised blocks</th>
<th>4 (on four rows)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nº Factors</td>
<td>11</td>
</tr>
<tr>
<td>Nº Plants per plot</td>
<td>3</td>
</tr>
</tbody>
</table>
As experimental layout a fully randomised block design with four repetitions was used. Generally, a plot consisted of 6 plants of which 3 were treated in the pre blossom period and 3 in the post blossom period. Therefore, the plants not treated before blossom could be considered as control until the post blossom period treatment was carried out and, therefore, allowing a better valuation of the uniformity of infestation. Besides, a more congruent set of findings for the statistical analysis was achieved. The treatments were made using a portable spraying machine type Comet MC 20/20 with a maximum pressure of 19 l/min and 20 bar, respectively. Application was done by hand at common spraying rates.

**Experimental pattern**

<table>
<thead>
<tr>
<th>cod.</th>
<th>Factors</th>
<th>Commercial name</th>
<th>% a. i.</th>
<th>gr, cc/hl</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Vamidothion</td>
<td>Kilval</td>
<td>37,5</td>
<td>125</td>
<td>Before blossom *</td>
</tr>
<tr>
<td>3</td>
<td>Imidacloprid</td>
<td>Confidor 200 SL</td>
<td>17,8</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Rotenone</td>
<td>Rotena</td>
<td>6</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Quassio</td>
<td><em>Picrasma excelsa</em> powder</td>
<td>1,8-2</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mineral Oil</td>
<td>Biolid E.</td>
<td>80</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Vamidothion</td>
<td>Kilval</td>
<td>37,5</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Imidacloprid</td>
<td>Confidor 200 SL</td>
<td>17,8</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Rotenone</td>
<td>Rotena</td>
<td>6</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Quassio</td>
<td><em>Picrasma excelsa</em> powder</td>
<td>1,8-2</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Mineral Oil</td>
<td>Biolid E.</td>
<td>80</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

* 3-4 days before blossom  
** 70% of petal fall

**Experimental practices**

Treatments were applied in the pre blossom period (3-4 days) and at post blossom (70% of petal fall).

**Treatment schedule**

<table>
<thead>
<tr>
<th>Date of treatment</th>
<th>Hour</th>
<th>Factors</th>
<th>Water volume (l/plant)</th>
<th>Water volume (l/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/03/99</td>
<td>15.30-17.15</td>
<td>2-3-4-5-6</td>
<td>1,3</td>
<td>1110</td>
</tr>
<tr>
<td>14/04/99</td>
<td>11.00-12.10</td>
<td>7-8-9-10-11</td>
<td>1,5</td>
<td>1250</td>
</tr>
</tbody>
</table>

**Statistical analysis** was carried out using ANOVA. Mean separation was done according to the LSD (p < 0.05). The data were transformed using arcsec √x.

**Results**

In table 1 are reported the *H. brevis* adults captured. In table 2 the results regarding damaged corymbs after different treatment timing are reported.
Tab. 1. Adults of *H. brevis* were captured using some traps (type Rebell).

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/03/99</td>
<td>1</td>
</tr>
<tr>
<td>31/03/99</td>
<td>61</td>
</tr>
<tr>
<td>06/04/99</td>
<td>121</td>
</tr>
<tr>
<td>13/04/99</td>
<td>6</td>
</tr>
<tr>
<td>20/04/99</td>
<td>1</td>
</tr>
<tr>
<td>28/04/99</td>
<td>0</td>
</tr>
</tbody>
</table>

Tab. 2. Percentage of attacked corymbs

<table>
<thead>
<tr>
<th>Cod.</th>
<th>Factors</th>
<th>gr, cc/hl</th>
<th>Timing</th>
<th>12th april (**)</th>
<th>28th april (***)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>% coryms damaged</td>
<td>Efficacy (Abbott)</td>
</tr>
<tr>
<td>1</td>
<td>Control</td>
<td>–</td>
<td>–</td>
<td>12 ab</td>
<td>56 a</td>
</tr>
<tr>
<td>2</td>
<td>Vamidothion</td>
<td>125</td>
<td>Before blossom</td>
<td>7 b 44</td>
<td>33 c 41</td>
</tr>
<tr>
<td>3</td>
<td>Imidaclorpid</td>
<td>50</td>
<td></td>
<td>2 c 86</td>
<td>8 d 86</td>
</tr>
<tr>
<td>4</td>
<td>Rotenone</td>
<td>250</td>
<td></td>
<td>10 ab 13</td>
<td>34 c 40</td>
</tr>
<tr>
<td>5</td>
<td>Quassio</td>
<td>500</td>
<td></td>
<td>9 b 27</td>
<td>36 bc 35</td>
</tr>
<tr>
<td>6</td>
<td>Mineral oil</td>
<td>2000</td>
<td></td>
<td>16 a -33</td>
<td>50 ab 11</td>
</tr>
<tr>
<td>7</td>
<td>Vamidothion</td>
<td>125</td>
<td>After blossom</td>
<td>9 n.s.</td>
<td>– 15 d 74</td>
</tr>
<tr>
<td>8</td>
<td>Imidaclorpid</td>
<td>50</td>
<td></td>
<td>8 n.s.</td>
<td>– 11 d 80</td>
</tr>
<tr>
<td>9</td>
<td>Rotenone</td>
<td>250</td>
<td></td>
<td>13 n.s.</td>
<td>– 41 abc 27</td>
</tr>
<tr>
<td>10</td>
<td>Quassio</td>
<td>500</td>
<td></td>
<td>15 n.s.</td>
<td>– 43 abc 23</td>
</tr>
<tr>
<td>11</td>
<td>Mineral oil</td>
<td>2000</td>
<td></td>
<td>13 n.s.</td>
<td>– 39 bc 31</td>
</tr>
</tbody>
</table>

n. s., non significant; *, significant at 5%; ***, significant at 1‰.

Fig. 1. Results obtained by the treatment applied in the two periods (pre and post blossom)
The data shown in Tab. 2 and Fig. 1 depicts the treatments that had been carried out. On the 12th of April only the treatment in which Imidacloprid was used, differed significantly from the other treatments. At that stage the plots selected for the post blossom treatment were sampled. They showed a similar population density of *H. brevis* like the one in the control plots. Hence, it could be assumed that the population was uniformly distributed all over the experimental area (this assumption is supported by the statistical analysis resulting in non significant differences in contrast to the results achieved by the treated blocks). On the 24th of April, an even smaller infestation in the plots treated with Imidacloprid in pre blossom than in all the other plots could be observed. Regarding the post blossom period of the same date, the treatments that resulted in the smallest infestation were Imidacloprid and Vamidothion, respectively.

**Discussion**

The results achieved by the study are notable in particular because difficulties had been encountered by applying an Integrated pest management for controlling *H. brevis*, therefore, the registered and recommended active ingredients did not always lead to satisfying results.

From this research it can be concluded that Vamidothion has its highest potential if applied after blossom whereas Rotenone, Quassio (derived from *Picrasma excelsa*) and Mineral Oil, which could represent an alternative for Biological Agriculture, did not provide entirely satisfying, but still interesting results. Particularly, regarding the pre blossom treatments Rotenone and Quassio act similarly as Vamidothion, while their gain is limited if applied after blossom. Imidacloprid, however, provided very good results also regarding this pest. The results by Imidacloprid appear to be both, suitable before and after blossom. This fact is of great interest taking into account the necessary flexibility needed for the timing of the treatments.

**Acknowledgements**

We would like to thank Dr. Fabrizio Steinebrunner for his help regarding the English translation.

**References**

Predators of the rosy apple aphid, *Dysaphis plantaginea* (Pass.), in Asturian (NW Spain) apple orchards

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Abstract: Alternative strategies to the common practice of spraying with insecticide in order to control the rosy apple aphid *Dysaphis plantaginea* (Pass.) (Homoptera: Aphididae) are required. Biological control by natural enemies is a possible tool. In Asturies, despite the tradition of growing local cider apple trees, there are no studies about the community of *D. plantaginea* predators and their impact on these aphid populations. The aim of this work is to fill this gap.

The presence of beneficials in the *D. plantaginea* colonies was important reaching in some surveys to 100 % of the infested terminals. The three most abundant predators were *Episyrphus balteatus* (DeGeer) (Diptera: Syrphidae), *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae) and *Aphidoletes aphidimyza* (Rond.) (Diptera: Cecidomyiidae). When the first colonies of *D. plantaginea* developed in April, only syrphids and coccinellids were present. Syrphid eggs or larvae occurred in more than 80 % of the colonies, coccinellids were less frequent but their population increasing progressively. Cecidomyiids appeared in mid-May and their number increased quickly. Other Coccinellidae and Syrphidae, as well as Anthocoridae and Miridae (Heteroptera), Cantharidae (Coleoptera), Forficulidae (Dermaptera) and Chrysopidae (Neuroptera) were also observed preying on *D. plantaginea* colonies.

Although these predators are considered to play an important role in the regulation of aphid populations, they did not prevent *D. plantaginea* damage that affected up to 37 % of the terminals in one orchard and up to 54 % in another. Some possible causes for this ineffectiveness are discussed.

Keywords: apple, aphids, predators, biological control.

Introduction

The rosy apple aphid, *Dysaphis plantaginea* Pass. (Homoptera: Aphididae), is along with the codling moth, the most important pest in Asturian apple orchards. It can curl leaves, distort shoots and reduce the fruit growth. To control *D. plantaginea*, one or more insecticide sprays are required in early spring. However, the range of insecticides respecting pollinator or beneficial arthropods is narrow, and the loss of efficacy because of induced resistance poses a serious problem with this key pest. Thus, alternative strategies are needed. The growing of resistant cultivars probably provides the best long term solution. A breeding programme with the resistant cultivar ‘Florina’ has been developed to transfer the resistance to our local cider apple cultivars (Dapena & Miñarro, 2001). Biological control by natural enemies, either by weed strips to enhance the number of aphidophagous predators (Wyss, 1995: Wyss et al., 1995), or augmentative releases of indigenous natural enemies (Wyss et al., 1999a), may be other powerful tools. However, despite the traditional growing of local cider apple trees, the community of *D. plantaginea* predators has not been still studied in Asturies. This work aims at describing this community in Asturian orchards and to estimate their effectiveness in the control of these aphid populations.
Material and methods

Study orchards
Trials were carried out in 1999 in one experimental and one commercial apple orchards. The experimental orchard of 0.3 ha at Villaviciosa, consisted of 5-year old apple trees of 17 different cider apple cultivars growing on Pajam 2 rootstocks. Neither insecticide, acaricide nor fungicide were ever sprayed in this orchard in order to allow the presence of both pests and beneficials.

The 0.4-ha commercial orchard at Pruvia, consisted of 8-year old cv ‘Reineta Encarnada’ and cv ‘Reineta Blanca del Canadá’ apple trees, grafted on M9 rootstocks. This orchard was conducted following organic guidelines. Thus, summer white oil and Rotenon were sprayed to control aphids and granulosis virus to control codling moth. Treatments against other apple pests were not needed. Copper and sulphur preparations were used against fungal diseases.

Sampling method
In order to minimise cultivar effects in the experimental orchard, four trees of each of the 17 varieties were sampled for the presence of \( D. \) plantaginea. Five shoots of each selected tree were marked with coloured plastic strips. From mid April to the moment when \( D. \) plantaginea left apple trees, all selected shoots were examined weekly for the presence of colonies. In the commercial orchard, 10 trees of each cultivar were selected. Five marked shoots per tree were weekly inspected.

Arthropod predators were assessed weekly during the spring aphid occurrence by visual controls on 20 shoots infested with \( D. \) plantaginea colonies in both orchards. These 20 shoots were selected randomly in the orchards among those which had a high infestation of \( D. \) plantaginea. All insects described as aphidophagous in this study were observed feeding on \( D. \) plantaginea. Some eggs and larvae were reared on \( D. \) plantaginea or \( Aphis poni \) colonies in laboratory in order to determine the species.

Results

Aphids
The percentage of growing shoots with \( D. \) plantaginea colonies was high in both apple orchards, reaching 50% in some moments (Fig.1). In the experimental orchard, the first colonies were observed at the beginning of April and the last ones at the end of June, when aphids migrated to \( Plantago \) spp., their secondary host (Fig.1). In the commercial orchard, aphids remained on the growing shoots up to mid-July (Fig.1). The Rotenon and summer oil sprays did not have strong consequences on \( D. \) plantaginea population (Fig.1). This may be due to the fact that the effectiveness of contact insecticides in curled leaves decreases substantially (Hull & Starner, 1983).

Predators
The three most abundant predator families in both orchards were Syrphidae, Coccinellidae and Cecidomyiidae (Fig.2). Anthocoridae and Miridae (Heteroptera), Chrysopidae (Neuroptera), Cantharidae (Coleoptera) and Forficulidae (Dermaptera) were also observed preying on \( D. \) plantaginea colonies. The most abundant and the first observed syrphid was \( Episyrphus balteatus \), although \( Scaeva pyrastri \), \( Syrphus ribesii \) and \( Epistrophe \) sp. larvae were also recorded. \( Adalia bipunctata \) constituted more than 80% of the coccinellids. \( Coccinella septempunctata \), \( Propylea quatuordecimpunctata \) and \( A. decempunctata \) were also identified. The cecidomyiid fly was \( Aphidoletes aphidimyza \).
Fig. 1. *D. plantaginea* occurrence and shoot damage in the experimental (a) and the commercial (b) orchards in 1999. Rotenone and summer oil were sprayed on 10/5, 21/5, 1/6 and 16/6 in the commercial orchard.

Fig. 2. Coccinellid, syrphid and cecidomyiid occurrence on *D. plantaginea* colonies in both the experimental (a) and the commercial (b) orchards in 1999.

In the first surveys only syrphids and coccinellids occurred in the *D. plantaginea* colonies: syrphids eggs or larvae were detected in more than 80% the aphid colonies in the experimental orchard, whilst coccinellids occurred in few number in both orchards (Fig.2). *A. aphidimyza*, the third most abundant predator, was observed for the first time in mid May in both orchards, and quickly increased in number (Fig.2). Syrphid larvae were the most abundant predator during the first part of the surveys, but when the abundance of *D. plantaginea* decreased, coccinellids and cecidomyiids were more important. Anthocorids and mirids occurrence was more important in the experimental than in the commercial orchard. In the former, anthocorids occurred in 50% of the *D. plantaginea* colonies in mid-June. *Forficula auricularia* (Forficulidae) and *Rhagonycha fulva* (Cantharidae) had a weak presence.

Spiders were rarely observed in both apple orchards and although they were not seen feeding on *D. plantaginea*, they can play an important role in decreasing aphid populations principally in autumn (Wyss et al., 1995).

The presence of ants attending *D. plantaginea* colonies was important and probably favoured the development of colonies because of their negative effect on predaceous arthropods.
Discussion

In a recent study, Wyss et al. (1999b) showed the predaceous efficiency of *A. bipunctata*, *E. balteatus* and *A. aphidimyza* on *D. plantaginea* colonies. In the present work, these three species are the most abundant predators. However, despite playing an important role in decreasing the aphid populations, they were not able to reduce *D. plantaginea* populations under an economic threshold (Fig.1). Some possible reasons may explain the ineffectiveness of these control agents in preventing *D. plantaginea* damage. In one hand, the response of apple leaves to the feeding of *D. plantaginea* is very rapid and symptoms may be observed within 24 hours (Forrest & Dixon, 1975). Thus, although aphid populations could be controlled by natural enemies, most of the infested shoots could already show the typical leaf-rolling. In this sense, the importance of these aphidophaga may be greater with the growing of low susceptible cultivars. Secondly, there is a considerably different developmental rate between prey and predator. If the predators develop considerably slower than their prey, they are not able to track the prey accurately and, as a consequence, are not as effective as if the developmental times were similar. This happens in, at least, the case of the aphidophagous coccinellids (Dixon et al., 1997). Thirdly, aphidophagous coccinellids behave as if they were ‘prudent predators’ (Hemptinne & Dixon, 1998). Optimal foraging theory for aphidophagous ladybirds (Kindlmann & Dixon, 1993) predicts that there is an optimal number of eggs laid in an aphid colony which maximizes the resulting offspring biomass. Theory also predicts that if the ovipositing females lay the optimal number of eggs, their offspring will not affect substantially the size of aphid colonies (Kindlmann & Dixon, 1993). Field and experimental results confirm the prediction of the model. Thus gravid females respond to both the abundance and quality of their prey, avoiding aphid colonies that are already exploited and/or too old to support the full development of the ladybird offspring, and so they are not effective biological control agents (Hemptinne et al., 1992; Hemptinne et al., 1993). There is also evidence that aphidophagous syrphids behave similarly (Hemptinne et al., 1993; Scholz & Poehling, 2000).

Parasitism has not been studied in this work, and although some parasited aphids were observed, parasitoids seem to play a minor role in regulating populations of *D. plantaginea*, probably due to the host alternation of this species, ant attendance and hyperparasitism (Cross et al., 1999).

Intraguild predation was not studied in this experiment. However, Wyss et al. (1999b) showed that the two most numerous predators in our apple orchards, *A. bipunctata* and *E. balteatus*, not only do not interact but also have a negative effect on aphid populations, explained by an additive model.

This work reinforces the need of future research in other strategies to improve the natural control of this aphid species, and may be the basis for research in strategies such as the augmentative release of predators or the increase of the natural enemy density by weed strips.

Acknowledgements

We are indebted to Santiago Pérez and his family for permitting investigations on their farm, to J.L. Hemptinne for reading and improving the manuscript and to Principado de Asturies and FICYT (Project PA-AGR97-01) for financial support.
References


Evaluation of the tolerance to the rosy apple aphid, *Dysaphis plantaginæa* (Pass.), in descendants of the crossing ‘Raxao’ x ‘Florina’

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**Abstract:** In a cider apple breeding programme the susceptible local cv ‘Raxao’ and the cv ‘Florina’, resistant to the rosy apple aphid, *Dysaphis plantaginæa* (Pass.) (Homoptera: Aphididae), have been crossed. Thirty-four hybrids have been previously selected for their resistance to apple scab and low susceptibility to powdery mildew. The results of the tolerance to *D. plantaginæa* of those 34 descendants are reported.

The progeny was tested in controlled conditions after infestation with aptera and in the field after natural colonisation. In the greenhouse test, 44.1 % of the assessed cultivars did not show the typical *D. plantaginæa* deformations and were considered as tolerant cultivars. Among the other 55.9 %, the deformation level was of different importance. The male parent and resistant control cv ‘Florina’ did not show symptoms and the susceptible control cv ‘Golden Delicious’ was the most damaged cultivar. The female parent cv ‘Raxao’ was also susceptible to *D. plantaginæa*. In the field trials, only 38.2 % of the hybrids showed *D. plantaginæa* deformations. The cultivars which showed deformations in the field were also susceptible in the greenhouse conditions, and the cultivars considered as tolerant in the greenhouse did not show deformations in the field trials. The results show clearly that cv ‘Florina’ is a good parent for the transmission of the tolerance to *D. plantaginæa*.

The present study takes another step in offering the grower new cultivars with interesting technological and agronomical implications, such as resistance to pests and diseases, which is considered to be a powerful tool in pest management programs.

**Keywords:** apple, aphids, cultivars, resistance, breeding

**Introduction**

Among the regions of the Cantabrian Coast, Asturies has the highest diversity of genetic resources of apples, and can be considered as a secondary centre of genetic variation. Currently, among the cultivars of the National Apple Germplasm Bank located at Villaviciosa (Asturies) there are 550 local cultivars, which are being characterized and evaluated (Dapena, 1996). Paralelly, since 1989, an apple breeding programme has been developed through the crossing of Asturian cider apple cultivars, with interesting agronomical and technological implications, with some cultivars or hybrids possessing important characteristics such as the *Vf* scab resistance character, high fire blight resistance, relatively late ripening and/or one fruit per inflorescence (kindly provided by the INRA, Angers, France). The local cv ‘Raxao’ and the cv ‘Florina’, resistant to apple scab and rosy apple aphid *Dysaphis plantaginæa* Pass. (Homoptera: Aphididae) and lightly susceptible to fire blight and European red mite (Lesspinasse *et al*., 1985) were crossed in 1989. Rat-Morris (1994) concluded that there was independence between the resistance of cv ‘Florina’ to apple scab and rosy apple aphid. Thirty-four descendants have been preselected for their resistance to apple scab and their low susceptibility to powdery mildew in nursery (Dapena, 1996). This work aims to complete the
evaluation of those 34 hybrids testing their response to *D. plantaginea*, which is a key pest in Asturian orchards.

**Material and methods**

The susceptibility of the 34 descendants was assessed after infestation with aptera in greenhouse conditions and after natural colonization in the field.

**Greenhouse conditions**

**Plant material**

The test was carried out in 1999 using cv ‘Golden Delicious’ and ‘Florina’ as susceptible and resistant control, respectively. The female parent cv ‘Raxao’ was also tested. Fifteen seedlings of each of the tested cultivars were grafted on MM 106 rootstocks and kept outside. Eight seedlings of each cultivar with active growing shoots and a comparable size were introduced into the greenhouse in a completely randomised distribution. An insecticide and a fungicide treatments were applied before the aphid infestation in order to kill all arthropods on the plants and prevent fungal diseases. The aphid movement from one plant to another was prevented putting the pots on dishes with water.

**Aphids**

Aphids used for infestation were derived from field populations and reared on susceptible plants. As aphid populations present a wide range of both genotypes and response to plants (Dixon, 1985), fundatrix were collected in the field from different strains in order to have enough variability in the attack response to the plants. Four adult apterous females or fourth-instar larvae were carefully placed on the first expanded leaf of each seedling. None of the aphids on each plant belonged to the same strain. When necessary, reinfestation was performed the day after to complete four aphids per plant. As some seedlings did not present aphids one and two weeks after the first infestation, two reinfestation were performed collecting the aphids directly in the field.

**Damage control**

Observations were made once a week from the day after the infestation to the end of the experiment 21 days later. Based on Rat-Morris (1993; 1994), shoot deformation was quoted from 0 to 5 as follows: 0= no damage; 1= leaf slightly curled at the edge; 2= leaf curled longitudinally; 3= typical *D. plantaginea* rolled leaves; 4= 2 to 5 typically rolled leaves; and 5= more than 5 typically rolled leaves. Following Rat-Morris (1994) one given cultivar was considered as tolerant when presenting only deformation 0 or 1.

**Orchard studies**

In orchard A, the 34 individuals obtained directly from the seed were planted in 1992. In orchard B, 11 of those 34 hybrids, selected for their production, low susceptibility to powdery mildew in the field and/or technological characteristics, were planted in 1999 in MM 106 and Pajam 1 rootstocks. Each cultivar was repeated randomly into three blocks. All the trees in both orchards were observed for *D. plantaginea* damage in the spring of 2000. Shoot damage was recorded as in the greenhouse test.
Table 1. Number of plants of each 34 hybrids ‘Raxao’ x ‘Florina’ presenting different levels of *D. plantaginea* damage, and susceptibility to this aphid species in field and greenhouse conditions. Cv ‘Florina’ and ‘Golden Delicious’ are, respectively, the resistant and the susceptible control. Cv ‘Raxao’ is the female parent.

<table>
<thead>
<tr>
<th>cultivar</th>
<th>damage level*</th>
<th>susceptibility**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>greenhouse</td>
<td>greenhouse</td>
</tr>
<tr>
<td></td>
<td>0 1 2 3 4 5</td>
<td>orchard A</td>
</tr>
<tr>
<td>1</td>
<td>3 1 2 1 0</td>
<td>s</td>
</tr>
<tr>
<td>2</td>
<td>7 1 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>3</td>
<td>3 0 2 1 1</td>
<td>s</td>
</tr>
<tr>
<td>4</td>
<td>0 3 4 1 0</td>
<td>s</td>
</tr>
<tr>
<td>5</td>
<td>7 0 1 0 0</td>
<td>s</td>
</tr>
<tr>
<td>6</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>7</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>8</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>9</td>
<td>6 1 1 0 0</td>
<td>s</td>
</tr>
<tr>
<td>10</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>11</td>
<td>6 2 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>12</td>
<td>1 1 1 4 1</td>
<td>s</td>
</tr>
<tr>
<td>13</td>
<td>3 2 3 0 0</td>
<td>s</td>
</tr>
<tr>
<td>14</td>
<td>2 2 1 0 2</td>
<td>s</td>
</tr>
<tr>
<td>15</td>
<td>3 0 2 3 0</td>
<td>s</td>
</tr>
<tr>
<td>16</td>
<td>8 0 0 0 0</td>
<td>s</td>
</tr>
<tr>
<td>17</td>
<td>4 1 2 1 0</td>
<td>s</td>
</tr>
<tr>
<td>18</td>
<td>2 3 2 0 1</td>
<td>s</td>
</tr>
<tr>
<td>19</td>
<td>3 2 2 0 1</td>
<td>s</td>
</tr>
<tr>
<td>20</td>
<td>7 1 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>21</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>22</td>
<td>6 0 1 0 1</td>
<td>s</td>
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<tr>
<td>23</td>
<td>3 4 1 0 0</td>
<td>s</td>
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<tr>
<td>24</td>
<td>5 0 1 0 1</td>
<td>s</td>
</tr>
<tr>
<td>25</td>
<td>7 1 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>26</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>27</td>
<td>1 0 1 2 3</td>
<td>s</td>
</tr>
<tr>
<td>28</td>
<td>2 1 3 1 0</td>
<td>s</td>
</tr>
<tr>
<td>29</td>
<td>1 0 0 1 3</td>
<td>s</td>
</tr>
<tr>
<td>30</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>31</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>32</td>
<td>6 2 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>33</td>
<td>4 2 2 0 0</td>
<td>s</td>
</tr>
<tr>
<td>34</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>Golden</td>
<td>0 0 0 0 1</td>
<td>s</td>
</tr>
<tr>
<td>Florina</td>
<td>8 0 0 0 0</td>
<td>t</td>
</tr>
<tr>
<td>Raxao</td>
<td>0 1 2 2 1</td>
<td>s</td>
</tr>
</tbody>
</table>

* 0: no symptoms; 1: leaf slightly curled at the edge; 2: leaf curled longitudinally; 3: typical symptom; 4: 2 to 5 typically damaged leaves; 5: more than 5 typically damaged leaves.

** s: susceptible; t: tolerant; n.p.: no present in this orchard.
Results and discussion

Greenhouse conditions

In the greenhouse test, 44.1% of the assessed hybrids did not show the typical D. plantaginea deformations (Table 1) and were then considered as tolerant cultivars. Among the other 55.9%, the deformation level was of different importance (Table 1). The male parent and resistant control cv ‘Florina’ did not show symptoms and the susceptible control cv ‘Golden Delicious’ was the most damaged cultivar (Table 1). The female parent ‘Raxao’ was also susceptible to D. plantaginea (Table 1). There were some susceptible hybrids that did not show symptoms in all of the 8 repeated seedlings (Table 1). This may be explained by some factors which could interfere with the development of the experiment. For instance, anthocorids were observed in some seedlings preying on aphids. Caterpillars (Lepidoptera) fed on some of the growing shoots. And some plants stopped growing during the experiment. However, these facts did not change the conclusion about the susceptibility of the plants, which coincided with the results obtained in the field trials.

Orchard studies

The results of the susceptibility observed in the field in orchard A are presented in Table 1. Typical deformations were reported in 38.2% of the progeny. This percentage, lower than the observed in the greenhouse assay may be explained by the inherent deviations in conditions between greenhouse and field situations, such as a lower infestation rate or the beneficial impact in the field. Therefore we only can say which of them are susceptible cultivars but we can not say anything about those which did not show symptoms. In orchard B, where the 11 hybrids are repeated, we are able to distinguish between tolerant and susceptible cultivars because of the cited factors are minimized in this orchard due to its aleatory design. The tolerant and the susceptible hybrids were exactly the same that in the greenhouse trial (Table 1). Thus, the cultivars which showed deformations in the field were also susceptible in the greenhouse conditions, and the cultivars considered as tolerant in the greenhouse did not show deformations in the field trials.

Rat-Morris (1993, 1994) has characterized the resistance of the cv ‘Florina’ to D. plantaginea, identifying both antibiosis and tolerance. Results showed a nutritional effect on aphids resulting in lower length, weight and fecundity of adult aptera, lower survival rate and longer instar duration. Production of alate morphs was increased and aphid location on the plant affected. On the other hand, cv ‘Florina’ did not show the typical symptoms, only a very light necrosis (Rat-Morris, 1994). In the present work, only tolerance was tested. Studying the inheritance of the resistance to D. plantaginea, Rat-Morris (1994) concluded that it was complex and might imply a maternal effect. Thus, when cv ‘Florina’ was used as male parent the percentage of tolerant individuals was only 2% (Rat-Morris, 1994). However in our study the percentage of tolerant descendants was 44.1%, which shows clearly that cv ‘Florina’ may be a good parent for the transmission of the tolerance to D. plantaginea, being indeed the male parent.

The case of polygenic versus monogenic resistance has the disadvantage that it is not as easy to handle (Knight and Alston, 1972). But the fact that some genes are implied in the heredity of this resistance reduces the risk for the appearance of resistance-breaking biotypes (Rat-Morris, 1994). However, three different sources of resistance-breaking have been found recently (Rat-Morris et al., 1999), although none of them spread to another tree nor appeared on the same tree the next year. Probably, due to the obligatory aphid migration to the
secondary host *Plantago* spp and the also obligatory sexual reproduction, the resistance-breaking biotypes are not likely to colonize a broad area.

Thus this attribute of resistance to *D. plantaginea* seems a very good long-term alternative to control this harmful aphid, which joined to the resistance to apple scab and powdery mildew would limit the pesticide inputs to those required against the codling moth. Thereby this work takes another step in offering the grower cultivars which will prove both economically and ecologically beneficial.

**Acknowledgements**

We are indebted to Elizabeth Rat-Morris for her methodological help and for improving the manuscript. The study was financially supported by Principado de Asturies, FICYT (Project PA-AGR97-01) and INIA (Project SC98-013).

**References**


Monitoring and control of currant clearwing moth 
(*Synanthedon tipuliformis* Cl.) and black currant stem midge 
(*Resseliella ribis* Marik.) on black currant plantations

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Department of Entomology, Research Institute of Pomology and Floriculture, Skierniewice, Poland

Abstract: Currant clearwing moth and black currant stem midge are important pests of blackcurrant and have to be controlled on many plantations in Poland. The first of pests develops one generation a year. The flight of adults was evaluated in virtue of pheromone traps. The flight starts at the turn of May and lasts up to the first days of August. The optimum time for control is the period of mass flight of moths i.e. between blooming and fruit harvest, but in some years and on some plantations also after the harvest. The black currant stem midge develops two generations a year, the first of which begins laying eggs at the turn of May, about four weeks after the development of first flowers, and lasts for 2-4 weeks. Midges of the second generation begin to lay eggs in wounds caused during fruit harvest. A method of detecting the pest and forecasting the control time was developed: artificial wounds on shoots were made, into which females began laying eggs. Well penetrating insecticides like acetamiprid, bensultap, etophenprox, phosalone and fenitrothion revealed as the most effective control agents against these pests. Their action was satisfactory towards both pests, thus recommending them as useful for the purposes of integrated pest control on black currant plantations seems to be reasonable.

Key words: currant clearwing moth, black currant stem midge, monitoring of pests, integrated pest control, *Synanthedon tipuliformis, Resseliella ribis*, black currant

Introduction

Currant clearwing moth is known as pest of currants and gooseberry since 100 years. Now it is a dangerous pest of currants in many countries, where currants are grown (Labanowska, 1996). In Poland it damages 20-50%, and sometimes even 90% of shoots (Leska, 1966; Pala et al., 1986). According to Balazs (1969), in Hungary 6.8-12.5% of the yield is lost, when 5-10% of shoots are damaged, but if the damage rises to 40-50% of shoots, the losses increase to 38.8 -59.5% of the yield. Many years ago, currant clearwing moths were controlled by watering the plantation with some systemic insecticides after fruit harvest (Leska, 1967; Witkowska & Wojnarowska, 1976). Later, a good control of the pest was available by spraying the plants during the period of moth flying (Ragazzini & Briolini, 1980, Pala et al., 1986, Frankenhuysen, 1988). Now, the best method of grasping the moth flying period is using pheromone traps (Szöcs et al., 1990).

The black currant stem midge is known as a pest of currants for 40 years, and its importance for currant plantations is difficult to overestimate (Labanowska, 1996). According to Bolyryiew (1963) the yield from shoots damaged by this midge decreases by about 47-64%. A good method to establish the flight period of black currant stem midge is to observe the females laying eggs on shoots (Labanowska, 1997).
Material and methods

The experiments were carried out over 1998-99 in the Research Institute of Pomology and Floriculture at Skierniewice. Detection of currant clearwing moth and observation of the flight of adults was based on pheromone traps (produced by Agri-Sense). The spray treatments have been conducted during mass flying of adults, in a parts (about 500 m²) of a larger black currant plantations, about 8-9 years old, cv. Ojebyn. A tractor sprayer "Sepia" or "Deflector" were used to apply the spray solution at the rate of 1000 l/ha. The effectiveness of insecticides was evaluated during October. The number of one-year-old shoots injured by larvae of currant clearwing moth has been counted. The results are listed in Table 1.

Table 1. Effectiveness of insecticides in control of the currant clearwing moth Synanthedon tipuliformis Cl. on black currants

<table>
<thead>
<tr>
<th>Insecticide (active ingredient)</th>
<th>Dose rate L or kg per ha</th>
<th>No. of treatments</th>
<th>Damaged shoots in %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1998</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sumithion Super 1000 EC (fenitrothion) and Trebon 10 S C (etofenprox)</td>
<td>1.125 0.9</td>
<td>1 1</td>
<td>2.3 a* 4.4 ab 12.4 b</td>
</tr>
<tr>
<td>Trebon 10 S C (etofenprox)</td>
<td>0.9</td>
<td>2</td>
<td>4.4 ab</td>
</tr>
<tr>
<td>Zolone 350 EC (phosalone)</td>
<td>2.6</td>
<td>2</td>
<td>12.4 b</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>–</td>
<td>–</td>
<td>34.2 c</td>
</tr>
<tr>
<td><strong>1999</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bancol 50 WP (bensultap)</td>
<td>1.0</td>
<td>3</td>
<td>1.4 a</td>
</tr>
<tr>
<td>Trebon 10 S C (etofenprox)</td>
<td>0.9</td>
<td>3</td>
<td>6.4 b</td>
</tr>
<tr>
<td>Zolone 350 EC (phosalone)</td>
<td>2.6</td>
<td>3</td>
<td>3.8 ab</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>–</td>
<td>–</td>
<td>18.4 c</td>
</tr>
</tbody>
</table>

Dates of treatment: June 5 and 19, 1998; May 26, June 10 and July 21, 1999
* Means followed by the same letter are not significantly different at the 5% level (Duncan's multiple range t-test)

Table 2. Effectiveness of insecticides in controlling black currant stem midge Resseliella ribis Marik.

<table>
<thead>
<tr>
<th>Insecticide (active ingredient)</th>
<th>Dose rate L or kg per ha</th>
<th>Damaged shoots In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bancol 50 WP (bensultap)</td>
<td>1.0</td>
<td>1.2 b*</td>
</tr>
<tr>
<td>Mospilan 20 SP (acetamiprid)</td>
<td>0.2</td>
<td>0.2 a</td>
</tr>
<tr>
<td>Trebon 10 S C (etofenprox)</td>
<td>0.9</td>
<td>0.4 ab</td>
</tr>
<tr>
<td>Zolone 350 EC (phosalone)</td>
<td>2.6</td>
<td>0.0 a</td>
</tr>
<tr>
<td>Check (untreated)</td>
<td>–</td>
<td>6.9 c</td>
</tr>
</tbody>
</table>

Date of treatment: May 26 and July 19, 1999. Date of counting: October 20, 1999
* Means followed by the same letter are not significantly different at the 5% level (Duncan's multiple range t-test)

The time of laying eggs by the females of black currant stem midge, and the date of control
were determined in virtue of eggs deposited on artificially incised, one-year-old shoots. The spray treatments were applied at the peak of laying eggs by females of the first generation and than - against the second generation, just after the harvest. The chemical control has been conducted in a parts (about 200 m²) of a larger black currant plantation, about 6-7 years old, cv. Titania. A knapsack "Turbine" motor sprayer was used to apply the tested insecticides in a volume of spray liquid of 1000 l/ha. The effectiveness of insecticides was evaluated in October, after the leaves had dropped, when injured one-year-old shoots were counted. The results are listed in Table 2.

Results and discussion

In 1998-99 the flight of currant clearwing moths began at the end of May and had lasted to the middle of August (Fig. 1-2).

![Figure 1. Currant clearwing moth – Synanthedon tipuliformis Cl. catches to pheromone traps](image1)

![Figure 2. Currant clearwing moth – Synanthedon tipuliformis Cl. catches to feromone traps](image2)

The optimum date for the pest control falls on the moment of mass flight of the moths in
June, between blooming and fruit harvest. Some of moths appeared in July, after the fruit harvest and had partially coincided with control of the second generation of black currant stem midge. In 1998, the best results of control were obtained with two spray treatments executed with fenitrothion at the first peak of moth flight and with etofenprox applied two weeks later. Also etofenprox used twice at above mentioned dates, showed satisfactory control of currant clearwing moth. Phosalone gave poorer results of control than etofenprox, but the differences were not significant. In 1999, the lowest number of damaged shoots appeared on bushes treated with bensultap. Etofenprox and phosalone gave results somewhat weaker than bensultap. In both experiments the treated bushes had a much lower number of damaged shoots, than had untreated ones (18-34% injured shoots). Also in Netherlands two spray applications of insecticides during the flight period were found to afford satisfactory control of the sesiid (Frankenhuyzen & Jansen, 1984; Frankenhuyzen, 1988).

![Figure 3. The number of eggs of the black currant stem midge – *Resseliella ribis* (Marik.) average per one cutting](image)

Similarly as in Europe, the black currant stem midge develops in Poland two generations a year (Burdajewicz, 1975; Labanowska, 1997; Winter, 1988). Females of the first generation start to lay eggs about four weeks after the beginning of bloom and it lasts 2-4 weeks (Fig. 3).

From fruit harvest in July beginning, females of the second generation start to lay eggs into the wounds evoked due to the mechanical harvest. In 1999, a good control of this pest was obtained with acetamiprid, phosalone, etofenprox and bensultap applied twice each, against the first and the second generations of black currant stem midge, respectively. The treated bushes showed a significantly lower percentage of damaged one-year-old shoots, as compared to untreated ones (about 7% injured shoots).

To summarize, the optimum term for the currant clearwing moth control falls during mass flight of the moth, i.e. between blooming and fruit harvest and in some years after fruit harvest, what coincides with the control date of the second generation of black currant stem midge.

Pheromone traps are very useful for observations of moth flying time. The optimum term for controlling black currant stem midge is the peak of laying eggs by females of the first and second generations.

Observations of egg laying by currant stem midge females is very useful to establish proper timing of controlling this pest.

Effectiveness of acetamiprid, bensultap and etofenprox is satisfactory in controlling currant clearwing moth and black currant stem midge. The results were similar to those obtained with
standard insecticides - phosalone and fenitrothion. Some of these insecticides are useful in the program of integrated pest control.

Acknowledgements

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Current pest management status in IFP in Uruguay

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Abstract: The integrated fruit production program (IFP) in Uruguay began in 1997 with the participation of 25 growers. At the present time there are more than 100 growers in the program. Most of the fruit production is at family owned with middle sized orchard farms. Most of the growers have in the same orchard farm, apples, pears and peaches. The distribution pattern of the different orchards (small size and different fruit species in the same farm) favors a strong interaction among neighbored orchards. The main frame for pest management in IFP is mating disruption for the key pest of each crop: Cydia molesta (OFM) on peaches, and Cydia pomonella (CM) on apples and pears. During the last growing season (1999/00) 73 % of the peach orchards received two or less insecticides sprays. Only late varieties required two or more insecticide sprays to control OFM. No secondary insect pests were detected. In the case of pome fruits most of the pear orchards received two to three insecticide sprays while most of apple orchards received three to four insecticide sprays. Almost all these insecticide sprays were to control secondary pests. After 3 years of IFP implementation, incidence of secondary pests on apples and pears increased significantly compared to conventional orchards. Only mite pests decreased significantly. Main secondary pest were native leafrollers (Bonagota cranaodes and Argyrotaenia sphaleropa), mealybugs (Pseudococcus viburni) and OFM. In spite of the high incidence of secondary pests, growers on IFP, sprayed 50% less insecticides than those on conventional production. To decrease current insecticide input in IFP, research programs are focused in attracticides to control leafrollers, combined mating disruption for OFM and CM on apples and pears and selective insecticides to control mealybug. The main concern for the development of new tools to control secondary pests is cost increase.

Key words: Integrated Fruit Production, IFP, Uruguay, peaches, apples, pears

Introduction

Most of the fruit production in Uruguay is at family level with middle sized farms (average 10 to 30 has). Almost all the growers have in the same farm, apples, pears and peaches. Not all the growers of each region are IFP participants, then the distribution pattern of the orchards allows a wide range of fruit species diversity and orchard management diversity.

The integrated fruit production program (IFP) in Uruguay began in 1997 with the participation of 25 fruit growers. At present time there are more than 100 growers in the program, representing about 5% of the total fruit area. As a landscape view each fruit region have small patches under the guidelines of IFP program. This scenario favors a strong interaction among the neighbored orchards and make it difficult to develop an area-wide program. However growers are very enthusiastic and program is in constant growth.

Current pest management in conventional orchards

The main pest management strategy in conventional orchards is pesticide spraying when pests reach economic thresholds. However several growers still spray insecticides in a calendar basis.
The key pests are codling moth (CM, *Cydia pomonella*) on apple and pears and oriental fruit moth (OFM, *Cydia molesta*) on peaches. In the case of CM, OP’s resistant strains have been detected since 1995, then insecticides input increased dramatically. Eight to twelve insecticide sprays are necessary in average to avoid CM fruit damage. In the case of peaches OFM increases its potential damage from early to late varieties. For midseason and late varieties five to seven insecticide sprays are necessary to control OFM.

For apples and pears, some additional insecticide or miticide sprays are necessary to control native leafrollers (*Bonagota cranaodes* and *Argyrotaenia sphaleropa*), mealybug (*Pseudococcus viburni*) and European red mite (*Panonychus ulmi*).

In the specific case of pears, pear psylla, (*Cacopsylla pyricola*) generally requires at least one insecticide spray after harvest.

For all the fruit species San Jose scale, (*SJS, Quadraspidiotus perniciosus*) may require specific summer sprays, but as a general rule it is routinely controlled during winter.

In summary, conventional apple and pear orchards have 10 to 15 insecticide and acaricide sprays while mid and late peach varieties have 6 to 9 insecticide sprays per growing season. Most of the insecticides used in conventional orchards are OP’s insecticides, mainly azinphosmethyl, phosmet, methyl parathion, methidathion and clorpyriphos.

**Background for pest management in IFP orchards**

The main control strategy for the key pests (OFM and CM) in IFP orchards is mating disruption. However, because of the size and arrangement of our orchards, mating disruption may require some additional insecticide sprays.

Decreasing insecticide sprays on apple and pear orchards allowed significant population increase of native leafrollers, then additional insecticide sprays may also be required. Monitoring pheromone traps for both leafroller species are used to decide insecticide sprays. In case that insecticide sprays are needed, spinosad is strongly recommended. Secondary pests did not arise on peaches.

Mealybugs and San José scale seems to increase their incidence in IFP apple and pear orchards due to the avoidance of broad spectrum insecticides. The only insecticide allowed to use for both pests after blooming is buprofezin, however winter treatments with oil and OP insecticides to control SJS are strongly recommended.

Pear psylla incidence depends on orchard and year. Generally psylla attack is after harvest. In this situation, insecticide sprays are very disruptive to natural enemies because their major activity is during fall. Insecticides allowed to be used are amitraz and abamectin.

**Current pest situation in IFP orchards**

Pest control under IFP guidelines was excellent the first two years of the program implementation, with remarkable reduction of insecticide sprays. However, there was a significant increase of secondary pests during the last growing season (1999/00).

For peaches, OFM populations were higher than expected, then insecticide input was higher than the first two years. Nevertheless 73 % of the peach orchards received two or less insecticide sprays. Only late varieties required two or more insecticide sprays to control OFM (Fig. 1).
For pome fruits, most of the pear orchards received two to three insecticide sprays (Fig. 2), while most of apple orchards received three to four insecticide sprays (Fig. 3). Some of these insecticide sprays were to control secondary pests like leafrollers and SJS.

Since the more dangerous pest that appeared during 1999/00 growing season in apple and pear orchards was OFM, most of the insecticide sprays were applied to avoid OFM damage. Fruit samples taken during all the growing season in orchards with some level of fruit damage
(Fig. 4) showed that most of the larvae inside the fruit from November to beginning of December were codling moth, while from December to February were oriental fruit moth.

![Figure 4. Percentage of CM or OFM larvae inside fruits during the growing season.](image)

For all fruit orchards, San Jose scale attacks were higher than expected, however the same situation was also observed in conventional orchards.

After three years of IFP implementation, the incidence of secondary pests on apples and pears increased, compared to conventional orchards. Main secondary pests were native leafrollers and mainly OFM. Only European red mite almost disappeared as a pest on apple and pear orchards under IFP guidelines.

In spite of the high incidence of secondary pests, 80% of the growers under IFP guidelines, used less than 50% insecticide sprays than those on conventional production.

Table 1. Accumulated leafrollers trap captures and fruit damage in different orchards treated with attracticides

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Treatment</th>
<th>A. sphaleropa traps captures</th>
<th>B. cranaodes traps captures</th>
<th>Leafrollers fruit damage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Untreated</td>
<td>56</td>
<td>130</td>
<td>4.16</td>
</tr>
<tr>
<td>1</td>
<td>Attracticides</td>
<td>5</td>
<td>32</td>
<td>1.50</td>
</tr>
<tr>
<td>2</td>
<td>Untreated</td>
<td>75</td>
<td>49</td>
<td>1.70</td>
</tr>
<tr>
<td>2</td>
<td>Attracticides</td>
<td>5</td>
<td>5</td>
<td>1.15</td>
</tr>
<tr>
<td>3</td>
<td>Untreated</td>
<td>186</td>
<td>32</td>
<td>2.83</td>
</tr>
<tr>
<td>3</td>
<td>Attracticides</td>
<td>1</td>
<td>1</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Current research for IFP program

The main researches for pest management in IFP focus to:

- Develop pest control strategies alternative to pesticides, mainly attracticides for leafrollers and mating disruption for OFM on apples and pears.
– Evaluation of new selective soft insecticides. In a short term prospective SJS and mealybugs are the main concern.

– Comparison of environmental impact of conventional and IFP orchard management.

Attracticides (200 traps/ha) were evaluated during 1999/00 to control both species of native leafrollers (B. cranaodes and A. sphaleropa). Preliminary results were very promising (Table 1) but it is still necessary to test this strategy under higher leafrollers populations.

OFM mating disruption is widely used on peaches, but it was not tested on pome orchard fruits. Next growing season (2000/01) OFM mating disruption will be evaluated on pear and apple orchards under CM mating disruption.

Buprofezin is currently used in IFP orchard for summer control of mealybugs and San Jose scale, however new selective insecticides have to be evaluated to improve their control.

Environment impact in orchards under IFP guidelines will be compared with conventional orchards.

Future prospects in IFP

Growers attitude is highly positive to the IFP program, however some handicaps in the pest control component have to be solved to improve the economic sustainability of the program.

In the case of peaches, current IFP pest management recommendations are widely used with good confidence of the growers and without any concern about potential attack of secondary pests or pest control cost increase.

In the case of pome fruits, the complexity of the pest control component make it difficult to implement without increasing costs. Current tools used in the program like CM mating disruption and selective insecticides plus potential tools to be used in the program like attracticides for leafrollers and mating disruption for OFM, will significantly increase the pest control cost, comparing to conventional orchards. Like in several countries in Europe, financial support from the government will be necessary to ensure the economic sustainability of the program.

References

Alternatives to fumigation for control of Apple Replant Disease in Washington State orchards

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Introduction

The poor growth of fruit trees that occurs after replanting on a site that previously supported the same or closely related species is termed “replant disease.” In apple, replant disease is widespread and has been documented in all of the major fruit-growing regions of the world (Traquair, 1984). Apple replant disease is characterized by uneven growth of young trees but, when severe disease pressure is encountered, poor growth may be exhibited by a majority of trees on the site and death of young trees may occur. Symptoms of apple replant disease include severe stunting, shortened internodes, rosetted leaves, small root systems, decayed or discolored roots, and reduced productivity. Affected trees have less lateral roots and few root hairs. Replant disease has significant economic implications due to the continuous reduction in productivity over the life of the orchard. In addition to tree replacement costs for sick or dead trees, affected trees generally bear fruit 2 to 3 years later than healthy trees and fail to attain comparable yields. In Washington State, failure to control replant disease typically results in nearly a $100,000 (US) per hectare reduction in gross returns over a 10-year period (Smith, 1995).

Although difficulty in reestablishing old orchard sites has been documented for over 200 years (Mai & Abawi, 1981), the cause of the disease has remained unclear. Supposed causal factors have varied among geographic regions or between orchards in the same area. Apple replant disease has been attributed to a number of possible abiotic factors (low or high soil pH, phytotoxins, poor soil structure, heavy metal and arsenic contamination) as well as biotic factors (pathogens, nematodes). While abiotic factors may be important in some instances, the dramatic tree growth response to soil pasteurization or fumigation indicates that replant disease is primarily a biological phenomenon (Mai & Abawi, 1981; Jaffee et al., 1982; Slykhuis & Li, 1985).

Currently, control of apple replant disease in commercial Washington State orchards is accomplished primarily through the use of pre-plant soil fumigation with materials such as methyl bromide, metam sodium, and chloropicrin. This practice is discouraged by Integrated Fruit Production (IFP) programs and is being restricted by loss of chemical fumigants. With the increase in acreage of organic apple production (Granatstein & Dauer, 2000a) and the shorter life of an apple planting due to variety renewal, the need for alternative control strategies has intensified. A new research program was launched in 1996 at the USDA-ARS Tree Fruit Research Laboratory to clarify the causes of replant disease in the state and to explore alternative control strategies, especially those that could replace the use of methyl bromide.
Causes of Replant Disease

Recent studies in Washington State indicate that a fungal pathogen complex is the predominant cause of replant disease (Mazzola, 1997; Mazzola, 1998a). Soil and root samples were collected from five apple orchards in several parts of the state. Samples were evaluated for the presence of bacterial and fungal organisms, as well as for nematodes. The only plant parasitic nematode found at a level of concern was Pratylenchus penetrans, and it exceeded the population threshold for damage in only one orchard. In contrast, a fungal complex, consisting of Cylindrocarpon destructans, Phytophthora cactorum, Pythium spp., and Rhizoctonia solani was consistently isolated from symptomatic trees in all orchards. These fungi were pathogenic to apple in greenhouse tests.

When soil from replant orchards was pasteurized, the growth response of apple seedlings was consistent and generally large (Table 1). Bioassays of selective biocides produced mixed results, with seedling growth generally less than pasteurization. The studies indicated that elimination of one fungal pathogen often led to the proliferation of another on the roots.

Table 1. Effect of pasteurization and selective fungicides on growth of ‘Gala’ apple seedling (mg) in replant soils from 5 orchards (greenhouse bioassay).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CV</th>
<th>DR-1</th>
<th>DR-2</th>
<th>GC-1</th>
<th>GC-2</th>
<th>GC-3</th>
<th>KM</th>
<th>WVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>626</td>
<td>549</td>
<td>633</td>
<td>661</td>
<td>249</td>
<td>504</td>
<td>435</td>
<td>495</td>
</tr>
<tr>
<td>Pasteurize (70°C)</td>
<td>731</td>
<td>720</td>
<td>828</td>
<td>1213</td>
<td>601</td>
<td>729</td>
<td>572</td>
<td>629</td>
</tr>
<tr>
<td>Benomyl</td>
<td>611</td>
<td>470</td>
<td>649</td>
<td>971</td>
<td>279</td>
<td>641</td>
<td>402</td>
<td>541</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>722</td>
<td>734</td>
<td>687</td>
<td>913</td>
<td>496</td>
<td>557</td>
<td>558</td>
<td>552</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td>70</td>
<td>91</td>
<td>69</td>
<td>127</td>
<td>84</td>
<td>101</td>
<td>104</td>
</tr>
</tbody>
</table>

Replant disease develops quickly in apple orchards. At one location, soils from contiguous apple plantings ranging in age from 0 to 5 years were sampled and bioassayed. The site had previously been in dryland wheat production for decades, with no history of orchard. By the third year in orchard, apple seedling growth suppression was evident relative to the control (Table 2). A part of this can be attributed to the loss of natural soil suppressiveness to R. solani. Significant shifts in the bacterial community of the apple rhizosphere were identified that correlate with the increase in replant disease (Mazzola, 1999). For example, Burkholderia declined from 86% of bacterial isolates examined from soil prior to apple production to 8% of the isolates from soil after 5 years of apple. The fluorescent pseudomonad population was initially dominated by P. putida (>65%), but within 3 years of orchard establishment, >85% of isolates were identified as P. fluorescens bv. III.

There is also a spatial component to replant disease. Growers often report a “wave” effect when a new planting is made with rows perpendicular to the former rows. Where the new row intersects the old, trees are often stunted. Bioassays of soil taken at different distances from the tree trunk showed that disease severity does decline with distance, especially in higher density plantings where the majority of tree roots, and thus the changes in microbial community, are confined to a 1.5-2 m band generally kept weed-free (Table 3).
Table 2. Interaction of orchard age and inoculation of soil with *Rhizoctonia solani* AG-5 on suppression of ‘Gala’ apple seedling growth (greenhouse bioassay of field soils).

<table>
<thead>
<tr>
<th>Orchard Age</th>
<th>Control</th>
<th>+ <em>R. solani</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-cultivated</td>
<td>0.88a</td>
<td>0.89a</td>
</tr>
<tr>
<td>First year</td>
<td>0.83a</td>
<td>0.77a</td>
</tr>
<tr>
<td>Second year</td>
<td>0.82a</td>
<td>0.81a</td>
</tr>
<tr>
<td>Third year</td>
<td>0.66a</td>
<td>0.36b</td>
</tr>
<tr>
<td>Fourth year</td>
<td>0.67a</td>
<td>0.47b</td>
</tr>
<tr>
<td>Fifth year</td>
<td>0.58a</td>
<td>0.37b</td>
</tr>
</tbody>
</table>

Means in the same row with the same letter are not significantly different (*P*=0.05).

Table 3. Effect of location and fumigation on growth of ‘Gala’ apple seedlings in replant soil (bioassay of field soil).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root weight (g)</th>
<th>Shoot weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row (control)</td>
<td>0.26a</td>
<td>0.69</td>
</tr>
<tr>
<td>Row – fumigated</td>
<td>0.52b</td>
<td>0.83</td>
</tr>
<tr>
<td>Aisle</td>
<td>0.61b</td>
<td>0.74</td>
</tr>
</tbody>
</table>

*p<0.0001 p=0.051*

**Alternative Control Strategies**

Based on the research into the cause of replant disease, four general strategies of control emerged: directly kill pathogens; change the environment to inhibit pathogens; avoid the pathogens through time or space; utilize plants resistant to the pathogens or tolerant of damage. Several alternative control strategies under investigation are discussed below.

The use of microbial biocontrol agents was explored. One commercial product, RootShield (a *Trichoderma* product from BioWorks, Geneva, NY) was tested in several locations and did not provide any improved tree growth over a non-treated control. A potential biocontrol organism was identified during the investigation of the microbial community shifts in orchards (Mazzola, 1998b). Suppression of *R. solani* AG-5 was induced by *Pseudomonas putida* strain 2C8, a naturally occurring inhabitant of the apple rhizosphere from an orchard soil previously cultivated to wheat. This organism has been tested as a possible biocontrol agent for replant disease in the greenhouse and in the field, using it as a root dip and a soil drench. As greenhouse results have been superior to field results, a procedure was developed to enhance field survival of the organism by raising it in a carbon-limited culture (Gu and Mazzola, 2000 in press). On-going studies show that this procedure has enhanced suppression of *R. solani* over both the original strain and the untreated control (Table 4). As the strain 2C8 appears to have primary activity against *R. solani*, it is likely that it will be effective only in conjunction with other treatments that suppress the remaining components of the pathogen complex.
Table 4. Colonization of the apple rhizosphere and suppression of *Rhizoctonia solani* AG-5 root infection by *Pseudomonas putida* strain 2C8 and its carbon starved derivatives at 30 days after planting (greenhouse study).

<table>
<thead>
<tr>
<th>P. putida strain</th>
<th>CFU((x 10^5)) /g root</th>
<th>% <em>R. solani</em> root infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>–</td>
<td>54.3c</td>
</tr>
<tr>
<td>2C8</td>
<td>1.8a</td>
<td>42.3b</td>
</tr>
<tr>
<td>2C8-26A</td>
<td>11.6b</td>
<td>16.7a</td>
</tr>
<tr>
<td>2C8-28C</td>
<td>13.2b</td>
<td>17.9a</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different (\(P=0.05\)).

A series of on-farm tests evaluated the potential for compost to provide general suppression of replant disease. Organic apple growers have been relying on this strategy, but no data were available to evaluate its effectiveness. While there was a weak (but statistically significant) increase in apple tree growth with increasing compost rate, the more important finding was the difference in average tree growth (cumulative % increase in trunk cross-sectional area over 3 years) from sites not previously planted to apple (500-800%) compared to replant sites that had been fumigated, ripped, fertilized and amended (200-500%) (Granatstein and Dauer, 1999; Granatstein and Dauer, 2000b). Thus, even with the best current practices, it appears that tree growth does not reach its biological potential on many replant sites. Another major avenue of research has been the use of fallow and cover crops to alleviate replant disease. Disease severity did not decline in the field with a one-year bare ground fallow treatment. Greenhouse experiments with short-succession wheat planting prior to apple seedling planting led to consistent improvements in tree growth relative to the control (Table 5). Recovery of *Rhizoctonia* and *Pythium* from apple root was lower from the wheat treatments, while *Cylindrocarpon* and *Fusarium* increased. Wheat cropping also reduced populations of *P. penetrans*. The suppression of *Rhizoctonia* varied greatly by wheat cultivar, as did the composition of the fluorescent pseudomonad community. The growth-promoting wheat cultivars (for apple) elicited a reduction in *Pseudomonas fluorescens* and *Pseudomonas syringae* levels, but enhanced levels of *P. putida*. The mechanism at work may be a combination of lack of substrate from wheat roots for apple pathogens and antibiotic suppression of pathogens by *P. putida* (Mazzola and Gu, 2000). Trials are in progress to validate this alternative control in the field setting.

As the wheat treatment did not lead to tree growth equal to soil pasteurization in many cases, the use of a biofumigant crop was evaluated. Much recent research has been done in this area, particularly with *Brassica* spp. (Brown and Morra, 1997). Experiments were conducted growing rapeseed plants and incorporating the residue into the soil, as well as amending soils with rapeseed meal, a by-product of the oil extraction process. The rapeseed meal appears to be more promising than the cover crop approach. Tree growth in rapeseed meal amended soil (0.1%) has been similar to pasteurization and fumigation in greenhouse and field studies, respectively (Mazzola et al., 2001). However, at higher amendments rates, the meal can be phytotoxic and kill trees (Table 6). The meal also appears to be providing substantial amounts of nutrients that may be enhancing tree growth in addition to any biological mechanism. Various sequences of rapeseed meal and wheat are being tested to search for optimal combinations, which may need to be adapted to different soil types.
Table 5. Impact of prior wheat cultivation on growth of ‘Gala’ apple seedlings in CV orchard replant soil artificially infested with *Rhizoctonia solani* AG-5 (greenhouse study).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Root weight (g)</th>
<th>Shoot weight (g)</th>
<th>Shoot height (cm)</th>
<th>% Root infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>1.14a</td>
<td>1.13a</td>
<td>9.8a</td>
<td>17.3b</td>
</tr>
<tr>
<td>Control (+)</td>
<td>0.91a</td>
<td>0.98a</td>
<td>9.1a</td>
<td>29.4c</td>
</tr>
<tr>
<td>Pasteurization (+)</td>
<td>1.37ab</td>
<td>2.28b</td>
<td>12.2a</td>
<td>44.0d</td>
</tr>
<tr>
<td>‘Eltan’ wheat</td>
<td>1.84bc</td>
<td>3.01c</td>
<td>16.4b</td>
<td>13.3c</td>
</tr>
<tr>
<td>‘Penawawa’ wheat</td>
<td>2.16c</td>
<td>3.38c</td>
<td>17.8b</td>
<td>2.2a</td>
</tr>
<tr>
<td>‘Rely’ wheat</td>
<td>1.42ab</td>
<td>2.93bc</td>
<td>16.8b</td>
<td>17.7b</td>
</tr>
</tbody>
</table>

All soils were inoculated with *R. solani* except Control (-). Means in a column followed by the same letter are not significantly different (*P*=0.05).

Table 6. Impact of rapeseed meal amendment on growth of ‘Gala’ apple seedlings in orchard replant soil (greenhouse study).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Seedling mortality</th>
<th>Root weight (g)</th>
<th>Shoot weight (g)</th>
<th>Shoot height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2a</td>
<td>1.01b</td>
<td>0.96a</td>
<td>8.5a</td>
</tr>
<tr>
<td>Pasteurization</td>
<td>0a</td>
<td>1.72c</td>
<td>3.52c</td>
<td>17.0c</td>
</tr>
<tr>
<td>0.1% rapeseed meal</td>
<td>0a</td>
<td>2.13d</td>
<td>3.19c</td>
<td>15.1bc</td>
</tr>
<tr>
<td>1.0% rapeseed meal</td>
<td>7a</td>
<td>1.92cd</td>
<td>5.64d</td>
<td>21.6d</td>
</tr>
<tr>
<td>2.0% rapeseed meal</td>
<td>77b</td>
<td>0.43a</td>
<td>1.56b</td>
<td>11.2b</td>
</tr>
</tbody>
</table>

Means in the same column followed by the same letter are not significantly different (*P*=0.05).

Table 7. Effect of soil treatment on apple tree (Gala/M26) growth and yield in a replant soil (field study planted 1998).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1998-99 Increase in trunk dia. (mm)</th>
<th>2000 Fruit yield (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11.06 cde</td>
<td>4.6 cd</td>
</tr>
<tr>
<td>Fumigation</td>
<td>12.19 bc</td>
<td>7.2 a</td>
</tr>
<tr>
<td>Trench</td>
<td>14.30 a</td>
<td>5.4 bc</td>
</tr>
<tr>
<td>Aisle</td>
<td>12.74 ab</td>
<td>6.4 ab</td>
</tr>
<tr>
<td>Strain 2C8</td>
<td>10.06 def</td>
<td>4.1 cd</td>
</tr>
<tr>
<td>Strain IBX</td>
<td>11.79 bc</td>
<td>4.8 cd</td>
</tr>
<tr>
<td>Trichoderma</td>
<td>9.45 ef</td>
<td>4.7 cd</td>
</tr>
<tr>
<td>Dividend</td>
<td>11.50 bed</td>
<td>3.4 d</td>
</tr>
<tr>
<td>Moncut + metalaxyl</td>
<td>10.72 cde</td>
<td>4.5 cd</td>
</tr>
<tr>
<td>Moncut</td>
<td>8.73 f</td>
<td>4.3 cd</td>
</tr>
<tr>
<td>Humic acid</td>
<td>9.73 ef</td>
<td>3.4 d</td>
</tr>
</tbody>
</table>

1 Treatment explanation: Trench = autumn trenching in planting row left exposed over winter. Aisle = moving new planting row to former drive aisle. Strain 2C8, Trichoderma, and IBX = microbial biocontrols. Moncut, metalaxyl, and Dividend = selective fungicides. Humic acid = soil amendment.
Developing an integrated approach

Given that no single alternative strategy for controlling apple replant disease can currently provide the level and consistency of control obtained with methyl bromide or other broad-spectrum soil fumigants, researchers must now work with the promising alternatives and integrate them into various configurations for eventual field testing. The biological cause of replant disease can vary substantially among orchards, soil types, and regions. And biologically based controls are likely to be less consistent in their effectiveness than chemical biocides. As promising combinations of practices for replant disease control are identified, these can then be evaluated in the context of overall orchard management, especially that of the orchard floor. Soil amendments for replant control will impact tree nutrition. Cover crops such as wheat will influence weed control and insect fauna. For example, current studies of orchard mulching in British Columbia have identified significant reductions in *P. penetrans* under certain mulch materials (Hogue, 1999). Where feasible, replanting a former apple site to a non-affected crop such as cherry is a biologically viable strategy, a form of crop rotation. Systems for delivering microbial biocontrol agents to turf (e.g. golf courses) are commercially developed and could be utilized in tree fruit for both disease control and crop nutrition. The on-going research on apple replant disease in Washington State points to the wealth of biological resources and relationships that may be exploited to control the disease in a more sustainable manner.

**References**

Reducing losses due to fungal rots in cider apple orchards

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National Association Cider Makers, Long Ashton Research Station, Bristol, BS18 9AF, UK

Abstract: Fungal rots reduce the yield and quality of cider apples and, if excessive, can lead to rejection of fruit consignments at the factory. Improving fruit quality is a key part of modern cider production and reducing rotting an important part of this. Studies on rot incidence in orchards of the main cider apple cultivars, Somerset Redstreak, Michelin and Dabinett, in the two main cider apple production areas of Herefordshire and Somerset between 1995-1997 showed that most rotting was due to Monilinia fructigena (brown rot) and Phytophthora spp. Delays in dispatch of harvested fruit to the factory increased rot incidence particularly in September when temperatures were higher. Phytophthora is a soil borne fungus that infects fruit when they come into contact with soil. Modern cider apple production techniques where fruit is mechanically harvested off the orchard floor make it difficult to implement control measures for Phytophthora, but losses can be minimised by ensuring rapid dispatch of fruit to the factory for processing. M. fructigena can only invade fruit via wounds. Studies on the epidemiology of brown rot in four cider orchards in two seasons showed that damage to fruit by sawfly (Hoplocampa testudinea) in early summer and codling moth (Cydia pomonella) in late summer provided the main entry points for M. fructigena. Control of these two pests in cider apple production is considered unimportant. In orchard trials where codling moth was controlled, rot incidence was reduced by 50%. Strategies for reducing rot incidence in cider apple orchards are discussed.

Key words: brown rot, Monilinia, Phytophthora, codling moth, sawfly

Introduction

Modern cider apples are produced in semi intensive bush orchards on MM106, MM111 or M26 rootstocks mainly in the west of England. Many different cider apple cultivars exist but Somerset Redstreak, Michelin and Dabinett are the main ones grown. Pest and disease control is important to maintain yield, but treatments for control of scab and powdery mildew are minimised since first quality fruit is not a requirement. Similarly use of insecticides is minimal and codling moth (Cydia pomonella) and sawfly (Hoplocampa testudinea) damaged fruit are usually common in most cider apple orchards. Fruit is machine harvested from September – December by shaking trees and collecting fruit off the ground. The collected fruit is then washed, sorted to remove debris and stored temporarily on a concrete holding area (the pad) prior to transport by lorry to the cider factory for processing. The method of harvesting means that rotted fruit are collected along with the healthy and, in seasons favourable for rotting, rot incidence can be high, particularly where fruit collection is delayed. Fruit consignments with high levels of rots are rejected by the factory, since the inclusion of excessive levels of rotted fruit in the processing reduces the efficacy of sulphur dioxide added to kill wild yeasts and results in poor quality inconsistent cider. Improving fruit quality is one of the key areas in modern cider apple production. The objectives of this project were to identify the main causes of rotting in cider apples and develop methods for reducing rot incidence.
Materials and methods

Identification of fungal rots in cider apples
Orchards containing the three main cider apple cultivars, Somerset Redstreak, Michelin and Dabinett, at two sites in Herefordshire and one site in Somerset were selected for study between 1995 and 1997. These were visited at or near harvest and the fruit examined for rots either on the tree or on the ground in the orchard. A sample of 100 rotted fruit was taken and the causes of rotting identified either directly by microscopic examination or indirectly by culturing onto Potato Dextrose Agar. Fruit was also sampled from the pad and from the fruit delivery area at the cider factory and similarly examined.

Effect of delayed fruit collection on rot incidence
A random sample of approximately 400 fruit was taken from harvested fruit on the concrete pad awaiting transport to the factory. These were divided into two samples. In one sample the incidence and identity of rots was recorded. The remaining sample was placed outside and similarly examined for rots approximately one week later, to simulate the effect on rot incidence of delayed fruit collection. Samples were taken in early October, mid October and mid November.

Studies on main causes of wounds in apples colonised by Monilinia fructigena
Orchards containing the main cider apple cultivars at two sites in Herefordshire and two in Somerset were chosen for the study on fruit damage. Each orchard was visited on three occasions, July and September and at harvest. At each visit the numbers of fruit infected with brown rot (Monilinia fructigena) on the tree and ground, and the cause of the damage colonised by the fungus, were recorded.

Table 1. Incidence of fungal rots per 100 rotted fruit for cvs. Somerset Redstreak, Dabinet or Michelin from two sites in Herefordshire and one site in Somerset in 1996.

<table>
<thead>
<tr>
<th>Fungal rot</th>
<th>Hereford</th>
<th>Somerset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Somerset Redstreak</td>
<td>Somerset Redstreak</td>
</tr>
<tr>
<td></td>
<td>(site 1)</td>
<td>(site 2)</td>
</tr>
<tr>
<td>Monilinia fructigena</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>Phytophthora spp</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Botrytis cinerea</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Botryosphaeria obtusa</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fusarium spp</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Penicillium spp</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Other rot</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Results

Identification of fungal rots in cider apples
Most rotting in the three years of the study was caused by M. fructigena and by Phytophthora species (mainly P. cactorum and P. syringae) (Tables 1 and 2). In the orchard in September
up to 25% of fruit infected with *M. fructigena* were recorded on some trees. *Botrytis cinerea*, *Botryosphaeria obtusa*, *Fusarium* spp. and *Penicillium* spp. were also recorded but usually at much lower incidence.

Table 2. % rotting in cider apples sampled from fruit consignments at the factory in October or November 1997

<table>
<thead>
<tr>
<th>Date sampled</th>
<th>Cultivar</th>
<th>% rotted apples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>M. fructigena</em></td>
</tr>
<tr>
<td>1 October</td>
<td>Major</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>S Redstreak</td>
<td>23</td>
</tr>
<tr>
<td>14 October</td>
<td>Ashton Bitter</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Michelin</td>
<td>3</td>
</tr>
<tr>
<td>10 November</td>
<td>Dabinett</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Michelin</td>
<td>8</td>
</tr>
</tbody>
</table>

**Effect of delayed fruit collection on rot incidence**

The incidence of rotting in samples assessed after seven days incubation outside increased by up to 23% (Table 3) compared to that in samples assessed for rotting at the time of sampling. The increase in rotting was dependent on cultivar and time of sampling. The greatest increases in rot incidence usually occurred in samples harvested in early October when temperatures were higher and rot spread in fruit therefore greater. However actual losses due to rots were greater towards the end of the fruit harvesting period in November, particularly in seasons favourable for *Phytophthora* rot.

Table 3. % Losses due to rots in cider apples assessed on day sampled from pad or seven days later in 1997

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Date sampled</th>
<th>% rotted apples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>M. fructigena</em></td>
</tr>
<tr>
<td>Brown’s Apple</td>
<td>1 October</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>8 October</td>
<td>6</td>
</tr>
<tr>
<td>Michelin</td>
<td>20 October</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>28 October</td>
<td>6</td>
</tr>
<tr>
<td>Dabinett</td>
<td>11 November</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>17 November</td>
<td>0</td>
</tr>
</tbody>
</table>

**Main causes of wounds in cider apples**

The results of the study on causes of wounds were similar for all sites. In samples examined in July, most brown rot colonisation of fruitlets was associated with damage due to apple sawfly (*Hoplocampa testudinea*) larvae (Table 4). In samples examined in September/October most of the brown rot was colonising wounds due to codling moth (*Cydia pomonella*)(Table 5) larvae. At some sites damage due to russet and cracking of fruit was also important.
Table 4. Main causes of wounds in cider apple fruitlets of Somerset Redstreak colonised by *M. fructigena* in July 1996

<table>
<thead>
<tr>
<th>Orchard Site</th>
<th>% Brown rotted fruitlets</th>
<th>Sawfly</th>
<th>Caterpillar</th>
<th>Bird</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herefordshire</td>
<td></td>
<td>72</td>
<td>9</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Somerset</td>
<td></td>
<td>38</td>
<td>19</td>
<td>2</td>
<td>40</td>
</tr>
</tbody>
</table>

Table 5. Main causes of wounds in cider apple fruits of Somerset Redstreak or Dabinett colonised by *M. fructigena* in September 1996

<table>
<thead>
<tr>
<th>Orchard Site</th>
<th>Cultivar</th>
<th>% Brown rotted fruit</th>
<th>Codling moth</th>
<th>Other insect</th>
<th>Bird</th>
<th>Apple scab</th>
<th>Russet/cracking</th>
<th>Contact spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herefordshire</td>
<td>S Redstreak</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Dabinett</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Herefordshire</td>
<td>S Redstreak</td>
<td>71</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Dabinett</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somerset</td>
<td>S Redstreak</td>
<td>97</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Dabinett</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Discussion

The results show that losses due to rots can be high from some orchards and that most rotting is caused by brown rot or *Phytophthora* spp.. The production methods used for cider apples mean that control of these rots may be more difficult compared to culinary and dessert apples. *Phytophthora* is a soil borne fungus and most fruit are infected by contact with the soil. Wet conditions are essential, firstly to activate the fungus in the soil and secondly for fruit infection (Edney, 1978). *P. syringae* is the main species responsible for losses during the harvesting period, but *P. cactorum* can be present earlier in the season. Since fruit is harvested from the orchard floor, it is difficult to prevent soil contamination of fruit, particularly in October and November when weather conditions are more likely to be wet. Pre harvest sprays of captan will protect fruit against *Phytophthora* rot (Berrie & Luton, 1996) but use of such products near harvest is undesirable and may interfere with fermentation. Cultural approaches to control such as covering the soil with a mulch are not compatible with present methods of harvesting. In the future shake and capture harvesting techniques may be developed which will minimise fruit contact with soil and avoid the problem. Until these are developed reducing losses due to *Phytophthora* is dependent on rapid harvesting, collection and processing of fruit.

Brown rot overwinters as cankers or mummified fruit on the tree or orchard floor and the fungus can only gain entry to fruit via wounds, although it can then spread to healthy fruit in the same fruit cluster by contact (Byrde & Willets, 1977). Because of the harvesting methods, most cider apple orchards have very little overwintering brown rot in spring. The studies here indicate that most brown rot on fruit is associated with insect damage. In July this is mainly sawfly and later mainly codling moth. The observations also suggest that the sawfly damage
to fruitlets gives an early opportunity for a build up of brown rot inoculum ready for invasion of wounds due to codling moth later in the summer. The damage caused by codling moth in cider apple orchards is considered unimportant, even though the incidence can be high, and control measures are not usually applied. Sprays for control of sawfly are occasionally applied. Since fungicide sprays have only a limited effect on prevention of brown rot, control is dependent on reducing the fruit damage that allows entry. In an unreplicated large plot orchard trial, a single spray of an insecticide applied in August reduced codling moth damage to fruit and brown rot incidence by 50%. Controlling codling moth in cider apple orchards in summer will increase insecticide inputs and costs, both of which are undesirable but may be unavoidable if fruit quality at harvest is to be improved.

Acknowledgements

This work was funded by the National Association of Cider Makers.

References

Evaluation of the Adem Apple Scab Prediction system on Bramley’s Seedling Apple, *Malus silvestris* x *Malus pumila* Mill in Northern Ireland

Mac An tSaoir, S.
Department of Applied Plant Science, Queens University Belfast, Northern Ireland, Horticultural and Plant Breeding Station, Loughgall, Co Armagh, BT 61 8JB

**Abstract:** The Adem scab prediction system was evaluated on Bramley’s seedling apple trees between 1997 and 1999 at the Loughgall Horticulture and Plant Breeding station in Co Armagh, Northern Ireland. During that period, the Adem system saved five spray applications compared to the standard 10 day spray programme, the yield of apples was reduced by 13% and the number of unmarketable apples increased by 5%. None of these differences were significant.

**Key Words:** Bramley, Ventem, Adem, *Venturia inaequalis*, model.

**Introduction**

The maritime climate enjoyed in Ireland generates rainfall on a regular basis throughout the growing season. Approximately 90% of the apple crop is Bramley and since the 1920’s this variety has been extremely susceptible to apple scab disease (*Venturia inaequalis*). Because the weather conditions are perfect for the disease, most growers apply a standard fungicide programme throughout the season (approximately 14 sprays per year). This form of apple production is at variance with the trend towards Integrated Fruit Production (IFP) which is developing across Europe (Cross et al. 1996). Whilst guidelines for IFP have been available in the U.K. since 1991, they have not been widely adopted by UK growers because of perceived higher production costs with higher risks (Berrie & Cross, 1996). The key to optimal fungicide use in an IFP programme is to have a model which will accurately assess the risk from the disease in a particular orchard at a particular time. Thus the grower will only apply a fungicide when justified. Before a model can be recommended for use, it must be evaluated in the particular environment in which it is to be applied. The Ventem® system (and its Adem® successor) is one such model which was developed at HRI East Malling, Kent and this paper reports on its use under Northern Ireland conditions over three growing seasons.

**Materials and methods**

The trial was sited on McAllister’s Hill at the Northern Ireland Horticultural and Plant Breeding Station, Loughgall, Co. Armagh. The site was surrounded by alder windbreaks.

The trees were Bramley’s Apple Seedling on M26 rootstock planted in the Autumn of 1983. The layout consisted of a fully randomised block design with 12 treatment slots arranged in five replicate blocks. Each of the 60 plots contained two assessed trees surrounded on all sides by shared, single guard trees. The trees were planted 4.3 m apart within rows with 6m between rows. The orchard was maintained in line with good local practice.

High volume fungicide formulations were applied at using a tractor mounted sprayer equipped with hand lances (at 1000L/Ha). Indar/Dithianon was applied as the standard
treatment. The control plots were unsprayed, the standard plots were sprayed every 10 days and the Ventem/Adem plots were sprayed according to the prediction model. In 1998 the Ventem programme (Xu & Butt, 1993) was replaced by the Adem version (which contained the same version of the scab model). A Metos weather station (Gottfried Pessl, Weiz, Austria) sited in the orchard, recorded data every 20 minutes which was subsequently fed into the programme. The data from each year was used as a replicate.

Results and discussion

The Department of Agriculture and Rural Development for Northern Ireland has been conducting research into the development and application IFP technology in Northern Ireland for some years (Mac An tSaoir and Mansfield, 1999). However, because the Bramley apple is susceptible to scab and the local climate is perfect for the scab fungus, IFP systems have not found favour with local growers. The environmental data relevant to disease development is shown in tables 1 and 2. Continuous moisture contributes to a large number of potential scab infection periods throughout the growing season. The major problem is not the volume of rain but rather the number of times in which it rains (Table 1) and the quantity of rain per incident. Rain showers of short duration are a regular feature of the weather and determining whether or not a scab infection has occurred is extremely difficult.

Table 1. Number of rain days (> 0.2mm)

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>11</td>
<td>22</td>
<td>12</td>
<td>9</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>15</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>1998</td>
<td>18</td>
<td>12</td>
<td>17</td>
<td>22</td>
<td>13</td>
<td>24</td>
<td>20</td>
<td>19</td>
<td>19</td>
<td>24</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>1999</td>
<td>22</td>
<td>19</td>
<td>21</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>18</td>
<td>21</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>23</td>
</tr>
</tbody>
</table>

The traditional method of determining infection periods using the Mills tables (Table 2) was also used as a comparison with the model system. Both systems matched each other.

Table 2. Infection Periods based on Revised Mills tables. ( ) – number of days in infection periods

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>3 (10)</td>
<td>4 (11)</td>
<td>3 (7)</td>
<td>7 (12)</td>
<td>5 (14)</td>
</tr>
<tr>
<td>1998</td>
<td>8 (13)</td>
<td>2 (5)</td>
<td>6 (9)</td>
<td>5 (8)</td>
<td>6 (11)</td>
</tr>
<tr>
<td>1999</td>
<td>4 (5)</td>
<td>4 (7)</td>
<td>5 (10)</td>
<td>4 (8)</td>
<td>7 (11)</td>
</tr>
</tbody>
</table>

In general, the reduction in the number of sprays using the computer model over the standard 10 day spray programme was usually due to extended periods of good weather (i.e. longer than 10 days), in which case it could be argued that the computer model was unnecessary. When there was a relatively short period of rain during the good weather however, the computer based evaluation was very important in the spraying decision making process.
The effect of the predictive model on the yield and quality of fruit is shown in Table 3. The yield data for 1998 was very low due to severe frost damage at flowering and there was a corresponding increase in yield in 1999, but since this affected the whole orchard, the differences between treatments remain valid. Over the three seasons an average of 12.3 sprays was applied to the standard plots generating an average yield of 138 kg of fruit of which 97% was marketable. The average yield of the unsprayed plots was 24 kg of which only 33.7% was marketable. The Adem managed plots averaged 10 sprays yielding 120 kg with 94% marketable.


<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Adem</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plot wt. (Kg)</td>
<td>No. of sprays</td>
<td>% unmark.</td>
</tr>
<tr>
<td>1997</td>
<td>12.1</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>1998</td>
<td>33.2</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>1999</td>
<td>22.7</td>
<td>0</td>
<td>61</td>
</tr>
<tr>
<td>Mean</td>
<td>22.7</td>
<td>66.3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>68.0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Mean plot weight: standard error - 22.08 p < 0.05
Mean % unmarketable: standard error - 2.01 p < 0.001
Mean number of sprays: standard error - 0.62 Not Significant
Total Plot Weight: standard error - 66.12 p < 0.05
Total Number of Sprays: standard error - 1.9 Not Significant

There was no significant difference in yield between the standard plots and the Adem plots in any season. Both were significantly higher than the unsprayed control. Similarly, there was no significant difference between the standard and Adem plots for the number of sprays used.

The significance of the data when accumulated over the experimental period did not change. The saving of five sprays and the 50kg yield reduction due to the use of the model, were not significant. However, a trend in the results is evident with a reduction in sprays used in the Adem plots and a corresponding reduction in yield. Given that 84% of pesticides applied to apples in Northern Ireland are fungicides (Kidd et al, 2000) any reduction in fungicide application would have a major benefit for the growers, the consumers and the environment.

There is always a risk that using a defined threshold to determine whether or not to apply a disease control treatment to a crop, that when the decision not to spray is taken a small level of disease will develop and thus a small level of crop reduction will develop. A similar risk of increased scab infection to the crop was reported by Berrie (1997).

Despite the frequent periods of rainfall, the data reported here demonstrates that predictive models are of use in spray programmes. In general, the number of sprays required will be reduced and all sprays applied will have been justified. The use of the model is continuing to be refined under our local conditions.
Acknowledgements

The assistance of John Mansfield and his orchard team in managing this experiment is gratefully acknowledged as is the help of Dr Sally Watson for statistical analysis. This research was funded by the Department of Agriculture and Rural Development for Northern Ireland.

References

Accuracy of a model simulating the dynamic of apple scab primary inoculum in the orchard

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Servizio Fitosanitario Regionale, Via di Corticella 133, 40129 Bologna Italy

Abstract: A system simulating the dynamic of *Venturia inaequalis* primary inoculum in the orchard air, previously elaborated, was validated under different epidemiological conditions in Emilia-Romagna (northern Italy), between 1997 and 1999. The model produced a flexible and accurate simulation of: i) the risk of the presence of airborne ascospores on each day of the season, ii) the occurrence of ascospore discharging events, iii) the hour of day when ascospores begin to be airborne. These model outputs were then used to calculate infection periods by means of a modified Mill’s criterion. A more accurate identification of the establishment of a scab primary infection was obtained; in particular, early unjustified alarms produced by the Mill’s criterion were reduced.

Key words: apple, *Venturia inaequalis*, weather, simulation model, airborne ascospores, infection

Introduction

In the Emilia-Romagna region (North Italy) a warning system for crop protection has been in operation since the early ’90s. In order to control apple scab, warnings are based on the presence of airborne inoculum and on meteorological conditions favouring infection; the former information comes from a network of spore traps, the second one from calculations based on a revised Mill’s criterion (Bugiani et al., 1996). Since spore traps are time-consuming, expensive and require adequate laboratory equipment, a system simulating the dynamic of scab primary inoculum was elaborated.

In the present work, this system was validated under different epidemiological conditions, and its use in the warning system was evaluated.

Materials and methods

Simulation model

The system estimating the dynamic of *Venturia inaequalis* primary inoculum in apple orchards was described in a previous work (Giosuè et al., 2000). It separates the primary inoculum season into five periods with different risks: ‘absent’ (ascospores are not yet mature), ‘potential’ (ascospores are mature but not yet ready to be discharged), ‘actual’ (ascospores can be discharged when favourable conditions occur), ‘present’ (ascospores are air-borne), ‘exhausted’ (all the ascospores have been ejected). These periods are determined by two mathematical models which use meteorological parameters as driving variables. The first model estimates the development of the overwintering pseudothecia and then determines when the first pseudothecia will contain pigmented and mature ascospores; the second model estimates the proportion of the season’s ascospores (PAT) which are air-borne on each discharging event.

The occurrence of ascospore discharging events (which is a ‘present’ risk) during the ‘actual’ risk is estimated by using the rules of Rossi et al. (2000), as well as the time of spore ejection in relation to the time of rainfall.
In the present work, the level of risk during the ‘actual’ risk was defined according to the expected values of PAT, as shown in Figure 1.

Figure 1. Defining the risk of airborne ascospores, based on model simulation of the proportion of the season’s *V. inaequalis* spores trapped on each discharging event (PAT). DDC_{LW} is a degree day accumulation.

Then, on each day during the primary inoculum season, the model produces three main outputs: i) the level of risk for the presence of airborne ascospores, ii) the occurrence of ascospore discharging events, iii) the hour of day when ascospores begin to be airborne.

**Experimental fields management**

Seven experiments were performed in Emilia-Romagna between 1997 and 1999, in commercial apple orchards. To obtain a representative level of the overwintering inoculum, the trees were sprayed with fungicide each year to control scab, following common use.

A 7-day recording volumetric spore sampler was installed in each orchard to sample the air at 150 cm above the ground. The number of *V. inaequalis* ascospores trapped were counted and expressed as trapped spores per m$^3$ of air per hour. The cumulative number of spores per m$^3$ of air was then calculated as the yearly total of hourly ascospore densities; afterwards, the cumulative proportion of ascospores trapped at each discharge was calculated on a 0-1 scale. Hourly meteorological data were obtained from the nearest station of the regional agrometeorological service.

**Data analysis**

The accuracy of the model was evaluated by comparing its estimates with the records from the spore traps. Regression analysis was used to compare observed and estimated proportions of the season’s ascospores trapped at each discharging event, while Pearson’s X$^2$ statistic was used to compare observed and expected ascospore discharges for both the occurrence (yes or no) and the time of ascospore discharge in relation to the time of rainfall (at night or in daytime).
Results and discussion

The data set used for validation showed a sufficient range of variation to be considered representative of the different epidemiological conditions: the first seasonal trapping occurred between mid March and the end of March, the primary inoculum season was 30 to 60 days long, and the number of the season’s ascospores trapped ranged between a few and more than 1000; more than 100 trapping events were observed in aggregate.

The model produced an accurate simulation of the dynamic of ascospore trappings during the season. Considering the entire data set, a significant (P<0.001) linear relationship was found between the observed PATs and those estimated by the model, that accounted for 94% of variance (Fig. 2). The agreement between observed and estimated data was high, because the intercept of the regression line was not significantly different from zero nor was the slope different from one.

![Figure 2. Regression line fitting the value of PAT (proportion of season’s ascospores trapped from the orchard air) observed and estimated at 7 locations (1997 to 1999), and its statistics.](image)

There was a close relationship between the risk level estimated by the model and the actual presence of ascospores in the orchard air (Table 1). No ascospores were trapped when the risk was ‘absent’ and only 3 discharging events occurred when the risk was ‘potential’, accounting for a negligible part of the total ascospores trapped (0.8%). Most ascospore ejections occurred when the risk was ‘actual’, especially beginning from the period of intermediate risk: 88% of the total ascospores were trapped during intermediate and high actual risk. Finally, 13 discharge events occurred when the risk was considered exhausted, accounting for about 1% of the total ascospores.

The rules used to define the occurrence of a discharging event during the period of ‘actual’ risk produced an accurate estimate of the presence of ascospores in the orchard air. In fact, there was a significant relationship between the actual presence of airborne spores and that expected according to the model (Table 2). Over the entire period of the primary inoculum season (313 days in aggregate), 283 cases (90%) were correctly estimated, while in 25 cases (8%) an ascospore discharge was expected but did not occur. In only 5 cases (less than 2%) a discharge event occurred although it was not expected: in all these cases very few
ascospores were sampled from the air (1 to 7 per m\(^3\) air per day) in the absence of rainfall. Three of these cases could be explained by supposing ascospores remained airborne for a long time after a preceding discharging event, while two cases cannot be explained, because no previous discharges occurred within a reasonable time interval. In any case, these unsuccessful results were of little importance, because the ascospores released in the absence of rainfall were not able to cause infection because sufficient wetness was not present.

Table 1. Number of discharging events of *V. inaequalis* ascospores occurring during the different periods of risk defined by the model and correspondent amount of ascospores trapped, expressed as a proportion of the total season’s ascospores.

<table>
<thead>
<tr>
<th>Risk</th>
<th>No. of discharging events</th>
<th>% of total ascospores trapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Potential</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Low</td>
<td>5</td>
<td>0.7</td>
</tr>
<tr>
<td>Intermediate</td>
<td>20</td>
<td>12.1</td>
</tr>
<tr>
<td>High</td>
<td>43</td>
<td>59.9</td>
</tr>
<tr>
<td>Intermediate</td>
<td>13</td>
<td>16.3</td>
</tr>
<tr>
<td>Low</td>
<td>10</td>
<td>9.1</td>
</tr>
<tr>
<td>Exhausted</td>
<td>13</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 2. Relationship between the discharging events of *V. inaequalis* ascospores observed and expected according to the model, over 7 primary inoculum seasons (313 days long, in aggregate). Data are expressed as number of discharging events and as % of the total events (\(\chi^2=195.4; P<0.0001\)).

<table>
<thead>
<tr>
<th>Expected</th>
<th>Observed</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>86</td>
<td>25</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.5%</td>
<td>8.0%</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>5</td>
<td>197</td>
<td>202</td>
</tr>
<tr>
<td></td>
<td>1.6%</td>
<td>62.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>91</td>
<td>222</td>
<td>313</td>
</tr>
</tbody>
</table>

Table 3. Relationship between the discharging events of *V. inaequalis* ascospores observed and expected during either daytime or nighttime based on the model. Data are expressed as number of discharging events and as % of the total events (\(\chi^2=29.6; P<0.0001\)).

<table>
<thead>
<tr>
<th>Expected</th>
<th>Observed</th>
<th>Day</th>
<th>Night</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>72</td>
<td>1</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>83.7%</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>Night</td>
<td></td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.1%</td>
<td>7.0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>79</td>
<td>7</td>
<td>86</td>
</tr>
</tbody>
</table>
The time of ascospore discharge in relation to the time of rainfall (at night or in daytime) was correctly estimated in 78 events out of 86 (91%) (Table 3); in one case, an ascospore ejection was expected in daytime but occurred in the dark, while in 7 cases a discharge was forecast at nighttime but occurred after dawn. All these wrong estimates occurred when more than 90% of the season’s ascospores have already been trapped, with very low densities of airborne ascospores (1 to 7 spores per m³ air per day were trapped in these case).

The model outputs were used to calculate infection periods by a modified Mill’s criterion. In general, a more accurate identification of the establishment of scab infections was obtained; in particular, the early unjustified alarms produced by Mill’s criterion were reduced. An example is shown in Figure 3. Each ascospore discharge and its risk level was determined by the model; the correspondent probability of infection was calculated by Mill’s criterion, based on temperature and wetness registered after the time when ascospores become airborne, and then compared with the time of both infection establishment and symptom appearance, the former inferred on the basis of length of incubation. Some ascospore releases were signalled; five of them were followed by a period with favourable conditions for infection. The first signalled infection did not result in scab onset; in fact, it should be considered negligible because it was associated with a low risk. On the contrary, the second signalled infection occurred with an intermediate risk, and actually originated infection.

Figure 3. Combining the risk for airborne ascospores (●) with the risk for infection (○) in apple scab management.
Legend: — period of probable infection; ™ period of symptom onset; λ ascospore discharge with Mill’s infection; ○ ascospore discharge without Mill’s infection

In conclusion, the model proved to be a flexible and accurate simulator of the presence of V. inaequalis ascospores in the orchard air. Thus, it can substitute the information from both pseudothecial examination and spore traps. In addition, the model improves the identification of the infection periods based on the Mill’s criterion.

Acknowledgements

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References

Effects of treatments with strong electrolysed water and fruit size on mould in storage mandarins

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Abstract: Strong acidic electrolysed water is known for its fungicidal effects. Satsuma mandarins of an organic orchard have been rinsed with or soaked in electrolysed water before putting them into storage. Effects on storage diseases, especially *Penicillium spp.*, have been examined. Rinsing with acidic electrolysed water, rinsing with acidic and alkaline water and soaking in alkaline water reduced the number of moulded fruits significantly. Mould occurred most in M-sized fruit.

Key words: *citrus*, storage, *penicillium spp.* electrolysed water

Introduction

Postharvest treatment is not allowed in Japan and *Penicillium italicum* and *Penicillium digitatum* are the most common problems in storage mandarins. Normally they are reduced by fungicide application before harvest. Electrolysed water is known for its fungicidal effects and there are some examples of its successful use, mainly against fungi on the plant surface like powdery mildew. Experiments on this topic were also carried out in previous years, when mould did not occur as much as expected and there were no statistically significant results. Therefore, this experiment was carried out in cooperation with an organic citrus orchard, where plant diseases are usually prevented or reduced by several plant extracts like wood vinegar and brown sugar in addition to cultivation methods.

Material and methods

Strong electrolysed water
Tap water enriched with a salt solution, here KCl, is electrolysed. In this experiment waters with the following characteristics were used.

<table>
<thead>
<tr>
<th>Strong acidic electrolysed water</th>
<th>Strong alkaline electrolysed water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &lt; 2.5</td>
<td>pH &gt; 10.5</td>
</tr>
<tr>
<td>ORP &gt; 1050 mV</td>
<td>ORP &lt; -800mV</td>
</tr>
<tr>
<td>total chlorine: ca. 25 ppm</td>
<td></td>
</tr>
</tbody>
</table>

Fruits and experimental design
*Citrus unshiu* cv “Aoshima” harvested on November 5th were graded and sorted by colour. The experiment was designed twodimensional with 5 treatments and 4 replications using 472 mandarins. The 4 replications represent the sizes LL, L, M and S together with SS. Fruits of the same colour were selected.
The fruits were treated with electrolysed water on November 6th. Before putting them into storage, they were dried at the sun.

Treatments were:
1. Rinsing with acidic water (30 sec)
2. Rinsing with acidic and alkaline water
   After rinsing with acidic water for 30 sec, fruit were rinsed with alkaline water for 30 sec.
3. Soaking in acidic water for 5 min
   The fruits were floating on the water and were turned around after 2min30sec.
4. Soaking in alkaline water for 5 min
   As in 3. the fruits were turned around after 2min30sec.
5. Untreated control

**Storage**
The fruits were put in a traditional storage hut with earthen floor and wooden drawers on November 6th. Storage was checked regularly. Moulded or rotten fruit were counted and removed. Percentage of fruits with mould and effectiveness were calculated. Statistical significance was calculated by Duncan’s multiple range test at 5% level and effectiveness is a comparison to the untreated control.

**Results and discussion**

*Penicillium spp.* developed soon and increased until January 3rd, when it stagnated for 4 weeks. From early to mid February the next increase could be noted. It occurred most in untreated fruit. Rinsing with acidic water, acidic and alkaline water as well as soaking in alkaline water had a reducing effect on *penicillium spp.* At the end of the trial, 10.6% of the untreated fruit had to be removed because of mould, whereas the number was 7.3% for soaking in acidic water, 5.9% for soaking in alkaline water, 5.8% for rinsing with acidic water and 5.5 % for rinsing with acidic an alkaline water. Both rinsing treatments and soaking in alkaline water reduced mould significantly. Soaking in acidic water seemed to show better results at the beginning, but at that time differences were not statistically significant. At the end of the trial effectiveness was around 40-50% for these three treatments. Mould developed most in M sized fruit.

**Discussion**

Some positive results could be earned this time, but machines for electrolysed water are still expensive and it is not practical to wash fruits at grower level. But it might be possible to develop a system, were electrolysed water could be used at grading houses or marketing organisations.

**Acknowledgements**

Special thanks to Yoshinori Hayato and Hayato Orchard, Yugawara, for cooperation, Kazumi Sugiyama, Shizuoka East Agriculture and Forestry Office for information, and Yoshikazu T. Yamaki, The University of Tokyo, for cooperation at previous experiments about the topic.

**References**


Insect problems in a scab resistant/tolerant apple orchard in Hungary

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Abstract Summarising the results the low number of insecticide application in apple scab resistant/tolerant plantation could not cover the damaging period of the insect pests (especially the leaf rollers and codling moth). After five years research period we can draw the conclusion that in the scab resistant apple plantations under Hungary's continental climate a new IPM system should be developed giving more attention to insect pests.

Key words pests, scab resistant cultivars, Cydia pomonella L., leaf rollers in applegrowing, IPM

Introduction

A way to reduce fungicide use without the risk of high scab infestation is the growing scab resistant/tolerant apple cultivars. New orchards planted with such apple cultivars can be good projects to study the possibility of the IPM apple growing.

The aim of our study was to determine the main insect pests in IPM technology and to establish their population density in the orchard.

Materials and Methods

Our investigations were carried out in a 3 ha orchard planted with scab resistant/tolerant cultivars and an other plot in the neighbourhood with conventional treatments. The following diseases and insects have been investigated in the experimental plot during the research period (1996-2000):

Diseases: powdery mildew, apple scab

The diseases were monitored by visual inspection twice a year (June and August), the insect pests by means of sex-pheromone traps and some of them (C. pomonella, P. heparana, A. podana and A. orana) by visual inspection too (twice a year).

Only selective insecticides (a.i. fenoxycarb, lufenuron) were used against the insect pests (codling moth, leaf miners and leaf rollers). The time of the application were determined by means of sex-pheromone traps. Fungicides with a side effect on apple scab were used against powdery mildew. The treatments in 2000 are presented in the Table 1.
### Table 1. Plant protection in scab resistant/tolerant apple orchard in 2000

<table>
<thead>
<tr>
<th>number of treatment</th>
<th>date</th>
<th>fungicide, insecticide, a.i.</th>
<th>dosis %, kg/ha, l/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 03.04.</td>
<td></td>
<td>Nevikén (7% polysulphid + light oil)</td>
<td>25</td>
</tr>
<tr>
<td>2 20.04.</td>
<td></td>
<td>Chorus 75 WG (75 % ciprodinil)</td>
<td>0,33</td>
</tr>
<tr>
<td>3 28.04.</td>
<td></td>
<td>Zato (trifloxistrobin)</td>
<td>0,15</td>
</tr>
<tr>
<td>4 05.05.</td>
<td></td>
<td>Kasumin 2 L * (2 % Kasugamicin) + Insegar (25 % fenoxy carb)</td>
<td>1,5</td>
</tr>
<tr>
<td>5 19.05.</td>
<td></td>
<td>Topas 100 EC (100 g/l penchonasol), Match 50 EC (50 g/l luphenuron)</td>
<td>0,5 1</td>
</tr>
<tr>
<td>6 20.05.</td>
<td></td>
<td>Streptomyacin * (20 % streptomycinsulphat)</td>
<td>0,5</td>
</tr>
<tr>
<td>7 30.06.</td>
<td></td>
<td>Zato Insegar Streptomyacin*</td>
<td>0,15 0,4 0,5</td>
</tr>
<tr>
<td>8 05.07.</td>
<td></td>
<td>Topas 100 EC Match 50 EC</td>
<td>0,5 0,8</td>
</tr>
<tr>
<td>9 03.08.</td>
<td></td>
<td>Zato Match 50 EC</td>
<td>0,15 0,8</td>
</tr>
<tr>
<td>10 17.08.</td>
<td></td>
<td>Zolone 35 EC (35 % phosalone), Topas 100 EC</td>
<td>1,75 0,5</td>
</tr>
</tbody>
</table>

*Erwinia amylovora* (Burill) Winslow et al. infection

### Results and conclusions

1. A reduced number of fungicide applications (5-6) was sufficient against the powdery mildew, neither apples scab nor powdery mildew infestation could be observed in 2000.
2. All the investigated leaf rollers could be observed during the research period, but the infestation level was different species by species and year by year.
3. The flight activity of leaf miners, codling moth and leaf rollers is presented in Fig 1-6. The first Figures (Fig. 1, Fig 3, and Fig. 5) show the data of 1997 (the beginning of the
observation), the data of 2000 summarised in Fig. 2, Fig. 4 and Fig. 6. In these figures can be followed the changes of the population density of each investigated species.

Fig. 1. Flight activity of *Leucoptera scitella* C., *Lithocolletis corylifoliella* H., *L. blancardella* F. in apple scab resistant orchard in 1997

Fig. 2. Flight activity of *Leucoptera scitella* C., *Lithocolletis corylifoliella* H., *L. blancardella* F. in apple scab resistant orchard in 2000
Fig. 3. Flight activity of leaf rollers in apple scab resistant orchard in 1997

Fig. 4. Flight activity of leaf rollers in apple scab resistant orchard in 2000
Fig. 5. Flight activity of *Cydia pomonella* L. in apple scab resistant and conventional treated orchard in 1997.

Fig. 6. Flight activity of *Cydia pomonella* L. in apple scab resistant and conventional treated orchard in 2000.
4. Damage of *P. heparana, A. podana* and *A. orana* was observed during the summer not only late autumn.

5. The flight of *C. pomonella* was observed during the whole vegetation period (from the end of April till the beginning of September) by pheromone traps. Heavily infested fruits could be observed in late summer or autumn (especially in 2000) in spite of the frequently use of selective insecticides (fenoxycarb, lufenuron 4 or 5 times in a year)

6. Beside of the codling moth *A. orana, S. ocellana* and *A. pulchellana* caused damage in the research field.

7. Low density of the larvae populations of leafminers (*L. scitella, L. corylifoliella, L. blancardella*) could be observed at the beginning of the research period. The populations of these insects were very low in 2000 (practically 0) but there was no correlation between the insecticide treatments and the number of larvae.

8. Among the mite species we could observe the *Aculus schlechtendali* Nal., the aphid *Dysaphis plantaginea* Pass.
Study of relationships established within the apple-tree biocenosis genetically resistant to apple scab and powdery mildew, aiming to setting management of Integrated Fruit Production

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2 Research Institute for Plant Protection, B-dul Ion Ionescu de la Brad, nr.8, sector 1, Bucharest, Romania

Abstract: Investigations started in 1999 at Research Station for Fruit Tree Growing Baneasa (SCPP Baneasa), in an apple plantation with cultivars resistant to scab, or scab and powdery mildew: Prima, Florina, Surprise, Jonagored and Pionier. Among the relationships set within the components of apple biocenosis, those belonging to type predators-pests, pathogens-antagonists, have been remarked. Bimonthly collection of biologic material revealed occurrence of predatory species *Coccinella septempunctata*, *Chrysopa* spp., *Orius* spp., *Anthocoris* spp., whose populations develop on account of existing pests. Study of floricolous range of phylloplane revealed absence of specific pathogens, *Venturia inaequalis* and *Podosphaera leucotricha* and its population with saprophytic microorganisms belonging to bacteria actynomyceta, and micromyceta. Saprophytic micromyceta with antagonistic role prevailed, *Epicoccum purpurascens* and *Chaetomium globosum* being dominant. *Cladosporum* and *Gliocladium roseum* installed in phylloplane, with medium frequencies. Sporadically, *Trichoderma viride* and *Tricothecium roseum* have been identified. Relationships established within the apple biocenosis revealed an equilibrium state, both inside predator populations and in the spectrum of saprophytic species.

Key words: fruit integrated production, apple plantation, resistant cultivars, biocoenosis, predators - pests, pathogens - antagonists

Introduction

Biocenosis including lignicolous plants and bushes which develop in a natural ecosystem, such as forest, where the elements of this can enter in a sustainable equilibrium, could undergo a lasting series of imbalances, due to an unreasonable intervention of man. Prevention of these imbalances can be achieved by the management of fruit-tree plantations, based on principle of Integrated Fruit Production.

Desire to penetrate the chain of all those acting for an ecological agriculture and pomiculture led, starting with the year 1995, determined the Research Station for Fruit Tree Growing Baneasa Bucharest, located in South of Romania, to build up research and development programmes, starting from the concept of Integrated Fruit Production.

The early results in this field have been presented at the International Conference on Integrated Fruit Production, held in 27.07-1.08 1998, Leuven- Belgium, in the paper "Aspects of apricot tree culture as related to the concept of sustainable fruit tree growing".

299
The present work proposed to bring its contribution referring to relationships predators-pests, pathogens-antagonists, penetrated to apple-trees populations with the cultivars resistant to scab, or scab and powdery mildew: Prima, Florina, Surprise, Jonagored and Pionier.

**Material and methods**

Studies have been performed in an apple orchard in 1998, with 1,080 trees ranged in randomized block. The cultivars used where: Prima, Florina, Surprise, Jonagored and Pionier. Each cultivar was represented by 216 trees.

In order to reveal relationships between pests and predators, insect collection has been made by the shaking method, twice every month and by sampling 50 leaves per variant/cultivar, when the visual inspections indicated occurrence of pests (mites), at the end of July and at the start of August. Aphid species have been evaluated on the attacked shoots, in orchard. Samples gathered have been analysed under a stereoscopic microscope.

Identification of anthagonsists from phylloplane involved collection of apple leaves from resistant cultivars.

Leaves have been further fragmented in laboratory, as dics 7 mm in diameter.

The fragments resulted have been distributed on the water-agar medium. After 12 days colonies of microorganisms occurring in the phylloplane have been determined.

**Results and discussion**

Analysis of the biological material collected in orchard since of the half of April up to the middle of August revealed presence of 9 pests, among which the aphids *Dysaphis devecta* Wlk. an *Aphis pomi* De Geer, cicadids *Cixius* spp. and the mites *Panonychus ulmi* Koch., summing up significant percentages (table 1), the other having but sporadical effective.

Evolution of the two aphid species lasted from spring up to the autumn.

Table 2 expresses evolution of attack frequency of both aphid species up on cultivars.

Presence of *Dysaphis devecta* has been noticed still at mid -April, maintaining up to the first decade of June. Surprise cvar was remarked by its affinity for this aphid species (40% frequency on May 25, and 52% on June 7, respectively). In the other cvars the attack recorded frequency up to 28% (Florina cvar).

*Aphis pomi* was first present on May 3, its frequency being 8% in Prima, and 4% in Surprise and Jonagored. The highest frequencies have been recorded by Pionier (32% on June 19, and 28% on July 3).

In order to attain a balance between pest entomofauna and the useful one, as well as between pathogens and antagonists, no chemical control applications have been used, being detrimental to useful entomofauna and to antagonists. Conciminantly to shakes effected in the orchard, spontaneous flora surrounding the apple tree plantation has been controlled, with a view to detect host plants for development of useful fauna and antagonists.

Table 3 presents structure of entomophages determined in samples collected from orchard, throughout the vegetation season. Abundance of numerous predatory or parasitic species can be noted, these contributing to maintain pests below the economic damage threshold.

Ratio aphids / entomophages was below 1 : 0 in April (fig.1), the period when the first colonies of *Dysaphis devecta* and *Aphis pomi* started colonization on apple tree shoots.

In the next period, this ratio oscillated from 2.00 up to 5.83, being influenced by reproduction of aphids, *Dysaphis devecta* and *Aphis pomi*, respectively.
Table 1. Principal pests occurring in the apple orchard 2nd year with cvs resistant to apple scab and powdery mildew under the conditions prevailing in the year 2000, at SCPP Baneasa

<table>
<thead>
<tr>
<th>Nr.</th>
<th>PESTS</th>
<th>No. of specimens</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td>1</td>
<td>ACARINA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><em>Panonychus ulmi</em></td>
<td>853</td>
<td>853</td>
</tr>
<tr>
<td>2</td>
<td>HOMOPTERA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td><em>Dysaphis dejecta</em></td>
<td>337</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td><em>Aphis pomi</em></td>
<td>73</td>
<td>2225</td>
</tr>
<tr>
<td></td>
<td><em>Cixius spp</em></td>
<td>–</td>
<td>262</td>
</tr>
<tr>
<td></td>
<td><em>Empoasca sp.</em></td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>COLEOPTERA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td><em>Phyllobius oblongus</em></td>
<td>31</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td><em>Sitona sp.</em></td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>THYSANOPTERA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td><em>Thrips spp.</em></td>
<td>5</td>
<td>18</td>
</tr>
</tbody>
</table>

Population of microorganisms generated in apple phylloplane was represented by the groups: bacteria, actinomycetes and fungi.
Fungi reached the highest percentage, being represented by saprophytic micromycetes, some of which with antagonistic action in phylloplane. Strict limitation of chemical treatments, structure of foliar tissue and action of anorganic and organic products ensured a balance microfloristic structure, fungi with antagonistic action being spread in phylloplane, and namely: *Epicoccum purpurascens*, *Chaetomium globosum* (with very high frequency), *Cladosporium* spp., *Gliocladium roseum* (with good frequency), *Trichoderma viride*, *Trichotecium roseum* (sporadic) (table 4).

Treatment with copper-based products (*Funguran* and *Bordeaux mixture*) to prevent bacteria *Erwinia amylovora*, induced a 70% decrease from the total of colonies occurring in the phylloplane, which did not reach the total number in the untreated variant.

The foliage fertilizer *Cropmax*, containing Fe, Mg, Zn, Cu, Mn, B, Ca, Mo, Co, Ni, plants vitamins, organic enzymes, favoured development of antagonists.

Monitoring ratio pest entomofauna / useful entomofauna, pathogens / antagonists, introduction in plantation of resistant cvs Prima, Florina, Surprise, Jonagored and Pionier, avoidance of excessive mechanized works to keep soil clean from weeds, keeping host-plants for the useful entomofauna around the plantation, led to application of only 6 phytosanitary treatments of which 3 with insecticides (active ingredients: Mineral oil 92%, Fosalon 25%, Cypermetrin 200g/l) as compared to 17-18 applications, which were currently practiced in intensive apple orchards.

Table 2. Behaviour of 5 apple cvs resistant to apple scab and powdery mildew to the attack by the aphids *Dysaphis devecta* and *Aphis pomi*

<table>
<thead>
<tr>
<th>Cvars</th>
<th>Aphid species</th>
<th>Date recordings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>17.04</td>
</tr>
<tr>
<td>Prima</td>
<td><em>D. devecta</em></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>A. pomi</em></td>
<td>-</td>
</tr>
<tr>
<td>Florina</td>
<td><em>D. devecta</em></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>A. pomi</em></td>
<td>-</td>
</tr>
<tr>
<td>Surprise</td>
<td><em>D. devecta</em></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><em>A. pomi</em></td>
<td>-</td>
</tr>
<tr>
<td>Jonagored</td>
<td><em>D. devecta</em></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>A. pomi</em></td>
<td>-</td>
</tr>
<tr>
<td>Pionier</td>
<td><em>D. devecta</em></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em>A. pomi</em></td>
<td>-</td>
</tr>
</tbody>
</table>
Table 3. Structure of entomophages from an apple orchard with cvs resistant to apple scab and powdery mildew

<table>
<thead>
<tr>
<th>Insect groups and species</th>
<th>Abundance</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute</td>
<td>Relative</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0. ARANEAE</td>
<td>226</td>
<td>20.32</td>
</tr>
<tr>
<td>0. DERMAPTERA</td>
<td>3</td>
<td>0.27</td>
</tr>
<tr>
<td>Forficula auricularia L.</td>
<td>2</td>
<td>0.18</td>
</tr>
<tr>
<td>Labidura riparia</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>0. HETEROPTERA</td>
<td>547</td>
<td>49.19</td>
</tr>
<tr>
<td>Anthocoris sp.</td>
<td>52</td>
<td>4.68</td>
</tr>
<tr>
<td>Orius sp.</td>
<td>119</td>
<td>10.70</td>
</tr>
<tr>
<td>Deracaeocoris lutescens Schill.</td>
<td>3</td>
<td>0.27</td>
</tr>
<tr>
<td>D.ruber L.</td>
<td>20</td>
<td>1.80</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>Philophorus perplexux Doug et.Scott.</td>
<td>15</td>
<td>1.35</td>
</tr>
<tr>
<td>Campylomma verbasci M.D.</td>
<td>281</td>
<td>25.27</td>
</tr>
<tr>
<td>Nabis sp.</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>Mirids (larvae)</td>
<td>56</td>
<td>5.03</td>
</tr>
<tr>
<td>0. NEUROPTERA</td>
<td>69</td>
<td>6.20</td>
</tr>
<tr>
<td>Chrysoperla carnea Steph (+larvae)</td>
<td>69</td>
<td>6.20</td>
</tr>
<tr>
<td>0. COLEOPTERA</td>
<td>77</td>
<td>6.93</td>
</tr>
<tr>
<td>Adalia bipunctata L.</td>
<td>11</td>
<td>1.00</td>
</tr>
<tr>
<td>Coccinella 7 punctata L.</td>
<td>40</td>
<td>3.59</td>
</tr>
<tr>
<td>Coccinella 14 punctata L.</td>
<td>2</td>
<td>0.18</td>
</tr>
<tr>
<td>Adonia variegata Goeze</td>
<td>2</td>
<td>0.18</td>
</tr>
<tr>
<td>Propylaea 14 punctata L.</td>
<td>5</td>
<td>0.45</td>
</tr>
<tr>
<td>Exochomus quadripustulatus L.</td>
<td>4</td>
<td>0.36</td>
</tr>
<tr>
<td>Coccinellidae (larvae)</td>
<td>13</td>
<td>1.17</td>
</tr>
<tr>
<td>0. Hymenoptera</td>
<td>190</td>
<td>17.09</td>
</tr>
<tr>
<td>Super fam. Chalcidoidea</td>
<td>190</td>
<td>17.09</td>
</tr>
<tr>
<td>Total effective</td>
<td>1112</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4. Apple leaf phyllosphaere in untreated

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Microecosystem chains</th>
<th>Apple leaf phyllosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf (leaf tissues)</td>
<td>Parasites</td>
<td>Alternaria mali</td>
</tr>
<tr>
<td>Water.oxygen</td>
<td>Antagonists</td>
<td>1. Bacteria; 2. Actynomycetes</td>
</tr>
<tr>
<td>Anorganic particles(N,P,K)</td>
<td></td>
<td>3. Fungi: Aurobasidium; Cladosporium; Epicoccum; Chaetomium; Gliocladium; Trichotecium; Trichoderma</td>
</tr>
<tr>
<td>Exudates, organic particles</td>
<td>Saprophytes</td>
<td>Alternaria spp.; Acremoniella; Temphysillum; Poecylomyces; Oedocephalum</td>
</tr>
<tr>
<td>Leaf cuticle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References


Prediction model of bitter pit risk incidence at post-harvest in Golden apples

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Abstract: Preharvest factors involved in fruit quality were studied in 60 commercial plantations of Golden apples during the 1995-1998 period making a total of 238 field-year situations. In order to evaluate which field factors affect bitter pit susceptibility under field conditions, these orchards were distributed around the whole Lleida fruit growing area (150,000 ha) to obtain a good sample of all soil types, irrigation systems and management conditions.

In spite of all the efforts carried out in recent years to solve the problems it causes, bitter pit continues to be responsible for the most important post-harvest losses. The Lleida area has more than 10,000 ha of Golden apples and susceptibility to bitter pit incidence is by no means uniform. Some sets of fruits show incidence of 25%, while the general mean is about 3%.

During the trial, systematic samples were taken in order to characterise the behaviour of the orchards. Moreover, all the agronomic techniques applied were recorded. Bitter pit incidence was evaluated at harvest and after storage.

A regression model was built up with the most significant variables and validated in 1999 on 32 new orchards. This model permits a high degree of success in the prediction of the fruit sets with high or low risk of bitter pit incidence. The variables that showed a high correlation with the incidence of bitter pit were yield efficiency (kg/cm²), K/Ca relation and N in fruit. Soil type also has a marked influence on bitter pit incidence and its inclusion markedly improves the model.

Key words: Bitter pit, Malus domestica, soil type, prediction, nutrients.

Introduction

One of the main aims of the fruit industry is to reduce the “non quality”, and in this sense, bitter pit is a major problem in Lleida, the largest apple producing area in Spain, where the Golden cultivar is the most widely grown. The conformation of apple quality is linked to many pre-harvest factors (Bramlage, 1993).

The study of these factors on the storage quality of apples has been the subject of considerable research in many producing regions around the world (Sharple, 1980; Marcelle, 1990; Ferguson & Watkins, 1992; Tomala, 1997). According to Naumann (1976), bitter pit appearance is related to soil management, fertilisation and irrigation practices, rootstock, use of growth regulators, pruning, moment of harvest and storage. In addition to these factors, a more recent paper (Tomala, 1997) also stresses the importance of yield, fruit size, number of fruit seed and the fruit position on the tree.

In recent years, several models have been developed for bitter pit prediction based on the mineral content of the fruit (Wills, 1976; Sharple 1980). Other models have taken into
account the fruit weight (Wolk & Lau, 1994) and weather variables (Johnson & Ridout, 1998). Some authors have proposed the use of fruit infiltration with Mg as an alternative to the bitter pit prediction models (Retamales et al., 2000).

This paper reports results from a large interdisciplinary project aimed at understanding apple quality ranging from field factors to post-harvest management, and developing sustainable agricultural systems. In the bitter pit incidence prediction model, explanatory variables, such as mineral fruit content and yield efficiency, are used in a similar approach to that of the above mentioned authors, but the soil type is introduced as a new factor.

Material and methods

The current research was carried out in commercial irrigated orchards of Golden Delicious apples in Lleida, northeast Spain. The latitude is 41° N and the altitude ranges from 100 to 300 m above mean sea level. The climate is semi-arid continental Mediterranean type; average annual rainfall is 400 mm and the average annual air temperature is 13.9° C, January being the coldest month (4.8° C) and July the hottest (24° C).

From 1995 to 1998 was the stage of model development for this research and the preliminary results have been reported elsewhere (Sió et al., 1998 a and b; Usall et al., 1998; Sió et al., 2000). 50 fields were studied in 1995. This number rose to 66 in 1996. There were 63 in 1997 and 59 in 1998 making a total of 238 different field-year situations studied. The results of this first stage research were validated in a different sets of commercial fields in 1999 (32 fields).

In both stages of the study, the fields were selected using the criteria in relation to soil type, irrigation system, crop behaviour, etc to cover all the different situations encountered in the area. A common feature of all the fields was the cultivar (Golden Delicious). The most common rootstock was EM-9, but 36 % of the orchards studied had others rootstocks (M.7, MM-106 and MM-111).

All observations and samples were taken in a previously delimited uniform area of about 5,000 m² inside the commercial field (a block of trees growing under the same soil type and culture conditions).

The pre-harvest factors studied were soil type, physical and chemical soil characteristics, mineral contents in fruit and leaves, agronomic practices (irrigation and fertilisation), yield and trunk cross-sectional area (TCSA). In this paper, reference is only made to the factors that are presented in the results. A full description of these can be found in Sió et al. (1998a).

Soil characteristics

The soil type in each orchard was recorded according to the Soil Map of Catalonia 1:25000 (Herrero et al., 1993; Ascaso and Margarit, 1995; Antunez et al., 1995). This information was checked and completed through the opening of a pit and/or soil borings which were described according to SINEDARES (CBDSA, 1983). In addition to the soil type in all cases drainage class, rooting depth and conditions, master horizons presents (thickness, structural characteristics, etc.) and underlying materials. The soil samples taken were analysed according to the official Spanish methods (MAPA, 1994).

Fruit and leaves mineral contents

90 days after full bloom, 100 leaves were taken from the central third of the current year’s shoots (Martin-Prével et al., 1984). The skin and flesh (without seeds) of 20 fruit per orchard were analysed at harvest time. The nitrogen was analysed by the Kjeldalh method (López-Acevedo, 1990) and, after acid digestion, P, K, Ca, Mg, B, Zn and Mn were analysed by HPLC.
Yield efficiency
The yield was recorded every year and computed from the data about commercial yield provided by farmers. Trunk cross-section area (TSCA) was calculated from trunk diameter 20 cm above the soil surface measured in late February (average of 30 trees per orchard).

Bitter pit incidence
At commercial harvest two large fruit samples (15-18 kg) were picked from each plantation. The fruit samples were taken fruit in the 75-85 mm diameter range. The first sample was stored for 20 days at room temperature, and the second for 6 months in controlled-atmosphere (CA) storage (3% CO₂, 2% O₂ and 1º C).

Statistical analysis and model validation
Only one response variable was studied for the model to predict bitter pit, this being the “incidence of bitter pit after 20 days storage at room temperature”. In a first stage, all the studied variables were included and through a stepwise regression and Rsquare (SAS Inst., 1989), the variables which best fitted the model were selected. This procedure was applied to both the whole set of orchards as well as to the most contrasted soil types. After that, only the variables which best fitted to the four soil types were retained and the model was validated in a set of 32 orchards studied in 1999 with the same methodology described above and where all four soil types were present in a balanced manner.

Results and discussion
The meteorological/climatic variables were not included in the model produced from the beginning and others related to the chemical soil fertility as well as the fertilisation practices were discarded because they were not correlated with bitter pit incidence during the statistical analysis. Such findings may be related to the range of variation of such properties in the set of orchards studied. This variation could be too narrow given that, although the orchards are scattered across a large area (about 150,000 ha), all the soils are highly calcareous and farmers tend to use similar fertiliser practices, which build up the content of available P and K, generally above the so-called “non answer level”. Fruit weight has usually shown a great influence on bitter pit incidence (Tomala, 1997). However, it was explicitly excluded from the model as it was decided to work on the model with only the fruit with the highest value on the Spanish market (75-85 mm in diameter).

The model retained in the end had only three variables. These were yield efficiency, fruit K/Ca ratio and fruit N. The balance between yield and vegetative growth has a great influence on bitter pit incidence. As a larger number of fruit per tree reduce such incidence (Ohme & Lüddders, 1983; Ferguson & Watkins, 1992) this variable was introduced as “yield efficiency” (kg fruit/cm² TSCA).

At the beginning of the study, the soil types were grouped into four contrasting groups (table 1). During the statistical analysis, significant differences in bitter pit incidence were observed between them (fig. 1). In such a situation, it was felt necessary to develop a model for each soil type.

Table 2 shows the models obtained. It can be seen that there was great similarity between the selected variables for all soil types, but the degree of bitter pit incidence differed widely between them. Soil type E1E2 (table 1) shows the poorest correlation due to the large number of samples without bitter pit. When the model developed for all soils (table 2) was validated for the orchards studied during 1999 (fig 2), the percentage of variance (R²=0.48) accounted for was similar to that obtained for soils A1A2, B1B2 and C3C4 during the model building process (table 2). In studies with multiple regression analysis reported by Sharples (1980)
and, more recently, by Johnson & Ridout (1998), not much more of the variation in bitter pit was accounted. Such findings reinforce the need to introduce other factors into such studies.

Table 1. Short description of the four contrasting soil types found in the Lleida fruit growing area

<table>
<thead>
<tr>
<th>Soil type A1A2</th>
<th>Uniform soils in valley bottoms and flat areas: deep, well drained, high water holding capacity, non saline, loam to silty loam soils.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type B1B2</td>
<td>Variable soils in valley bottoms, flat areas and footslopes: deep to very deep, moderately well to imperfectly well drained, high water holding capacity, slightly saline, silty loam to silty clay loam soils.</td>
</tr>
<tr>
<td>Soil type C3C4</td>
<td>Highly variable soils in slopes: shallow to moderately deep, well drained, medium water holding capacity, non saline to slightly saline, silty loam soils.</td>
</tr>
<tr>
<td>Soil type E1E2</td>
<td>Uniform soils of platforms: shallow, well drained to somewhat excessively drained, low water holding capacity, non-saline, gravely loam soils.</td>
</tr>
</tbody>
</table>

Table 2. Bitter pit prediction models

<table>
<thead>
<tr>
<th>Soil type groups</th>
<th>Bitter pit prediction model</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>All soils</td>
<td>Y = -17.99-11.08* Yield efficiency (kg/cm²)+0.58<em>fruit K/Ca+39.98</em>fruit N (R²=0.28)</td>
<td></td>
</tr>
<tr>
<td>A1A2</td>
<td>Y=-9.09-32.70* Yield efficiency (kg/cm²)+0.47<em>fruit K/Ca+34.02</em>fruit N (R²=0.45)</td>
<td></td>
</tr>
<tr>
<td>B1B2</td>
<td>Y=-40.61-5.22* Yield efficiency (kg/cm²)+0.93<em>fruit K/Ca+83.74</em>fruit N (R²=0.55)</td>
<td></td>
</tr>
<tr>
<td>C3C4</td>
<td>Y= 5.41-22.77* Yield efficiency (kg/cm²)+0.06<em>fruit K/Ca+43.68</em>fruit N (R²=0.50)</td>
<td></td>
</tr>
<tr>
<td>E1E2</td>
<td>Y=8.77-3.18* Yield efficiency (kg/cm²)+0.42<em>fruit K/Ca+ 3.54</em>fruit N (R²=0.24)</td>
<td></td>
</tr>
</tbody>
</table>

Y: % of fruit with bitter pit (20 days at room 20º C temperature); fruit K, fruit Ca, fruit N: % element, dry weight fruit K, fruit Ca, fruit N: % element, dry weight
+ See table 1 for the characteristics of the four soil types.

When the soil type is introduced into these models, a significant improvement is obtained for certain soil types (table 2), although a large part of the variance remains unexplained, perhaps because the soil type itself is strongly correlated to mineral nutrition and yield efficiency. However, when the model is applied both to the “average conditions”, which are not very relevant in terms of bitter pit risk, and to the conditions where the development of bitter pit is more likely (low yield efficiency, high fruit K/Ca ratio, high fruit N), the situation reached is very different (fig 3) with very large differences between soil types in the predicted bitter pit levels. Thus the soils with the highest bitter pit incidence potential were the B1B2 (table 1) with limited drainage, some compaction and, in some cases, with some salinity. The
Fig. 1. Bitter pit incidence (% of fruit with bitter pit) in the different soil type groups during the 1995-98 period (248 orchards) storing the fruit for 20 days at room temperature after harvesting and after 6 months in C.A. (post-harvest). Means with the same letter are not significantly different according to Duncan’s test (P≤0.05).

Fig. 2. Validation results (32 orchards studied in 1999) of the bitter pit prediction model built with the orchards studied during the 1995-98 period.

Fig. 3. Predicted values of bitter pit incidence (%) obtained applying the model to a “high risk” situation (low ratio yield efficiency-vigour, high ratio fruit K/Ca and high fruit N content) and to an “average” situation (medium values for the above-mentioned parameters).
apples from E1E2 soil type (table 1) had the lowest potential for developing bitter pit and these soils are well to somewhat excessively drained, non-saline and have a gravely loam texture and low rooting depth.

It has to be born in mind that aspects such as yield efficiency, or even the fruit mineral content, may be strongly modified by atmospheric factors (frost, high temperatures, etc.) with little possible control by the producer. It seems that in situations aiming towards sustainability, such as Integrated Fruit Production, the soil types with the lowest potential for disorder development will be used as the basis for integrated bitter pit management.

Acknowledgements

This research was possible because of the co-operation of farmers who willingly provided their fields, and especially the technician from the “Agrupacions de Defensa Vegetal de Lleida”, who supplied a large part of the field data. The “Laboratori Agroalimentari” (DARP – Generalitat of Catalonia (Catalan Regional Government)) analysed the samples. DARP – Generalitat of Catalonia, IRTA and INIA (Project INIA SC 97-041) provided financial and material support.

References


Biological control of *Monilinia laxa* on stone fruits

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**Abstract:** Postharvest losses due to brown rot caused by *Monilinia laxa* in stone fruits are of considerable importance all over the world. Fungicides are a primary mean of controlling *M. laxa* but new and effective means, such as biological control, that pose less risk to human health and environment should be developed. This work studied the biocontrol efficiency of pre- and post-harvest treatments with spores of *Epicoccum nigrum* to nectarines and plums infected with *M. laxa*. In both assays treatment of the antagonist resulted in significant (P≤0.05) and effective control of *M. laxa* rot on plums or nectarines in postharvest.

**Key words:** Antagonist, biological control, postharvest diseases, brown rot, *Monilinia laxa*, *Epicoccum nigrum*

**Introduction**

Stone fruits represent an important part of perishable commodities where losses due to diseases amount to about 23% of the harvested crops. *Monilinia laxa* (Aderh. et Ruhl.) Honey is a important pathogen in stone fruit-growing areas of Spain. This fungus causes blight of blossoms and twigs, cankers on woody tissues, and rot of fruits, where it is most destructive. Infections of *M. laxa* that cause postharvest losses in stone fruits are originated from preharvest quiescent or latent infections (Emery et al., 2000), or from the germination of conidia on the surface of ripe fruit, followed without pause by penetration and decay. Postharvest control of *M. laxa* is usually initiated before harvest in the field by cultural methods but fungicides are a primary mean of controlling *M. laxa*. The evolution of resistance in *M. laxa* to certain fungicides, the increasing costs of chemical and cultural methods, and the threat of regulatory restrictions, all point to the need for new and effective control methods that pose less risk to human health and environment (Zehr, 1982).

Biological control using fungal antagonists has emerged as one of the most promising alternatives, either alone or as part of an integrated control strategy. Melgarejo et al. (1985) began an approach to the biological control of twig blight caused by *M. laxa* by screening antagonists among the fungal microflora of peach twigs. *Epicoccum nigrum* Link isolate 282 was shown as a biocontrol agent against *M. laxa* in peach orchards when antagonist was applied on twigs (Melgarejo et al., 1986). Further experiments were carried out on peach twigs in experimental and commercial orchards in Zaragoza (Spain) from 1986 and 1992 with various preparations of spores and/or mycelium of *E. nigrum*. Madrigal et al. (1994) obtained biocontrol of peach twig blight, this control was variable each year, depending on the relative disease severity in the first 2-3 weeks after infection and the climatic humidity conditions.

Despite the high potential of biocontrol in the postharvest environment few attempts have been carried out to control postharvest diseases of stone fruits. *E. nigrum* controlled brown rot in postharvest experiments in peaches artificially inoculated with *M. laxa* (Melgarejo et al., 1986). Pratella et al. (1993) recorded the biocontrol of *M. laxa* and *Rhizopus stolonifer* with bacterial endophytes in stone fruits in postharvest conditions. The control of disease obtained
by postharvest use of antagonists might be improved if preharvest applications were included. Some studies have demonstrated that infection of fruit by postharvest pathogens often occurs in the field prior to harvest (Roberts, 1994, Biggs, 1995).

The objective of the present study was to evaluate the efficacy of the biocontrol agent *E. nigrum* applied in pre- or post-harvest to control the brown rot of fruits caused by *M. laxa*.

**Material and methods**

**Field trials**

During 1998 and 1999 growing seasons assays of *E. nigrum* were carried out in commercial nectarine orchards in Tudela (Navarra, Spain) naturally infected with *M. laxa* and grown under standard cultural practices. In both seasons nectarine trees cv. Fairlane were treated 21, 7 and 2 days before harvest with the following treatments: T1) spore suspension in water of *E. nigrum* (10^4 spores/ml) T2) triforine (Saprol, 150 cc/ml), T3) water (control). Treatments were applied with a hand gum operating at a pressure of 10 atmospheres. Eighty were treated per tree and four trees were used per treatment. Guard trees were used to separate randomized treatments and replicates. Nectarines were harvested on 8 September (year 1998) and 10 September (year 1999) and placed in storage boxes according to replicate and treatment and stored in commercial conditions. After 10 days the number of fruits rotted by *M. laxa* per treatment were recorded. Concentration and viability of *E. nigrum* spore suspensions applied to fruits were estimated for each treatment. Populations of *E. nigrum* on fruit surface were also studied as follows: 20 peel plugs per fruit of 145 mm in diameter were shaken in 50 ml sterile phosphate buffer (pH 7) on a rotary shaker for 20 min at 150 rpm and then sonicated for 10 min in an ultrasound bath. Serial dilutions of the washings were made and plated on Potato Dextrose Agar (PDA) containing 0.5 gl^-1 streptomycin sulphate and 5 ppm dichloran. After incubation at 25ºC in the dark for 7 days the isolated viable colonies per cm^2 (cfu cm^-2) were estimated for each sample. This study was carried out before and after treatments and in postharvest with four nectarines per treatment.

Data were analysed by analysis of variance (Snedecor & Cochram, 1980). When F-test was significant at P≤0.05, treatment means were compared by Student-Newman-Keuls test (Snedecor and Cochram, 1980). Before analysis incidence and population data were subjected to arcsin and log transformation respectively to achieve homogenization of variances.

**Postharvest assays**

The test was carried out using plums as plant material. Plums were surface sterilised and dried in the flow cabinet. A 20 µl drop of the spore suspension of *E. nigrum* adjusted to about 1x10^6 spores/ml was placed on each fruit, at the insertion point of the peduncle, left to dry and a 20 µl drop of the spore suspension of *M. laxa*, adjusted to about 1x10^4 spores/ml was applied on it. The drops were left to dry and the fruits were placed in sterile Petri plates without a lid. Controls were fruits inoculated with the pathogen and untreated. Two replicates plates and three fruits per plate were used per treatment. Plates were placed in hermetic containers with sterile water (100% relative humidity) which were incubated at 25ºC. The percentage of infected fruits (incidence) and lesion diameters (severity) caused by *M. laxa* were assessed at 8 days.

Data were analysed by analysis of variance (Snedecor and Cochram, 1980). Treatment means were compared by a Student-Newman-Keuls test (Snedecor and Cochram, 1980) when significant effects were found (P≤0.05). Before analysis data were transformed to arcsin to achieve homogenization of variances.
Results

Field trials
Disease incidence was higher in 1999 than in 1998 and was related to control of disease (Table 1). Applications of *E. nigrum* in preharvest reduced brown rot on fruits in postharvest when disease incidence was low. Disease reduction on nectarines treated in preharvest with *E. nigrum* or Triforine was about 50% in 1998. However, when disease pressure was high (year 1999) there were no more control of disease with any treatment.

Table 1. Percentage of rot caused by *Monilinia laxa* 10 days after harvest in nectarines treated with *Epicoccum nigrum* or triforine in 1998 and 1999

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: <em>E. nigrum</em></td>
<td>5.2 ± 3.0 a</td>
<td>82.3 ± 5.4 a</td>
</tr>
<tr>
<td>T2: Triforine</td>
<td>6.1 ± 2.3 a</td>
<td>71.0 ± 9.2 a</td>
</tr>
<tr>
<td>T3: Control</td>
<td>11.5 ± 0.6 b</td>
<td>91.5 ± 3.8 a</td>
</tr>
</tbody>
</table>

1Data are means of four replicates (one tree) in which 80 nectarines were recorded ± standard error of the mean. Means followed by the same letter in each column are not significantly different (P ≤ 0.05) by Student-Newman-Keuls test.

Population dynamics of *E. nigrum* on nectarines surface during the whole experiment are shown in Table 2. Conidia concentrations sprayed onto fruits were 1 x 10^5 spores per ml in both years of assay. Percentage of viable spores ranged from 40 to 80%. *E. nigrum* population on fruit surfaces were higher in 1998 than in 1999. No significant differences were observed in colony forming units/cm² in 1998 or 1999. However, *E. nigrum* was not recorded in three data samples in 1999.

Table 2. Population of *E. nigrum* isolated from nectarine surface (colony-forming units per cm²) before and after the treatments assayed during two growing seasons (1998 and 1999)

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>After first treatment</td>
<td>8.23 ± 3.45</td>
<td>1.1 ± 0.63</td>
</tr>
<tr>
<td>Before second treatment</td>
<td>1.05 ± 0.47</td>
<td>0</td>
</tr>
<tr>
<td>After second treatment</td>
<td>0.86 ± 0.42</td>
<td>1.91 ± 2.91</td>
</tr>
<tr>
<td>Before third treatment</td>
<td>3.50 ± 0.98</td>
<td>3.12 ± 0.18</td>
</tr>
<tr>
<td>After third treatment</td>
<td>10.7 ± 7.84</td>
<td>0</td>
</tr>
<tr>
<td>Harvest</td>
<td>2.75 ± 0.85</td>
<td>0</td>
</tr>
</tbody>
</table>

1Data are means of four replicates ± standard error of the mean.

Postharvest assays
*E. nigrum* untreated and *M. laxa* inoculated plums showed rotting symptoms and were nearly covered by mycelium of the pathogen 8 days after inoculation. *E. nigrum* was effective in controlling brown rot (Table 3). Incidence and severity of the disease were significantly higher in untreated than in treated plums.
Table 3. Percentage of infected fruits and lesion diameters caused by *Monilinia laxa* in plums treated with *Epicoccum nigrum* 8 days after inoculation with *M. laxa*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% disease incidence</th>
<th>Diameter of lesion (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. nigrum</em></td>
<td>25 b</td>
<td>4.5 b</td>
</tr>
<tr>
<td>Control</td>
<td>100 a</td>
<td>26.0 a</td>
</tr>
</tbody>
</table>

Data are means of six replicates. Means followed by the same letter in each column are not significantly different (P≤0.05) by Student-Newman-Keuls test.

Discussion

Preharvest applications with *E. nigrum* spore suspensions reduced the brown rot on nectarine in postharvest, and control was similar to fungicidal treatment when disease incidence was low. *E. nigrum* is a member of the epiphytic microflora of peach twigs (Melgarejo et al. 1985), the present results suggest its potential to reduce *M. laxa* inoculum, the number of latent infections and/or to protect injuries by colonization. However, control of disease was not obtained with high disease incidence in 1999. Melgarejo et al., 1985 demonstrated that biocontrol of *E. nigrum* against *M. laxa* in peach blossoms was variable depending on the relative disease severity, the climatic conditions and the nutrients added to inoculum. Perhaps the antagonist population in 1999 did not reach the threshold concentration for satisfactory control.

*E. nigrum* population on fruit surfaces were higher in 1998 than in 1999. Climatic conditions could affect its survival and growth in field conditions in 1999. Studies on preharvest biocontrol treatments using *Trichoderma harzianum* and *Ulocladium atrum* in relation to control of *Botrytis* on various crops (Elad & Kishner, 1993; Köhl et al., 1995) found that microclimatic conditions had a significant effect on survival of the populations of biocontrol agents. McKenzie et al. (1991) found that unformulated pure conidial suspensions of *T. harzianum* did not survive effectively under field conditions. Further research is needed to improve the survival of *E. nigrum* in commercial formulations.

Application of *E. nigrum* spores to plums after harvesting reduced brown rot disease and development of lesions in postharvest. This supports previous studies by Pascual et al. (1998), which demonstrated that *E. nigrum* controlled fruit rot of cherries caused by *M. laxa*. Postharvest environment provides a special milieu for developing biological control systems because more standardized and controllable environmental conditions exit (Droby & Chalutz, 1992). Since 1983, an explosion of research has occurred in this area, mostly on fruit diseases. Research is needed on ways of potentiating antagonistic activity through additives such as nutrients, wetting agents, or spreader-stickers.

All of these results suggest that strategies based in application of preharvest and postharvest treatments of *E. nigrum* to control brown rot of disease in stone fruits are promising. Production and improvement of inocula of the antagonist *E. nigrum* are now in progress.

Acknowledgements

We wish to thank to the Department of Post-harvest of UdL-IRTA, Lleida (Spain) and to C. Simón for technical assistance. This research was in part supported by projects ALI-1999-0652-02-02 and QLK5-CT-1999-01065.
References

Elad, Y. & Kirshner, B. 1993: Survival in the phylloplane of an introduced biocontrol agent (Trichoderma harzianum) and populations of the plant pathogen Botrytis cinerea as modified by abiotic conditions. Phytoparasitica 21: 303-313.
Use of a model simulating *Taphrina deformans* infection on peaches for optimal disease control

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**Abstract:** Some experiments were carried out in northern Italy (1996 to 1999) to verify the possibility of using a model accounting for the effect of host phenology and weather (rainfall and air temperature) on infection by *T. deformans* of peaches as a tool supporting decision-making for tactical disease control. Many treatments, each consisting of a single fungicide (Ziram or Dodine) spray, applied at different times, were compared with an untreated control. The most effective fungicide sprays were those applied within 5 days before the most severe seasonal infection (77% effectiveness). Sprays applied up till 15 day before infection maintained more than 50% of effectiveness in reducing disease incidence compared to the untreated control, while the earlier sprays gave below 50% effectiveness. Fungicides applied after infection had low effectiveness: already after few days, effectiveness was 44%. Even though the model confirmed its accuracy in signalling leaf curl infections, it showed some limits for scheduling fungicide sprays, and needs improvements. Nevertheless, the use of reliable short-time weather forecasts makes a profitable use of model already possible.

**Key words:** peaches, leaf curl, weather, simulation model, fungicide effectiveness

**Introduction**

*Taphrina deformans*, the fungus causing leaf curl on peaches, is usually controlled with fungicides applied in the period between leaf fall and bud break. However, several experiments performed in recent years have demonstrated that, in the presence of a high inoculum level and of favourable environmental conditions for infection, it is necessary to spray fungicides also after bud break, till petal fall (Ponti & Spada, 1997).

From the late 90s, epidemiological studies were conducted in order to improve disease management. Among these, an Israeli model simulating infection (Safran & Levi, 1995) was validated and modified (Giosuè et al., 2000). At the same time, some experiments were performed to verify the possibility of using such a model in supporting decision making for tactical disease management.

**Materials and methods**

**Simulation model**

The model calculates an infection risk on each day, based on host susceptibility, rainfall and air temperature. The phenological stage of the peach trees is the first factor of risk; risk is set at zero until plants reach bud break, thereafter it is set at one. The risks related to rainfall and air temperature are calculated by mathematical equations, when rainfall is greater than 9.5 mm per day and maximum air temperature exceeds 3°C, respectively. Disease symptoms are expected to appear after an incubation period of 14 to 28 days.
Experimental fields management

Seven experiments were performed between 1996 and 1999, in peach orchards located in the eastern Po Valley (Italy) that had shown severe leaf curl symptoms in the previous season. Since in two orchards many cultivars were observed, 15 cases (year x location x cultivar) were considered in aggregate (Tab. 1). To ensure the presence of an abundant overwintering inoculum, no fungicides were applied either at leaf fall or at the end of winter. To obtain representative situations, the peach plants were grown according to common practice; the orchards considered were traditionally cultivated in the palmate or in the vase-shaped system.

Automatic weather stations were placed in the proximity of each orchard to measure the meteorological data.

Several treatments were included in all the experiments, each consisting of a single fungicide spray applied at different times (Tab. 1). In the first 5 experiments, fungicide sprays were scheduled a priori, based on the calendar or on the tree phenology, while in the two experiments carried out at Zattaglia, applications were scheduled according to the simulation model: the model was operated using either the local weather forecast or the measured weather data. Thus, sprays were respectively applied just before a likely infection or after an infection signalled by the model, as soon as possible. An untreated control was included in all the experiments. Fungicides used were Ziram (162 g of active ingredient per hl) or Dodine (60 g per hl). The experimental design was a completely randomised block design, with 4 replicates of 3 contiguous trees.

After bud break, the trees were periodically observed to determine the time of symptom onset on leaves and fruits; when symptoms stopped appearing, disease incidence was assessed as a percentage of affected shoots or fruits.

Data analysis

The effectiveness of fungicide applications was expressed as a percentage, by comparing disease incidence in each sprayed plot (DIₚ) with that in the untreated control (DIₜ): DIₚ/DIₜ·100. Data were then arcsin-transformed to make the variance of the residues uniform, then processed by the analysis of variance. Differences between means were tested by the LSD Test at P≤0.05.

To compare the effectiveness of fungicide sprays in relation to the time elapsed between application and infection, data were processed as follows: i) the days when infection occurred were determined by the model; ii) the day of the most severe seasonal infection was determined on the basis of the observed disease incidence; iii) the time elapsed between each fungicide application and this infection was calculated; all these time periods were grouped in 5-day intervals; mean and standard errors were calculated for each time interval. At the end of this phase, the mean effectiveness of fungicides applied either before or following the most severe leaf curl infection was then obtained. The two active ingredients used were not distinguished, because they had proved not to be significantly different in disease control (Ponti et al., 1993).

Results and discussion

The experiments were carried out under different epidemiological conditions, which made it possible to observe a representative range of leaf curl outbreaks: in the untreated plots, incidence of affected shoots ranged from 16 to 100%, while, as usually occurs, fruits were less affected and frequently infection free (Tab. 1).

Some primary infections occurred at each experimental site, but just one of them accounted for the greatest part of the disease symptoms observed during the season. This
severe infection usually occurred in the second half of March, or in the second half of February for ‘Zincal5’, which has an early bud break compared to the other cultivars (Tab. 1).

The day when any infection occurred was inferred by comparing the results from the simulation model with the appearance of leaf curl symptoms; the day of the most severe infection was determined in the same way. For instance, at Zattaglia 1997, the model signalled the following infections (Fig. 1): on 14 February, which produced the onset of very light symptoms in the middle of March; two infections on 19 and 25 March that led to a clustered appearance of very severe symptoms in the second ten days of April; a clustered infection from 20 to 22 April, with sporadic symptoms in the middle of May. At Zattaglia 1999 (Fig. 1), the most important infection on leaves occurred on 26 March: the correspondent disease symptoms appeared in the first ten days of April and accounted for almost the total seasonal symptoms. On fruits, there was only one infection, on 8 April, that affected 15% of fruits.

Table 1. Characteristics of the experiments carried out between 1996 and 1999. The date of occurrence of the most severe leaf curl infection was inferred by comparing model simulations and field observations. DI is the % incidence on shoots and fruits.

<table>
<thead>
<tr>
<th>Location - Year</th>
<th>Cultivar</th>
<th>Fungicide applications</th>
<th>Most severe infection</th>
<th>DI (%) shoots/fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesena - 1996</td>
<td>Zincal5</td>
<td>Dodine</td>
<td>19, 21/2</td>
<td>100/0</td>
</tr>
<tr>
<td></td>
<td>Big Top, Sweet Red, Early Star</td>
<td>6/2 16/2 26/2 8/3 29/3</td>
<td>16/3</td>
<td>98/0</td>
</tr>
<tr>
<td>Tebano - 1996</td>
<td>Aurelio Grand</td>
<td>Ziram</td>
<td>1/2 7/2 16/2 21/2 29/2 7/3 18/3 28/3 5/4</td>
<td>16/3</td>
</tr>
<tr>
<td>Conselice – 1996</td>
<td>Caaldesi 2020</td>
<td>Ziram</td>
<td>1/2 7/2 15/2 21/2 29/2 7/3 18/3 28/3 5/4</td>
<td>12,16/3</td>
</tr>
<tr>
<td>Cesena - 1997</td>
<td>O’Henry</td>
<td>Ziram</td>
<td>5/2 14/2 18/2 28/2 8/3 20/3 27/3</td>
<td>19, 24/3</td>
</tr>
<tr>
<td>Cesena - 1997</td>
<td>Zincal 5</td>
<td>Ziram</td>
<td>24/1 11/2 21/2 3/3 10/3</td>
<td>15/2</td>
</tr>
<tr>
<td></td>
<td>Fidelia, Scarlet Red, O’Henry</td>
<td>11/2 21/2 3/3 20/3</td>
<td>19/3, 24/3</td>
<td>42/0, 52/0, 38/0</td>
</tr>
<tr>
<td></td>
<td>Silvia, Zaiger</td>
<td>3/3 10/3 20/3</td>
<td>19, 24/3</td>
<td>16/0, 52/0</td>
</tr>
<tr>
<td>Zattaglia - 1997</td>
<td>Julia</td>
<td>Ziram</td>
<td>4/2 15/2 17/2 28/2 10/3 20/3 26/3</td>
<td>19, 25/3</td>
</tr>
<tr>
<td>Zattaglia - 1999</td>
<td>Julia</td>
<td>Dodina</td>
<td>2/3 7/3 20/3 23/3 28/3 3/4 9/4 14/4</td>
<td>26/3 --</td>
</tr>
</tbody>
</table>

In all experiments, the time of fungicide applications significantly influenced disease incidence on shoots and fruits, at P<0.05 (not shown). Thus, the effectiveness of each treatment changed significantly. In general, effectiveness increased as the day of fungicide application approached near to the day of the most severe seasonal infection, while it decreased when fungicides were applied after such a day. For instance, at Zattaglia 1997 (Fig.1), the most effective sprays were applied on 10 and 20 March, the former preceding
infections on both 19 and 25 March, the latter preceding only the one on 25 March. At Zattaglia 1999 (Fig. 1), the most effective fungicides were sprayed on 20 and 23 March, just before the dreadful infection on 26 March. Fungicides applied soon after infection (on 28 March) were less effective, and the ones applied later were nearly ineffective. Similarly, on fruits, the sprays applied soon after the infection on 8 April were ineffective compared to the ones applied before.

Figure 1. Incidence of shoots (λ) and fruits (ν) affected by T. deformans in plots one-time sprayed once with fungicides on different days, in relation to the days when light (O) or severe (Ø) infections were signalled by the simulation model. Arrows show: period of symptom onset in accordance with the model (↔), actual appearance of light (Ø) or severe (Ø) symptoms. Means with different letters are significantly different at P ≤ 0.05.

Figure 2. Effectiveness of fungicides applied before (ν) and after (λ) infection by T. deformans. Points represent mean values and vertical lines their standard errors (mean ± s.e.), while dotted lines fit the mean values.
The dynamic of fungicide effectiveness over time compared to the most severe seasonal infection on leaves was determined by combining the data collected in all the experiments, as previously described. In aggregate, 64 times when fungicides were applied were considered; they were uniformly distributed between 40 days before and 20 days after infection, with effectiveness ranging between total and no effectiveness (Fig. 2).

The most effective fungicide sprays were applied within 5 days before infection, with 77% of effectiveness and low variability (±6.8%). Sprays applied up till 15 days before infection maintained more than 50% of effectiveness in reducing disease incidence compared to the untreated control, while the earlier sprays gave below 50% effectiveness. Fungicides applied after infection had, on average, a low effectiveness, with high variability: already after a few days, effectiveness was 44% (±11.1%).

A full understanding of the mechanisms explaining these results is, at present, difficult, because of poor knowledge of the life cycle of *T. deformans*. Probably, early fungicide applications did not influence the infecting propagula directly, but reduced the inoculum present on the plant and available for further infection. The increase in effectiveness of fungicides applied from 20 days to just before infection probably resulted from an interaction between sanitation, direct effect on the infecting propagula and residual dose of active ingredient on the infection site. Finally, the very low effectiveness of the sprays applied after infection had occurred is probably due to penetration of the pathogen inside the host tissue.

Two aspects of the present work demand a final comment. They concern reliability of the simulation model and its use in tactical disease control. The results confirmed the accuracy of the model, but exhibited two limits. Based on weather data, the model simulates, on each day, the probability that an infection had occurred on such a day. Thus, information is obtained post factum. Furthermore, the model correctly signals some infections during the season, but do not predict the severity of each of them. The present work showed that only the fungicides applied in the few days preceding the most severe seasonal infection guaranteed an optimal effect on disease control, while sprays made at any time after this infection had occurred do not have sufficient efficacy (Fig.2); thus, information post factum is of little utility.

In conclusion, the model needs some improvements, aimed at overcoming the limits it showed when used as a decision support tool for disease control. For this reason, two studies are in progress: one on the dynamic of the inoculum density during the season; one on the environmental conditions favouring infection, particularly on wetness duration after rainfall.

Nevertheless, the use of reliable short-time weather forecasts makes use of the model already possible. Taking for granted the fall application of fungicides to reduce the overwintering inoculum, a first spray must be recommended after bud break of peaches, when the model (operated using weather forecasts) signals a likely infection. Further fungicide applications could be advised in the same way, taking into account the time elapsed since the preceding spray, its residual efficacy, the dynamic of host growth and the consequent presence of new infection sites, with particular reference to flowers or fruits.

**Acknowledgements**

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**References**

Role of wood destroying fungi in orchards in Austria

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Abstract: Only few species of wood destroying fungi were found in commercial orchards on living trees, most species live on fruit trees in extensively cultivated orchards. Susceptibility of wood to fungal decay differs between tree species, apple as well as plum, apricot, cherry or peach are highly susceptible while pear remains almost unaffected.

Key words: Fungi, wood decomposition, Austria, orchard

Introduction

Wood decomposing fungi play an important role in many ecosystems. In fruit production they are an economic factor causing yield loss or killing trees. Fruit trees are attacked by several species of macrofungi (Jahn, 1979; Kreisel, 1961). Most wood rotting fungi are members of the family Polyporaceae. Ryvarden & Gilbertson (1993, 1994) recorded more than 90 species of wood decomposing polypores on Malus, Pyrus and Prunus. One focus of this study is the diversity and abundance of fungal species decomposing wood of fruit trees (Malus, Pyrus, Prunus) in the eastern part of Austria.

Material and methods

Fungal records are based upon long term monitoring of several Austrian mycologists and data from the herbarium of the Austrian mycological society.

Many fungal records resulted from a scientific study comparing the efficiency of wound treatment products sponsored by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. Species determination was based upon Breitenbach & Kränzlin (1986,) Jahn (1979), Jülich (1984), and Ryvarden & Gilbertson (1993, 1994).

Results and discussion

In Austria, more than 100 species were recorded in orchards on or below fruit trees, including mycorrhizal and saprophytic species (Table 1).

For most of the species, records on wood of fruit trees were rare. Less than 30 percent of the recorded species were found on more than one tree genus. Only 15 species are known to be typical orchard inhabitants, most of them occur in extensively cultivated orchards. Nine fungal genera were dominant in many orchards and frequently found on older trees: Armillaria, Schizophyllum, Coriolopsis, Stereum, Phellinus, Inonotus, Laetiporus, Aurantio-porus, and Sarcodonital. Pathogenicity of these genera, as mentioned in literature and observed by the author, decreased from Armillaria to Sarcodonital.
Table 1: Fungal species recorded in Austrian orchards. No sign...wood decomposing fungus, +...mycorrhizal fungus, #...litter decomposing fungus, !...species from the red list. Records more than twice in bold letters. Data source: mycological herbarium of the Austrian Mycological Society, further records from Forstinger, H., Hausknecht, A., Dämon, W., and Kovacs, G. (unpublished data).

<table>
<thead>
<tr>
<th>Fungus species</th>
<th>rare on living trees</th>
<th>on dead wood</th>
<th>on roots</th>
<th>rare on living trees</th>
<th>on dead wood</th>
<th>on roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abortiporus biennis</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Cyphellops anomala</td>
<td>o o o</td>
<td></td>
</tr>
<tr>
<td>Aleurodiscus cerussatus</td>
<td></td>
<td></td>
<td>o</td>
<td>Dacrymyces stillatus</td>
<td></td>
<td>o o</td>
</tr>
<tr>
<td>Amanita solitaria +</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Daedaleopsis confragosa</td>
<td>o o</td>
<td></td>
</tr>
<tr>
<td>Amphinema byssoides</td>
<td>o o</td>
<td></td>
<td>o</td>
<td>Daedaleopsis tricolor</td>
<td>o o o</td>
<td></td>
</tr>
<tr>
<td>Antrodiella fragrans</td>
<td></td>
<td></td>
<td>o</td>
<td>Datronia mollis</td>
<td>o o</td>
<td></td>
</tr>
<tr>
<td>Armillaria gallica</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Dermea mollis</td>
<td></td>
<td>o o</td>
</tr>
<tr>
<td>Armillaria mellea s.str.</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Encoelia furfuracea</td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>Armillaria ostoyae</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Entoloma clypeatm +</td>
<td>o o o</td>
<td></td>
</tr>
<tr>
<td>Armillaria tabescens</td>
<td>o o o o o o</td>
<td></td>
<td>o</td>
<td>Entoloma dythalooides +</td>
<td>o o o</td>
<td></td>
</tr>
<tr>
<td>Armillaria viridiflava</td>
<td>o o</td>
<td></td>
<td>o</td>
<td>Entoloma niphoides +</td>
<td>o o o</td>
<td></td>
</tr>
<tr>
<td>Athelia epiphylla #</td>
<td></td>
<td></td>
<td>o</td>
<td>Eutypa lata</td>
<td>o o o o o</td>
<td></td>
</tr>
<tr>
<td>Aurantioporus fissilis !</td>
<td>o o o o o</td>
<td></td>
<td></td>
<td>Eutypella prunastri</td>
<td></td>
<td>o</td>
</tr>
<tr>
<td>Auricularia mesenterica</td>
<td>o o o o o o</td>
<td></td>
<td></td>
<td>Exidia glandulosa</td>
<td></td>
<td>o o</td>
</tr>
<tr>
<td>Bisporella citrina</td>
<td>o o</td>
<td></td>
<td></td>
<td>Flammulina velutipes</td>
<td>o o o o o</td>
<td>o o</td>
</tr>
<tr>
<td>Bjerkandera adusta</td>
<td>o o o o o o</td>
<td></td>
<td>o</td>
<td>Fomitopsis pinicola</td>
<td>o o o</td>
<td>o o</td>
</tr>
<tr>
<td>Bjerkandera fumosa</td>
<td>o o o o o o</td>
<td></td>
<td>o</td>
<td>Ganoderma applanatum</td>
<td>o o o</td>
<td>o o</td>
</tr>
<tr>
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In intensively cultivated orchards *Schizophyllum, Trametes, Stereum, Coriolopsis*, and locally *Armillaria* were frequently observed. Occasionally *Chondrostereum purpureum* was observed causing silver leaf disease, but sporophores of this fungus could only be found after death of the respective tree. Some aggressive parasites can kill the living sapwood and cambium, but most species observed destroy heartwood, and even when fruiting damage to bark, cambium, and sapwood is localised.

*Schizophyllum commune* Fr.
Pruning and sunscald injuries are particularly important sites of infection by decay fungi. Although several fungi cause wood decay in apples and related trees, the most commonly encountered is the split gill *Schizophyllum commune* Fr. This common cosmopolite fungus produces its small, white, fluffy, papery or leathery seashell shaped “conks” in clusters on
infected branches and stems. The sporophores are persistent, shriveling in dry weather, but
reviving after rains, producing enormous amounts of spores.

*Schizophyllum* causes twig and branch decline and local cambium necroses. It was
frequently found on apple, plum, and apricot, and records from all over Austria and all kinds
of fruit trees are documented.

**Armillaria spp.**
The honey mushroom *Armillaria mellea* (Vahl: Fr.) Kummer is feared by fruit growers. As a
root rot pathogen it can invade through intact bark of major roots, progressively destroying
the living root tissues and leading to serious decline and ultimate death of fruit trees.
*Armillaria* species are also known as "bootlace fungi" because many of the species can spread
several metres through soil, along root surfaces or under the bark by producing rhizomorphs
that resemble bootlaces. These rhizomorphs are aggregates of hyphae, with a black
"melanised" outer rind, and they play an important role in infection. In orchards, spread from
tree to tree is achieved by mycelial growth during root-to-root contact or by the rhizomorphs.

In Austria *Armillaria mellea* is found on *Malus* and several cultivated species of *Prunus*. *Armillaria ostoyae* (Romagn.) Herink [= *Armillaria obscura* (Schaeff.) Herink] is common on
conifers, but also found on several hardwoods. There are no records of this species from fruit
trees in orchards.

*Armillaria gallica* Marxmüller & Romagn (= *Armillaria lutea* Gillet) is regarded as less
pathogenic species. It is frequently found on *Prunus* when trees are stressed by environmental
factors. *Armillaria tabescens*, which mainly occurs in the southern part of Austria, is not
known to attack fruit trees there, but it is feared as pathogen e.g. in Northern America. *Armillaria cepistipes*, which has not yet been recorded from orchards, is not easy to identify
and might be an overlooked species with pathogenic as well as saprobic activity.

**Stereum, Trametes and Coriolopsis**
Sporophores of *Stereum*, *Trametes* and *Coriolopsis* may look sometimes very similar. They
all form small conks up to 10 cm wide, with more or less distinct zonations on the surface. *Stereum* has a smooth hymenophore, *Trametes* and *Coriolopsis* have poroid hymenophores.
The three genera differ in their ecological role. *Coriolopsis gallica* (Fr.) Ryv. has an
underestimated parasitic potential. It was frequently found on living trees, especially apricots,
causing heartwood rot and local cambium necrosis. *Trametes versicolor* (L.:Fries) Pilát was
frequently found in orchards and indicates dead wood in a more advanced state of
decomposition. *Trametes* often follows *Schizophyllum* and *Stereum* in fungal succession on
wood. *Stereum rugosum* PERS.: FR. was observed causing bark necrosis on living stems,
*Stereum hirsutum* (Willd.:Fr.) SF.Gray was frequently found on dead wood, but it is known to
live as a symptomless endophyte.

Susceptibility to decay also differs between tree species. *Malus* and *Prunus* were highly
susceptible. Pear remained almost unaffected (Forstinger, 1999).

Most species found were white rot fungi which are able to degrade all components of
wood cell walls. Brown rot fungi selectively remove cellulose and hemicellulose from wood
(Ryvarden & Gilbertson, 1993); only three species from this ancient wood decomposing type
were recorded (*Fomitopsis, Laetiporus, Oligoporus*).

Eradication of wood destroying fungi is virtually impossible. Infection precedes
discovery and the fungus often has time to spread all over the heart wood of the tree when
recognised by producing sporophores (e.g. *Chondrostereum purpureum* (Pers.:Fr) Pouzar). Removal of infected tree parts is not as effective as preventive treatment.
The beneficial effects of dressing fresh pruning wounds with wound protecting agents leads are controversial. Even if there are fungicides mixed into the agent, diffusion into the woody tissue is limited. Welsh & Janne (2000) postulate that wound dressings are therefore purely cosmetic and can not prevent fungal damage to the wound area, and pruning paint may even slow down the healing process. Under the agent layer there exist perfect moisture conditions for fungal growth and already established fungi as well as germinating fungal spores.

The list of fungi presented shows only a part of the potential of orchard trees for biodiversity conservation. A very small group of economically important pathogenic fungi are confronted with many species of ecological importance and scientific interest. Even fungi from the red list of endangered species in Austria could be found in extensively cultivated orchards (Niklfeld & Grims, 1997).

Acknowledgements

The research project was financed by the Federal Ministry for Agriculture, Forestry, Environment and Water Management. We were fortunate to have the possibility to work at the Institute of Phytomedicine at the Federal Office an Research centre for Agriculture. Without the cheerful help of Heinz Forstinger, Anton Hausknecht and other members of the Austrian Mycological Society the number of fungi recorded in orchards would be neglectably small. I also wish to thank Alexander Urban for his review of the manuscript.

References

Fungal endophytes of European Elder (*Sambucus nigra*) and their role in the occurrence of corymb wilt symptoms

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**Abstract:** The presence of endophytic fungi in the shoots of elderberries originating from orchards with different severity of corymb wilt was investigated throughout two years. The results showed differences in the colonisation of shoots by fungal endophytes, depending whether they derive from symptomless or affected orchards. The examined tissues of affected shoots harbour a significantly higher amount of endophytic fungi and the spectrum of isolated genera is different too. Wilt symptoms on artificially inoculated twigs occurred four weeks after the inoculation with *Phoma sambuci-nigrae*.

**Key words:** Endophytes, *Phoma sambuci-nigrae*, *Sambucus*, Elder, Plant-diseases, wilt

**Introduction**

With an area of 1,200 ha European Elder (*Sambucus nigra*) is the most important soft fruit crop in Austria. Because of their high content of anthocyanes the berries are used in food industries.

At suitable sites elder can be produced without high effort in plant protection. Wilt symptoms only occur at unfavourable sites especially in years with high precipitation. It can cause crop damages up to 90%: the branches of the ripening corymbs turn dark, the water and nutrient supply to the berries is interrupted and the corymb (or parts of it) wilt. By the use of certain systemic fungicides, the symptoms are reduced. Therefore the role of endophytes in connection with the incidence of wilt symptoms was investigated. To examine whether there is any pathogenicity of the isolated fungi, infection experiments in greenhouse and field were carried out.

**Material and methods**

In a field survey shoots from 14 orchards showing symptoms of different severity were taken in 4 weeks interval throughout the 1999 and 2000 growing seasons and compared to the shoots from healthy orchards.

The shoots were dissected into segments: the basal internode, the most apical internode (giving rise to the berry stalks) and the berry stalks. To eliminate secondary infections by epiphytes the samples were surface sterilised with ethanol and sodium-hypochlorite (Schulz et.al.,1993). Thereafter samples were transferred to a selective primary isolation medium containing 0,01% streptomycin and oxytetracyclin (Bills, 1996).

For the development of sporulating structures emerging isolates were then transferred to a medium containing 0,5% malt-, 0,2% yeast-extract and 20% elder leaf-juice. If necessary sporulation was stimulated by black-light illumination.
In spring 2000 three years old potted trees were stem inoculated with fresh isolates of the 4 most abundant fungi. The method described by Wright (1933) was adopted: instead of a cork borer a scalpel was used and the wound was sealed with parafilm.

**Results and discussion**

Shoots deriving from plants with frequently incidence of wilt symptoms had a higher degree of colonisation than shoots from healthy plants. Four genera of fungi were dominant: *Fusarium, Alternaria, Phoma* and to a lesser extent *Cladosporium*.

Severely attacked orchards harbour a significantly higher amount of endophytic fungi in all the tissues of the shoots that were investigated (first and third internode, berry stalks) and perform differences in the composition of isolated genera. Figure 1 shows the frequency of endophytic fungi isolated from the third internode of eight sites with symptoms of different severity.

![Figure 1. Frequency (total number of isolates from 16 samples) of endophytic fungi isolated from the most apical internode of eight different sites (date of sampling 26.08.1999, 06.09.1999). The sites Gleisdorf, Puch-Lebing, Voitsberg, Wollsdorf and Ligist-1 showing severe symptoms, whereas at Ligist-2, Puch-Harl and Mitteregg the disease did not occur.](image)

The most abundant genera isolated from attacked orchards were *Alternaria, Fusarium* and *Phoma*. Taken together, these three genera were isolated from more than 90 % of the samples gained from attacked orchards. *Alternaria* is the only genera that was also frequently isolated from sites where the disease did not occur (Ligist-2, Puch-Harl, Mitteregg), whereas
Phoma and with one exception Fusarium, dominated only in orchards showing wilt symptoms.

The Phoma isolate was confirmed as Phoma sambuci-nigrae (Sacc.) Monte et.al.. Two different species of Fusarium were isolated frequently: F. sambucinum and a species which could be distinguished from F. sambucinum by the shape of the macroconidia, the pigmentation and the presence of 0-1 septated conidia.

A total of 17 genera (including Ascochyta, Camarosporium, Cercospora, Cladosporium, Colletotrichum, Coniella, Epicoccum, Geniculosporium, Phlyctema, Phomopsis, Ramularia, Sordaria, Stagonospora, Verticillium and three sterile mycelia) were only isolated at certain sites, times or plant tissues. It is therefore unlikely that they are connected with corymb wilt symptoms.

![Figure 2: Frequency (total number of 32 isolates) and species composition of endophytes depending on the time of sampling at the severely attacked site in Gleisdorf.](image)

Figure 2 shows the patterns of the colonisation of young shoots. The colonisation starts early in the season (the first isolates were gained from the basal parts of the young shoots in May). The infection frequency increased sharply in July when the colour of the berries turn from green to black and is at the highest level a week before harvest (06.09.) when clear symptoms were already observed.

At the first sampling before bloom Phoma and Fusarium, which were the dominating genera later in the season, were already isolated from the basal internode of the young shoots. During winter, samples were taken from one year old wood and examined for endophytes. As Phoma sambuci-nigrae and the two Fusarium species were also isolated out of the wood of one year old shoots, it is suggested that they pass the winter in the shoots and from there colonise the young shoots in spring.

Artificial inoculation experiments: three weeks after inoculation the leaves of twigs inoculated with Phoma sambuci-nigrae appear slightly discoloured and the whole shoots appears drooped. One week later these twigs wilted completely from the site of infection
upwards. Twigs infected with Fusarium, Alternaria resp. Cladosporium showed no symptoms. Longitudinal sections of wilting shoots were examined by direct microscopy and the colonisation of the host tissue and the growth of hyphae of Phoma sambuci-nigrae in the vessels was observed. The fungus was reisolated from the dead twigs.

Hirsch & Braun (1992) describe endophytic fungi as fungi colonising living plant tissue without causing any overt negative effects. In this sense the term endophyte is not correctly used for Phoma sambuci-nigrae. The fungus remains in the basal part of the elder shoots during the season in a quiescent phase without causing any symptoms of the host. Only in cases that favour the development (wet moist conditions) it occupies also the apical parts of the shoots and the berry stalks and can be isolated from there. In the dry summer of 2000 the disease did not occur - even in sites normally showing severe symptoms. Phoma sambuci-nigrae was isolated from the basal internodes but not from the apical internodes and the berry stalks.

The consequences of the appearance of the two Fusarium species needs to be further investigated. Both only occur on affected trees and rapidly colonise the tissues of the young shoots, but yet did not show any wilt symptoms in the infection trials. F. sambucinum is associated with various plant diseases, including canker and dieback in woody plants and hops (Domsch & Gams, 1993).

With an 5mm increment borer wood samples were taken from branches and trunks of all 14 sites and the cores examined for endophytes. The infection trials with fungi originating from the cores are currently evaluated.

Acknowledgements

I would like to thank J. de Gruyter from Plantenziektenkundige Dienst in Wageningen for the estimation of the Phoma isolates on species level and my colleague J. Altenburger for assistance in laboratory- and field works.

References


Usage of UV-C light to protect Fuji apples from Penicillium expansum infection

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Abstract: Storage rots of Fuji apples in Brazil are mainly caused by Penicillium expansum. This research aimed to study the UV-C effect on reduction of the fruit rot and on epiphytic inoculum of Penicillium on apple fruits. First, different UV-C doses ranged between 153 to 7740 erg.mm⁻².s were used to verify their effect on conidia survival and in rot development in inoculated apples. Results showed that all doses reduced P. expansum population and did not affect apple rot number or size. After that, a dose of 5.9 erg.mm⁻².sec was evaluated in a warehouse about the effect on epiphytic Penicillium population and the rot amount in different apple samples after the shelf life period. Results showed reduction of 90-100% of the Penicillium population on fruits and 37-70% of the rots during the shelf life period. The benefits of the method made it recommendable to be applied in the integrated management of the blue mold rot disease in the Southern region of the country.

Introduction

Storage rots of Fuji apples in Brazil are mainly caused by Penicillium expansum, reaching under poor management condition about 8% of fruits at the end of the storage period. The most susceptible cv is Fuji. Methods used to prevent blue mold rot are prophylactic and chemical control (Valdebenito Sanhueza, 1992, 1996) both being restricted because of risks on environmental and human health impacts. Between physical methods of control recommended to manage the disease in apples UV-C had been shown promising because left no residues in the fruit and has not the irradiation disadvantages (Lu et al,1987 & 1991, Stevens et al, 1991 & 1997). This research aimed to study the UV-C effect on reduction of the fruit rot and on epiphytic inocula of Penicillium on apple fruits under controlled and commonly used condition for apple management in Brazil.

Material and methods

Control of Penicillium expansum conidia with UV-C light
The effect of 153,179, 258,461,537,774,922,1074,1538,1580,1790,2580,4610,5370 and 7740 erg.mm⁻².sec on conidial survival was evaluated after treating 5 mL aqueous suspensions contained in petri dishes (6 cm diameter). Samples of each treatments were spread in PDA petri dishes and after 6 days at 24°C incubation, the colony number was recorded. The trial had completely randomised design with three repetitions. Regression analysis was done with UV-C doses and the colony number data.

Effect of UV-C doses on the development of apple rot by P. expansum
The same UV-C doses used on conidial suspensions was applied 6 h before and after the inoculation of wounded Fuji apples with P. expansum conidia suspension (10⁴ con/mL). The apples were maintained under laboratory conditions (16°C - 24°C) for 7 days and then the number and size of lesions were recorded. Four apples were used per treatment and the test was repeated once.
Effect of UV-C over epiphytic population of Penicillium and rot development during shelf life of Fuji apples

An UV-C dose of 5.9 erg.mm².sec was evaluated using an UV-C lamp set established in the drier tunnel used in the warehouse and the dose was established using a UV-C radiometer UVP, model UVX. Three apple samples were used in each trial to study the rot incidence after the shelf life period. The initial and final *P. expansum* inocula was studied shaking a sample(150 rpm) of the treated and untreated apples during 30min, in containers with a sterilised 0.001% of Tween 80 solution. Samples of the washing were spread in petri dishes with PDA ammended with 150 ppm of streptomycin, incubated at 24°C for 5days and then, the *P. expansum* colony number was recorded. Fruits with and without UV-C treatment were storage under room conditions and fruit rot was recorded. Obtained data from both treatments were compared with the Chi square test.

Results and discussion

Control of Penicillium expansum conidia and apple rot with UV-C light

Results showed that all UV-C doses evaluated in the laboratory kills spores in the suspensions (Fig. 2.) agreeing with previous works with fungi having clear conidia. However, no other paper related to *P. expansum* spores was found. UV-C treatments did not affect neither the number nor the size rot of the apples. This results conflict apparently with the reported results of Stevens et al, 1989&1996 and the difference could be related to the environmental conditions used after the treatment in our work. Apples in the above cited authors report were storaged in paper bags, with no light to favour the expression of resistance mechanisms and ours, were non protected and maintained under normal room conditions.

Effect of UV-C over epiphytic population of Penicillium and rot development during shelf life of Fuji apples

The UV-C dose of 5.9 erg.mm².sec diminished the *Penicillium* epiphytic propagules in all apple samples and reduction ranged around 90-100%. (Table 1). The control of the disease incidence was 37-70% (Table 2). The benefits of the method in the system used in our research suggest that the disease control was mainly related to the apple desinfesting consequences of the UV-C treatment. The benefits of this method makes it recommendable to be applied in the integrated management of the blue mold disease of apples and presently, has broad acceptance in the Southern apple region of Brazil.

Figure 1. UV-C lamps in the fruit drying tunnel
Figure 2. Effect of UV-C doses on conidial survival of *Penicillium expansum*

Table 1. Effect of UV-C doses on epiphytic population of *Penicillium* in Fuji apples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Population on fruits (^1) (\text{(N x 300)})</th>
<th>Population Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without UV-C (5,9 erg.mm(^2).sec)</td>
<td>With UV-C (5,9 erg.mm(^2).sec)</td>
</tr>
<tr>
<td>A.1</td>
<td>1,2</td>
<td>0,0*</td>
</tr>
<tr>
<td>A.2</td>
<td>11,3</td>
<td>1,1*</td>
</tr>
<tr>
<td>A.3</td>
<td>2411,0</td>
<td>211,0*</td>
</tr>
</tbody>
</table>

1. Average data related to three replicates with three apples each.
   - Data from column are different (Chi square test, \(p<0,05\))

Table 2. Effect of an UV-C treatment on the blue mold rot of Fuji apples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Shelf life Period (\text{days})</th>
<th>Apple rot (^1) (%)</th>
<th>Disease Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without UV-C (5,9 erg.mm(^2).sec)</td>
<td>With UV-C (5,9 erg.mm(^2).sec)</td>
<td></td>
</tr>
<tr>
<td>A .1</td>
<td>8</td>
<td>22,0</td>
<td>6,0*</td>
</tr>
<tr>
<td>A .2</td>
<td>21</td>
<td>47,0</td>
<td>28,0*</td>
</tr>
<tr>
<td>A .3</td>
<td>21</td>
<td>3,4</td>
<td>1,3*</td>
</tr>
<tr>
<td>A .4</td>
<td>10</td>
<td>37,0</td>
<td>24,4</td>
</tr>
</tbody>
</table>

1. Average data related to 10 boxes with 100 fruits each.
   - Data of both columns are different (Chi square test, \(p<0,05\))
Aknowledgements

The authors thank Dr. Marcia Reolon and Ana Czermainski for the statistical analysis.

References


Severity of apple scab in monoculture and mixture of apple cultivar's orchards

Sylwester Masny and Anna Bielenin
Research Institute of Pomology and Floriculture, Department of Phytopathology, ul. Pomologiczna 18, 96-100 Skierniewice, Poland

Abstract: The experiment was conducted during five years in Experimental Orchard near Skierniewice on five apple cultivars, Elstar, Idared, Jonagold, Lobo and McIntosh, planted in monoculture and in four mixture systems for each of these cultivars. No fungicides were used in this orchard against apple scab (Venturia inaequalis (Cooke) Aderh.). Every year, when the primary infections finished, the evaluation of leaf infection was made. In the first years of observation some differences in level of infection of leaves were noted. For example, two cultivars, Elstar and Jonagold, were heavier affected when grown in monoculture than in mixture systems. In 1997 during epidemic of scab in Poland all cultivars in tested systems were strongly affected (100% scabbed leaves). In 1998 fruit and leaves infection of all tested cultivars was lowest in monoculture except leaves infection of Idared. In next year percent of infected leaves of McIntosh was significantly higher in monoculture than in mixture systems. For the other cultivars no differences in percent of infected leaves were observed between planting systems. However, evaluation of leaf surface covered by fungus revealed higher infection in monocultures than in mixture systems. Strong variation of results during the experimental years makes any general conclusions impossible and proves the necessity for further research.

Key words: apple, apple scab, cultivar monoculture and mixture, planting strategy

Introduction

Apple scab caused by Venturia inaequalis (Cooke) Aderh. is the most widespread and important disease of apple trees. Control of disease is based on fungicidal sprays to prevent the primary infection, which is initiated by ascospores released from pseudothecia. The risk of serious infections can be decreased by limiting the level of inoculum. Gessler et al. (1994) postulated that the population of V. inaequalis consists of many different races virulent to specific apple cultivars. It could be suggest that infection of apple scab can be reduced when different cultivars of apple trees will be grow in mixture system. Obviously, this planting strategy will not replace chemical control of apple scab, but could significantly decrease fungicide applications in orchard and will be profitable for consumer and the environment.

The aim of this work was to compare the severity of apple scab infection in monoculture and mixture systems of planting.

Materials and methods

Experiments have been conducted since 1995 in The Experimental Orchard at Dąbrowice near Skierniewice on five apple cultivars, Elstar, Idared, Jonagold, Lobo and McIntosh, which were planted on 10 plots of size 40m x 40m each. Monoculture systems (one cultivar on one plot) are located on five plots and on the remaining five plots trees have been grown in different mixed systems (in each plot one cultivar is missing). Each cultivar is represented by 66 trees on the plot. Fungicides are not used against apple scab in this orchard.
The experiment consisted of 25 combinations (5 apple cultivars grown in 5 different systems, i.e. monoculture and four different mixed combinations). Detailed evaluation of degree of apple scab infection level was started in 1997 when trees were three years old. Samples of 800 leaves and 400 fruits per combination were checked. The results were analysed statistically by analysis of variance and the significance of differences was estimated by Duncan's test at 0.95 probability level.

Results and discussion

Table 1. Percent of infected leaves of 5 apple cultivars grown in different planting systems.

<table>
<thead>
<tr>
<th>Tested cultivar</th>
<th>Year</th>
<th>Monoculture</th>
<th>Mixture without cv. Lobo</th>
<th>Mixture without cv. Jonagold</th>
<th>Mixture without cv. Elstar</th>
<th>Mixture without cv. Idared</th>
<th>Mixture without cv. McIntosh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elstar</td>
<td>1997</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>2.2 a</td>
<td>10.5 bc</td>
<td>11.5 bc</td>
<td>x</td>
<td>15.0 c</td>
<td>6.2 b</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>99.6 b</td>
<td>83.5 a</td>
<td>98.4 b</td>
<td>x</td>
<td>92.8 ab</td>
<td>91.3 ab</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>18.6 c</td>
<td>1.9 a</td>
<td>4.1 ab</td>
<td>x</td>
<td>0.8 a</td>
<td>9.5 bc</td>
</tr>
<tr>
<td>Idared</td>
<td>1997</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>45.2 b</td>
<td>38.2 ab</td>
<td>48.4 b</td>
<td>26.1 a</td>
<td>x</td>
<td>32.7 ab</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>98.7 a</td>
<td>99.2 a</td>
<td>96.3 a</td>
<td>95.9 a</td>
<td>x</td>
<td>93.1 a</td>
</tr>
<tr>
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<td>2000</td>
<td>7.3 b</td>
<td>0.8 a</td>
<td>1.8 a</td>
<td>2.5 ab</td>
<td>x</td>
<td>2.8 ab</td>
</tr>
<tr>
<td>Jonagold</td>
<td>1997</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>8.3 a</td>
<td>26.1 b</td>
<td>x</td>
<td>10.0 a</td>
<td>22.5 b</td>
<td>12.6 a</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>99.9 a</td>
<td>98.1 a</td>
<td>x</td>
<td>98.6 a</td>
<td>98.7 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>25.9 c</td>
<td>10.8 ab</td>
<td>x</td>
<td>8.6 a</td>
<td>15.3 abc</td>
<td>22.7 bc</td>
</tr>
<tr>
<td>Lobo</td>
<td>1997</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>9.8 a</td>
<td>x</td>
<td>21.5 bc</td>
<td>14.7 ab</td>
<td>23.1 c</td>
<td>12.8 a</td>
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<td>x</td>
<td>99.8 a</td>
<td>99.7 a</td>
<td>98.0 a</td>
<td>99.6 a</td>
</tr>
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<td></td>
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<td>10.73 b</td>
<td>x</td>
<td>4.75 a</td>
<td>2.45 a</td>
<td>5.70 ab</td>
<td>4.11 a</td>
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<tr>
<td>McIntosh</td>
<td>1997</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>10.3 a</td>
<td>34.1 b</td>
<td>32.0 b</td>
<td>30.8 b</td>
<td>35.6 b</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>97.8 b</td>
<td>65.2 a</td>
<td>73.2 a</td>
<td>60.5 a</td>
<td>73.8 a</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>36.1 b</td>
<td>18.9 a</td>
<td>20.2 a</td>
<td>14.9 a</td>
<td>13.6 a</td>
<td>x</td>
</tr>
</tbody>
</table>

The severity of apple scab infection on the different apple cultivars varied during the years of our study. In the first visual observations in 1995 and 1996, when weather was not favourable for scab development, some differences were noted. Especially Elstar and Jonagold cvs in 1995 and Lobo cv in 1996 showed distinctly heavier scab level in monoculture than in mixture systems. These results are in accordance to the suggestions of Blaise and Gessler (1994) that in field conditions in monoculture of one single susceptible cultivar there is 100 % inoculum of a compatible pathotype. However, when the orchard consists different cultivars, the initial
inoculum are not uniform and only part of ascospores infects each cultivar. So final intensity of lesions in mixed plots should be smaller. The presence of specific virulence for individual cultivar in population of *V. inaequalis* has been shown by Wiesmann (1931) and Palmiter (1933).

Table 2. Percent of leaf surface covered by *Venturia inaequalis* on infected leaves of 5 apple cultivars in 1998, 1999 and 2000.

<table>
<thead>
<tr>
<th>Tested cultivar</th>
<th>Year</th>
<th>Monoculture</th>
<th>Mixture without cv. Lobo</th>
<th>Mixture without cv. Jonagold</th>
<th>Mixture without cv. Elstar</th>
<th>Mixture without cv. Idared</th>
<th>Mixture without cv. McIntosh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elstar</td>
<td>1998</td>
<td>0.02 a</td>
<td>0.07 bc</td>
<td>0.08 c</td>
<td>x</td>
<td>0.1 c</td>
<td>0.04 ab</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>30.8 c</td>
<td>2.5 a</td>
<td>11.2 b</td>
<td>x</td>
<td>4.4 a</td>
<td>4.1 a</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.2 c</td>
<td>0.03 a</td>
<td>0.05 ab</td>
<td>x</td>
<td>0.02 a</td>
<td>0.09 b</td>
</tr>
<tr>
<td>Idared</td>
<td>1998</td>
<td>0.34 bc</td>
<td>0.31 c</td>
<td>0.38 c</td>
<td>0.17 a</td>
<td>x</td>
<td>0.24 ab</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>15.6 b</td>
<td>7.4 a</td>
<td>5.0 a</td>
<td>4.4 a</td>
<td>x</td>
<td>4.7 a</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.1 b</td>
<td>0.01 a</td>
<td>0.02 a</td>
<td>0.02 a</td>
<td>x</td>
<td>0.03 a</td>
</tr>
<tr>
<td>Jonagold</td>
<td>1998</td>
<td>0.1 a</td>
<td>0.2 b</td>
<td>x</td>
<td>0.1 a</td>
<td>0.2 b</td>
<td>0.1 a</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>17.0 c</td>
<td>6.7 a</td>
<td>x</td>
<td>6.8 a</td>
<td>6.5 a</td>
<td>9.2 b</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.3 b</td>
<td>0.1 a</td>
<td>x</td>
<td>0.1 a</td>
<td>0.2 ab</td>
<td>0.2 ab</td>
</tr>
<tr>
<td>Lobo</td>
<td>1998</td>
<td>0.1 a</td>
<td>x</td>
<td>0.2 b</td>
<td>0.1 a</td>
<td>0.2 b</td>
<td>0.1 a</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>52.8 b</td>
<td>x</td>
<td>28.6 a</td>
<td>38.8 ab</td>
<td>39.9 ab</td>
<td>30.6 a</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.10 b</td>
<td>x</td>
<td>0.05 a</td>
<td>0.03 a</td>
<td>0.06 a</td>
<td>0.04 a</td>
</tr>
<tr>
<td>McIntosh</td>
<td>1998</td>
<td>0.1 a</td>
<td>0.3 b</td>
<td>0.3 b</td>
<td>0.2 b</td>
<td>0.3 b</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>51.6 b</td>
<td>2.6 a</td>
<td>5.2 a</td>
<td>2.1 a</td>
<td>5.6 a</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.4 b</td>
<td>0.2 a</td>
<td>0.2 a</td>
<td>0.2 a</td>
<td>0.1 a</td>
<td>x</td>
</tr>
</tbody>
</table>

However, the next year 1997 has brought the epidemic of apple scab in Poland and all cultivars irrespectively of planting systems were strongly affected (100% scabbed leaves). It suggests that under weather conditions favourable for disease development even smaller level of inoculum in mixed plantings could be enough for initiation of severe infection. Consequently, in autumn 1997 urea was applied to limit pseudothecia formation and reduce primary inoculum (Meszka et al.,1999). As a result, the level of leaf infections in 1998 was low and different in tested combinations. Some of the results were opposite to noted before. Distinctly less symptoms of leaf scab were observed on Elstar and McIntosh cvs. in monoculture than in mixed systems. Also the same tendency was find in fruit infection.

Wet season 1999 favoured leaves and fruits infection. Influence of planting system on percent of affected leaves was clear only in McIntosh cv. Percent of leaves with scab symptoms was significantly higher on monoculture plot than on mixed ones. On the other hand, no differences were found in percent of scabbed fruits irrespectively of combination.

Dry and extremely hot spring of the year 2000 resulted in low level of apple scab infection. Even on the most susceptible cultivar McIntosh the infection of leaves did not reach 40%. In such
situation differences between levels of leaf scab were visible. More leaves of all cultivars were infected on the monoculture plots than mixed ones. No fruits showed scab symptoms.

The most promising data were obtained in the last two years through evaluation of intensity of scab symptoms expressed as a percent of leaf surface covered by fungus. Significantly stronger leaves damage was noted in monoculture than in other systems of planting. In some mixed combinations reduction of scab was drastically high. Mixed planting without Lobo cv. was the best combination.

The results obtained in this experiment indicate influence of planting system on scab level. It was marked mostly in years with lower pressure of disease. In the most of cases mixed cultivar orchards were better than monocultures and gave the reduction of scab severity. Possibility of planting of mixed cultivar orchards in practice for reduction of scab pressure was earlier mentioned by Sierotzki et al. (1994) and Blaise & Gessler (1994), but the variation of results during the experimental years makes general conclusions not possible yet. This calls for further research.

<table>
<thead>
<tr>
<th>Tested cultivar</th>
<th>Year</th>
<th>Monoculture</th>
<th>Mixture without cv. Lobo</th>
<th>Mixture without cv. Jonagold</th>
<th>Mixture without cv. Elstar</th>
<th>Mixture without cv. Idared</th>
<th>Mixture without cv. McIntosh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elstar</td>
<td>1998</td>
<td>4.1 a</td>
<td>3.9 a</td>
<td>3.1 a</td>
<td>x</td>
<td>1.2 a</td>
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</tr>
<tr>
<td></td>
<td>1999</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>x</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>x</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Idared</td>
<td>1998</td>
<td>34.8 a</td>
<td>51.4 b</td>
<td>53.6 b</td>
<td>45.3 ab</td>
<td>x</td>
<td>43.4 ab</td>
</tr>
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<td>100</td>
<td>100</td>
<td>x</td>
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<td>0</td>
<td>0</td>
<td>x</td>
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<td>0</td>
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<td>100</td>
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<td>100</td>
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<td>97.0 ab</td>
<td>100.0 b</td>
<td>100.0 b</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>x</td>
</tr>
</tbody>
</table>

References


The suppression of ascospore production of *Venturia inaequalis* and changes in the microbial population of apple leaves after autumn urea treatment

Beata Meszka and Anna Bielenin
Research Institute of Pomology and Floriculture, 96-100 Skierniewice, ul. Pomologiczna 18, Poland

Abstract: Microscopic observations done in spring at the beginning of ascospore discharge in orchard showed that autumn application of 5% urea had reduced the number of pseudothecia (in about 90%) and ascospore production. From few pseudothecia (0.5-4.5) which developed on the urea treated leaves the first discharge of ascospores was insignificant and late. It was observed too, that nitrogen applied on the surface of leaves stimulated the development of microflora. Population of bacteria in the urea treated leaves reached the maximum after 7 weeks and at this time was approximately thirty times higher than the population in the control leaves. Also the changes in the population balance induced by urea were observed. After urea treatment the typical flora was rapidly converted to only Gram-negative, non-chromogenic microorganisms.

Key words: *Venturia inaequalis*, ascospore, urea, microbial population, integrated control

Introduction

Primary infections by the apple scab fungus *Venturia inaequalis* (Cooke) Aderh., originate mostly from ascospores formed in overwintered leaves on the ground of orchard. In the 60's Burchill et al. (1965) found that ascospore productivity in the spring was markedly reduced when leaves were treated with urea in the previous autumn. It was observed too, that nitrogen applied on the surface of leaves stimulating the development of microflora, results in faster decomposition of apple leaves.

The aim of this work was the evaluation of urea action in suppressing pseudothecial formation and the microbial changes induced by urea in Polish conditions.

Material and methods

In the autumn of 1998 and 1999 the experiments were conducted in Research Orchard at Dabrowice and in Experimental Orchard at Skierniewice, located in central part of Poland. Scabbed leaves of McIntosh, Gloster and Spartan cvs. were collected in autumn and one part of leaves (four hundred from each cultivar) were dipped in 5% urea suspension. Then treated and untreated leaves were stored in nylon nash bags on the orchard floor over the winter. Assessing of pseudothecia development was done at the time of the first ascospore discharge observed in the orchard. Leaves of all cultivars were sampled every 7 days and 1 cm² of the leaf surface was checked for pseudothecia production randomly in four replicates. After that pseudothecia were removed from leaves, crushed on microscopic slides and then checked for ascospore production.

The evaluation of urea action on microbial changes was conducted in the autumn and in the spring on leaves of McIntosh cv. Untreated and treated with urea leaves were collected every two weeks, dipped in sterile water and jolted for one hour. Afterwards bacteria were
isolated by dilution plating method on Nutrient Agar supplemented with 5% of saccharose. After 2-3 days of incubation at 25°C, bacterial colonies were counted. Identification of isolated bacteria was carried out with the key of Bradbury (1988). Following features of bacteria were checked: Gram stain and morphology, heat test for spores, nitrate reductase, oxidation and fermentation of glucose, fluorescent pigment and Kovacs oxidase.

**Results and discussion**

Microscopic observations done in spring at the beginning of ascospore discharge in orchard showed that autumn application of 5% urea had reduced the number of pseudothecia and ascospore production. In the season of 1999 on the leaves on which urea was applied pseudothecia developed only on 25% leaves of McIntosh and 30% leaves of Gloster and Spartan (Fig 1), and in the season 2000 on 15% leaves of McIntosh, 26% of Gloster and 43% of Spartan (Fig 2). On the leaves that were not sprayed with urea these numbers were significantly higher and reached 88%-100%. Similar results were achieved by Vojvodic (1970), Burchill et al. (1965), Cimanowski et al. (1997). Additionally urea caused a significant reduction in the pseudothecia formation and ascospore production. The average number of pseudothecia observed on the leaves treated with urea was estimated on 0.54 to 4.5 pseudothecia on 1 cm² of scab spot while on the leaves without urea the number was several times higher, from 17 to 48 pseudothecia on 1 cm² of scab spot.

![Figure 1](image.png)

Figure 1. Effect of urea application on pseudothecia formation in 1999. A – percent of leaves with pseudothecia; B – average number of pseudothecia on 1 cm² of scab lesion

Microbial population on the leaves was checked immediately after urea treatment in autumn 1998, in spring and autumn 1999 and in spring 2000. A marked stimulatory effect of urea was observed 6-7 weeks after spring treatment, while just after application number of bacteria was lower than in the control leaves. This suggests that urea may have actually suppressed microbial activity for a short period after application. Then the number of microorganisms in the control leaves has decreased while in the urea treated leaves it was continually high (table 1 and 2). The opposite tendency was observed when leaves were treated with urea in autumn. The results showed that immediately after treatment the number
of microorganisms per 1 g dry matter of urea treated leaves was higher than in control (Table 1 and 2). Also the changes in the population balance induced by urea were observed. The microflora of non-treated leaves were represented by Gram-possitive and Gram-negative organisms and in the first four weeks the pigmented or chromogenic forms were dominating. After urea treatment the typical flora was rapidly converted to only Gram-negative, non-chromogenic microorganisms, which included high number of fluorescent Pseudomonanads and other Gram-negative bacteria antagonistic to Venturia inaequalis. Generally it was recorded that urea stimulated growth of bacteria on the fallen apple leaves. This is very likely that this inhibitory effect of urea on formation of the pseudothecia can be related to the increased number of bacteria, particularly Gram-negative, which are antagonistic to V. inaequalis and as recorded Crosse et al. (1968) this is related to decomposition of metabolites, which are necessary for growth of pseudothecia.

Figure 2. Effect of urea application on pseudothecia formation in 2000. A – percent of leaves with pseudothecia; B – average number of pseudothecia on 1 cm² of scab lesion

Table 1. The number of bacteria per gram of dry leave matter

<table>
<thead>
<tr>
<th>Treatments</th>
<th>The time of leaves collection (in weeks)</th>
</tr>
</thead>
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<tr>
<td></td>
<td>2</td>
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<tr>
<td>Autumn- without urea</td>
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</tr>
<tr>
<td>Autumn- urea 1998</td>
<td>1822</td>
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<tr>
<td>Spring - without urea</td>
<td>194 *</td>
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<tr>
<td>Spring - urea 1999</td>
<td>6</td>
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</table>

* each numerical value in the table should be multiplied by 10⁶  
(nt)- not tested
Table 2. The number of bacteria per gram of dry leave matter

<table>
<thead>
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<th>Treatments</th>
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</thead>
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<tr>
<td>Autumn- urea 1999</td>
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<td>Spring - without urea</td>
<td>340*</td>
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<tr>
<td>Spring - urea 2000</td>
<td>6</td>
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</tbody>
</table>

* each numerical value in the table should be multiplied by $10^6$
(nt)- not tested

References


Incidence des haies sur les peuplements d'arthropodes prédateurs en verger de poiriers

J.F. Debras et R. Rieux
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Introduction

L'arboriculture fruitière est un secteur où se posent de nombreux problèmes phytosanitaires. De nombreux insectes, sont responsables d'une part importante des pertes et dégâts enregistrés dans les cultures. Le verger de poiriers en particulier est victime de nombreux ravageurs. Parmi ceux-ci, seul un petit groupe d'espèces dangereuses, à la fois par leur présence constante dans la culture, par le choix de leurs cibles sur le végétal et par leur capacité à accroître rapidement leurs populations, sont qualifiables de ravageurs-clés. Parmi ces derniers, en France, le psylle du poirier, Cacopsylla pyri (L.), a nécessité un aménagement des procédés de lutte.

Le travail effectué au sein du laboratoire d’interactions biocénotiques en verger de la station de Zoologie de l'INRA d'Avignon, sur l'aménagement de la lutte intégrée en verger de poiriers concerne l'étude du rôle et des possibilités d'utilisation en lutte intégrée de haies composites.

Le but de l'expérimentation est l'aménagement de l'environnement des cultures, dans le cadre de la protection intégrée, vise l'enrichissement en auxiliaires des parcelles. Notre étude à pour objectif de démontrer que la haie a un rôle à jouer non seulement comme réservoir d'auxiliaires mais aussi dans la diffusion des peuplements d'arthropodes prédateurs à l'intérieur des parcelles.

Matériel et méthodes

Dix parcelles de Poiriers dont l'entomofaune a été suivie sur une période de un à trois ans. Sept parcelles sont bordées d'une haie composite suivant le modèle préconisé par notre laboratoire. Trois sont sans haie. La méthode utilisée pour suivre l'entomofaune est celle du battage. C'est une méthode qui consiste à faire chuter dans un réceptacle les arthropodes présents sur le végétal. Nous avons utilisé l'entonnoir de Steiner (1962) modifié par nous-mêmes. Nous avons adapté au bas de celui-ci un dispositif permettant de fixer un flacon dans lequel nous avons rajouté un peu d'alcool à 40°. La récolte est ensuite stockée dans des flacons à 5°. Les battages ont été réalisés deux fois par mois de la manière suivante : un battage était fait dans la haie puis dans un rang du verger opposée à la haie, un autre dans un rang proche de la haie. Le but étant de confirmer le rôle de diffusion de la haie. L'hypothèse étant que les résultats devaient être supérieur dans la partie proche de la haie à ceux obtenus dans la partie opposée à la haie, en ce qui concerne le phénomène de diffusion des auxiliaires.

Nous avons considéré comme prédateurs de psylles :
- Toutes les araignées qui par leur mode de piégeage peuvent être considérées comme prédatrices de psylle.
Les Anthocorides et les Forficules.
Les punaises hétéroptères, autres que les Anthocorides, connues pour être prédatrice de psylles (Nabides et Mirides).
Les névroptères (Chrysopes et Hémerobes).
Les acariens Thrombididae et Anystidae.

Nous avons utilisé l'indice de Shannon pour caractériser le rôle réservoir de la haie ainsi que le rôle de diffusion de l'entomofaune de la haie à l'intérieur de la parcelle. Plusieurs indices peuvent exprimer la diversité, nous avons choisi l'indice de Shannon : L'indice de Shannon est emprunté à la théorie de l'information par les écologistes dans l'étude des biocénoses ; c'est un indice de diversité. Il a l'avantage d'être faiblement corrélé à la taille des échantillons, ce qui convient bien à l'étude comparative des peuplements où le nombre et l'abondance des espèces sont très variables.

La diversité d'une biocénose est déterminée par deux composantes :
- la richesse en espèces : plus le nombre d'espèces est grand, plus grande est la diversité de la faune.
- la distribution du nombre d'individu par espèces : si une communauté contient une espèce très dominante en effectif, sa diversité en sera diminuée ; mais la diversité sera élevée si toutes les espèces sont également nombreuses.

L'indice de Shannon se calcule de la façon suivante :

\[ H = - \sum \left( \frac{n_i}{N} \right) \log_2 \left( \frac{n_i}{N} \right) \]

\(- n_i = \) le nombre d'individus de l'espèce
\(- N = \) nombre total d'individus comptabilisés

Cet indice exprime l'importance relative de chaque espèce collectée ainsi que la relation entre le nombre total d'espèces et d'individus. Il varie de 1 à 6 ; il est maximum dans les écosystèmes stables de type forestier. Il donne la valeur de la richesse en espèces d'un écosystème.

L'indice d'équitabilité, issu de l'indice de Shannon, caractérise la distribution des effectifs des espèces d'une communauté ; l'équitabilité est d'autant plus grande que la distribution est homogène ; elle diminue si une espèce est dominante.

\[ e = \frac{H}{H'} = \frac{H}{\log_2 S} \]

\(- H' = \) l'équitabilité maximale
\(- S = \) la richesse totale

L'équitabilité varie entre 0 et 1, elle tend vers 0 quand la quasi-totalité des effectifs correspond à une seule espèce du peuplement et tend vers 1 lorsque chacune des espèces est représentée par le même nombre d'individus.

Résultats

La richesse des peuplements en auxiliaires d'une parcelle cultivée et bordée d'un environnement de feuillus ou de haies composites est toujours supérieure à la richesse des peuplements en auxiliaires des parcelles sans haie (Figure 1).

Lorsque des parcelles cultivées sont bordées de haies, la richesse en auxiliaires de ces parcelles est directement liée à la richesse en auxiliaires de l'environnement mais lui est toujours inférieure (rôle réservoir de la haie) (Figure 2).
A l'intérieur même des parcelles étudiées, il existe un gradient par rapport à la haie : plus on se rapproche de la haie et plus la richesse de l'entomofaune augmente (Diffusion des auxiliaires de la haie vers le verger) (Figure 3).

Figure 1. Comparaison de Shannon des vergers avec haie et des vergers sans haie

![Figure 1. Comparaison de Shannon des vergers avec haie et des vergers sans haie](image1)

Figure 2. Comparaison du Shannon (H) des haies et du Shannon (H) des vergers

![Figure 2. Comparaison du Shannon (H) des haies et du Shannon (H) des vergers](image2)

**Conclusion**
Protéger et favoriser les auxiliaires contribue à la modernisation de l'agriculture par la réduction des intrants, et à une gestion saine de l'environnement agricole. De telles mesures d'aménagement de l'environnement des cultures par création d'un réseau de haies composites ou de bandes enherbées à composition végétale raisonnée paraissent tout à fait inséparables pratiquement au niveau des exploitations en vue d'une agriculture plus extensive et moins polluante.

Figure 3. Variation de l'indice de Shannon (H) à l'intérieur des parcelles

Les haies ne constituent pas un frein à la propagation des auxiliaires. Bien au contraire ce sont de véritables chemins d'accès aux cultures. Elles seront d'autant plus efficaces qu'elles feront partie d'un ensemble de haies, elles mêmes reliées à un environnement naturel.

A titre d'estimation, l'installation d'un maillage de haies en bordure de parcelles d'un maximum de 5 ha pourrait avoir, une emprise au sol de près de 10 %, ce qui avoisine les préconisations communautaires de diminution des surfaces cultivées - le reste pouvant être constitué de bandes enherbées - tout en assurant une valorisation de la production due à la limitation résultante de la lutte chimique.
Effects of vineyard soil management and fertilization on grape diseases and wine quality

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2 CRPV Sez. Vitivincola, Via Tebano 54, 48018-Tebano, Ravenna, Italy

Abstract. The objectives of this study were to evaluate, over a 4-year (1995-1998) period of time, the effect of soil management and fertilizer supply on nitrate soil concentration, grapevine mineral status, fruit yield and wine quality. In a twenty-year old vineyard of cv Trebbiano romagnolo, grafted on hybrid S.O.4 rootstock, a split plot experimental design was arranged with two soil management techniques (complete tilled and strip weed control) as main plots and 4 fertilizer regimes as sub plots including: 1) unfertilized control, 2) hog manure at a rate of 30 t ha⁻¹ year⁻¹, 3) mineral-organic compound, 4) mineral compound. Treatment 3 and 4 yearly supplied 60, 24 and 28 kg ha⁻¹ of N, P₂O₅ and K₂O, respectively. The application of mineral-organic and mineral fertilizers enhanced soil nitrate availability. While no clear effect of fertilizers on grapevine mineral status, in 1996, complete tilled soil management increased N and P concentration in the petioles. Yield and cluster weight were not affected by fertilization or soil management. Grape quality, at harvest, did not change in relation to fertilizers and only in 1998, soluble solid concentration (SSC) was improved by strip weed control. Clusters and leaves from strip weed control soil showed a lower incidence of grape mildew, powder mildew, and brown rot compared to complete tilled management. Among the fertilizers, mineral-organic gained the highest score in the ranking test of preference regardless the soil management.

Key words: nitrate, brown rot, powder mildew, grape mildew, soil tillage, weed strip control

Introduction

The vineyard management in Emilia-Romagna Region (Northern Italy) underwent to a substantial change over the past ten years and the viticulturists have been oriented toward integrated grapevine production and environment sustainability. As a result, soil management and agronomic practices have been pursued the improvement of wine quality and the reduction of chemicals inputs (Schaller, 1991). The expanded hog industry provides a large availability of manure which can be used as a fertilizer to increase soil fertility. This management allows a recycle process of organic waste that is otherwise difficult to dispose. The objectives of this study were to evaluate the effect of soil management and fertilizer on soil nitrate concentration, grapevine mineral status, fruit yield, and wine quality.

Material and methods

The experiment was carried out over a 4-year period of time (1995-98), on a vineyard of cv Trebbiano romagnolo (Vitis vinifera), grafted on hybrid S.O.4 (V. riparia X V. berlandieri), trained to modified Sylvoz and located in the South-East Po Valley, near Faenza. The vines were planted in 1980 and spaced 3.5 X 2 m apart. Before the beginning of the experiment, the entire vineyard floor was tilled and fertilizer management provided 60-80 kg of N as ammonium sulfate once every 3-4 years. The clay to loamy-clay soil had a pH (H₂O) of 8.1, and (in mg kg⁻¹) N 1000, P 8.5, and K 560. A split plot experimental design was arranged
with 2 soil management (main plots) and 4 fertilizers (subplots). In both the complete tilled and strip weed control soil management, the following fertilizers were randomly arranged and replicated 4 times: 1) unfertilized control. 2) Hog manure, at a rate of 30 t ha⁻¹ year⁻¹ of fresh matter with the following concentrations (in g kg⁻¹) N 6; P₂O₅ 0.2; K₂O 1.6, organic C 13.5, and humification index of 0.5. 3) Mineral-organic commercial fertilizer, Super-Robur™ containing organic N 1.2%; ureic N 1.8%; ammonium N 12%; P₂O₅ 6%; K₂O 7%; SO₃ 22%; and organic matter 13.1% to supply a yearly rate of 60, 24, and 28 kg ha⁻¹ of N, P₂O₅ and K₂O, respectively. 4) Mineral fertilizers such as urea, superphosphate and potassium sulfate to supply a yearly rate of N, P₂O₅ and K₂O of 60, 24 and 28 kg ha⁻¹, respectively. All fertilizers were applied when shoot length was 5-10 cm on the 1.5-m wide grapevine strip. The grass in the alley, sowed in 1994, included Festuca spp. (65%), and Lolium spp. (35%). From 1996 to ‘98, water extractable soil nitrate was detected once a month all over the growing season, from 100 g of soil sampled at a depth of 20-40 cm on the vine row and on the alley. Mineral composition of petioles and leaf blades were detected at blooming and veraison in 1996 and only at blooming in 1997. Fruit yield, number and average weight of clusters were recorded from 1995 to 1998. In 1995, incidence of grape mildew (Plasmopara viticola B. et C.) was evaluated on leaves by simple observation and reported as a percentage of leaf surface affected by the disease. Powder mildew (Oidium tuckeri Berk) disease was evaluated on clusters on 1996 and reported as percentage of cluster berries with fungi mildew. Brown rot (Botrytis cinerea Pers.) was evaluated from 1995 to ‘98 and reported as previously described. At harvest, from a sample of 100 g of berries randomly collected from several clusters, a juice was extracted to evaluate SSC, pH and acidity. In addition, in 1997 and 98, 25 kg of grape from each of the 4 replications of each of the 8 treatments, were pooled together to produce wine. Wine quality was evaluated the following year by 18 tasters which preferences were ranked and compared according to the Kramer test (Ubigli, 1998). Data were subjected to analysis of variance and Student Newman Keul test separated the treatment means.

**Results and discussion**

From mid-April through mid-August of 1997 and ‘98, unlike hog manure, mineral and mineral-organic fertilizer increased the soil nitrate concentration on the vine row (Fig. 1). The similar rate of inorganic N supplied with mineral and mineral-organic (containing 1.2 % of organic N) induced the same soil nitrate concentration. Nitrate concentration was higher in complete tilled than in strip weed soil (Fig. 1). Nitrate concentration on the alley was not affected by fertilizers and only in 1997 it was higher in complete tilled than in strip weed control soil (data not reported). The application of fertilizers on the 1.5-m wide vine row prevented the alley from increasing the nitrate concentration, even when complete tillage of the soil was adopted. Although hog manure provided a large amount of N, the risk of nitrate leaching was reduced compared to mineral and mineral-organic fertilizers, especially in strip weed control soil.

At bloom of 1996, both leaf petiole and blade mineral contents were not affected by treatments (data not reported). In 1996, at veraison, N concentration was higher in petioles fertilized with mineral-organic compound than hog manure; Ca was increased by mineral fertilizer (Tab. 1); N and P concentrations were higher in complete tilled than in strip weed control plots. Leaf blade P was higher in control than in mineral fertilizer treatment (Tab. 1); Ca and Mg increased following hog manure application, while K was depressed by organic-mineral fertilization (Tab. 1). The high availability of nitrate in plots supplied with mineral and mineral-organic fertilizers did not result in an increase in leaf blade N concentration in 1996. This result is in agreement with Conradie & Saayman (1989) who did not find, over a
ten-year-investigation, a clear increase in the N content of both blades and petioles. Nitrate soil concentration might be involved in the low P concentration observed in petioles of vine treated with mineral fertilizer. In fact, Conradie & Saayman (1989) reported a decrease in P concentration in petioles as a consequence of N supply. The negative effect of strip weed control soil management on petiole N and P concentration was already observed by Giulivo et al. (1988) who found this effect on leaf blades of cv Tocai grafted to Kober 5BB.

![Graph showing nitrate concentration](image1)

Figure 1. Effect of fertilizers (upper) and soil management (lower) on nitrate soil concentration detected on grapevine row.

Although some statistical differences were detected in the first two years of study, fruit yield, number of cluster per vine and average weight were not affected by fertilizer application or soil management (data not reported). In 1998, SSC of berry juice was higher in control than mineral and mineral-organic fertilized treatment (Tab. 2). The complete tilled soil management also increased the SSC and pH in clusters at harvest (Tab. 2). Total acidity was not affected by fertilizers or soil management (Tab. 2).
Table 1. Effect of fertilizers and soil management on petiole and leaf blade mineral concentrations evaluated at varaison of 1996.

<table>
<thead>
<tr>
<th>Fertilizers</th>
<th>Leaf petioles</th>
<th></th>
<th>Leaf blades</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>K</td>
<td>Ca</td>
</tr>
<tr>
<td>Control</td>
<td>0.71ab</td>
<td>0.46</td>
<td>0.61</td>
<td>2.85b</td>
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<td>Hog manure</td>
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<td>0.44</td>
<td>0.63</td>
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<tr>
<td>Mineral-organic</td>
<td>0.76a</td>
<td>0.42</td>
<td>0.49</td>
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<td>Mineral</td>
<td>0.75ab</td>
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<th>Soil management</th>
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<tbody>
<tr>
<td>Tilling</td>
<td>0.77</td>
<td>0.47</td>
<td>0.63</td>
</tr>
<tr>
<td>Strip weed</td>
<td>0.69</td>
<td>0.36</td>
<td>0.55</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td>***</td>
<td>*</td>
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Table 2. Effect of fertilizers and soil management on soluble solid concentration (SSC), acidity, and pH of berry juice in 1998.

<table>
<thead>
<tr>
<th>Fertilizers</th>
<th>SSC (%Brix)</th>
<th>Acidity (g/l)</th>
<th>pH</th>
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<tbody>
<tr>
<td>Control</td>
<td>21.9a</td>
<td>5.2</td>
<td>3.21</td>
</tr>
<tr>
<td>Hog-manure</td>
<td>21.3ab</td>
<td>5.0</td>
<td>3.21</td>
</tr>
<tr>
<td>Mineral-organic</td>
<td>20.4c</td>
<td>5.3</td>
<td>3.21</td>
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<tr>
<td>Mineral</td>
<td>20.8bc</td>
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<tr>
<td><strong>Significance</strong></td>
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<tr>
<td>Strip weed</td>
<td>20.6</td>
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<tr>
<td><strong>Significance</strong></td>
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</table>

Over a 4-year-period of time the fertilizers tested in this trial had no positive effect on yield, even when strip weed control was introduced. Our results differ from other reports (Bertamini et al., 1999), where alley weed such as Festuca and Lolium adversely affected yield. Possible explanation for this discrepancy are the lower length of this experiment and the lower vine density here adopted (1425 vines per hectare) compared with the above mentioned investigation (3128 vine per hectare).

In 1998, hog manure reduced the percentage of berry affected by brown rot than mineral and mineral-organic fertilizers (Tab. 3). In 1995 and 1998 strip weed control decreased the percentage of berry affected by brown rot disease compared with the complete tilled soil management (Tab. 3). Percentage of leaf area with grape mildew and percentage of berry with powdered mildew were not affected by fertilizers and were higher in complete tilled than in strip weed control (Tab. 3). These results are in agreement with Bertamini et al. (1999) who reported a positive effect of grassed alley on grapevine tolerance to fungi disease.
In 1997, wine obtained from strip weed plots was indicated by all the tasters as characterized by a peculiar aroma. In 1998, N was added to all musts to improve fermentation rate and the preference analysis was carried out separately for each soil management. The preference test of wine produced in 1998 did not show any difference induced by treatments (Fig. 2), however wine from mineral-organic fertilized plots in both complete tilled and strip weed control soil scored the highest number of preferences (Fig. 2).

Table 3. Effect of fertilizers and soil management on percentage of leaf and berry affected by fungus diseases

<table>
<thead>
<tr>
<th></th>
<th>Grape mildew</th>
<th>Powdery mildew</th>
<th>Brown rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf (%)</td>
<td>Cluster (%)</td>
<td>Leaf (%)</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>1995</td>
<td>1996</td>
<td>1995</td>
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<tr>
<td>Control</td>
<td>15</td>
<td>1.8</td>
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<td>Hog-manure</td>
<td>17</td>
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<tr>
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<tr>
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<td>9</td>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilling</td>
<td>18</td>
<td>4.2</td>
<td>27.9</td>
<td>5.9a</td>
</tr>
<tr>
<td>Strip weed</td>
<td>9</td>
<td>0.6</td>
<td>15.4</td>
<td>2.5b</td>
</tr>
<tr>
<td>Significance</td>
<td>**</td>
<td>**</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

In conclusion, since hog manure did not increase soil nitrate nor depressed wine quality, it appears to be an excellent tool to increase soil fertility (particularly organic matter) contributing to recycle organic waste. The alley weed competition for N uptake might be...
responsible for the lower incidence of fungus disease in strip weed control plots, however the lower N in must might negatively affect the fermentation rate and contribute to deteriorate the aroma of the wine. Nitrogen fertilizer should be applied in relation to soil management so as to reduce soil nitrate concentration and disease incidence while pursuing the highest quality production.

References


Fruit development, yield and quality in response to irrigation and nitrogen application on *Golden delicious* apples

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**Abstract:** Although integrated fruit production (IFP) relates more to pest management, irrigation and fertilization are two main growing factors affecting yield and quality in fruit production. Many authors oriented their researches to irrigation or fertilization management but few studies focuses on both parameters and their relationship to an integrated fruit production view.

The objectives are: (1) to evaluate the effects of irrigation strategies and to compare two irrigation systems: drippers and microsprinklers (simulating flooding irrigation conditions), (2) to analyze N fertilizing response and (3) to evaluate the irrigation-fertilization interaction. Five irrigation treatments and four N treatments (for drippers) and two N treatments (for microsprinklers) are compared, focusing on threshold doses determined by integrated fruit production.

First year data show how fruit development, harvest results – yield, individual fruit mass, fruit size, fruit load- and fruit quality parameters – firmness, color, soluble solids, titratable acidity, starch test and physiological disorders- are influenced by irrigation and fertilization and how can be physiologically explained. Results after cold storage and next years data will help us to validate these first results in order to achieve the above objectives.

**Key words:** *Malus domestica*, irrigation, nitrogen fertilization, production, quality, cold storage.

**Introduction**

Irrigation and N fertilization are two key aspects for orchard management. The IFP guidelines for irrigation are to get the maximum efficiency, to promote the use of methods to monitor soil water status (i.e.: water balance). The recommended irrigation systems are drip or microsprinkler irrigation. To manage fertilizers (N in this case), soil and plant analysis and other orchard components should be taken into account, trying to minimize foliar sprays. Turning into fertigation is desirable. Splitting N applications is encouraged as a rule. The recommended amount of N to be applied is about 80 kg N·ha⁻¹, although in some countries or specific areas the figures are even lower.

**Material and methods**

Two thousand four hundred apple trees (*Malus domestica* Borkh) on M9 Pajam® 2 rootstock, planted on a loam soil at 4 m by 1.4 m (1700 trees·ha⁻¹), at the Estació Experimental de Lleida (IRTA) field in Gimenells (Lleida) were used for this experiment.

The orchard was designed with 12 “TopRed” and “Early Red One” cultivar rows, and with three “Golden Smoothee” that were uniformly distributed within the plot, resulting that each “Golden Smoothee” row was surrounded by two red cultivar rows, forming a group of five rows, which were replicated four times. “Golden Smoothee” trees were used as control trees and the two red cultivar rows in each side of the control row were used to avoid water infiltration from other irrigation treatments.
Five irrigation treatments and two N treatments were organized in a split-plot design, with irrigation as the main factor. Irrigation was scheduled based on the water balance method and two irrigation systems were studied: drip and microsprinkler (simulating flooding conditions). Irrigation treatments were 1) drip irrigation (D) giving full ETc on a daily basis, 2) microsprinkler Control (MC) giving full ETc and irrigating when 18 mm are achieved (60% of the waterholding capacity), 3) microsprinkler with early excess (200% of MC from budbreak until mid-July) and late deficit irrigation (50% of MC from mid-July until harvest) (MED), 4) microsprinkler with early deficit (50% of MC from budbreak until mid-July) and late excess irrigation (200% of MC from mid-July until harvest) (MDE), and 5) microsprinkler irrigation once every two weeks (MF) with a constant 60 mm dose. An extra completely randomized blocks experimental design was established only for drip irrigation with four N levels (0-40-80-200 units·ha⁻¹), using four extra elemental units for 0-40 N levels. Trees were daily fertigated for drip irrigation and during each irrigation for microsprinklers. Extra N was applied manually every two weeks.

The experimental unit consisted of ten trees and only the central five were controlled. Trees were managed according to commercial practices of pest and weed control, chemical thinning and hand pruning.

From mid May, when treatments were established, to harvest, general and physiological measurements were taken. Both water and fertilizers applications were monitored weekly. Soil water content was recorded hourly using Watermark® sensors at 20-35 cm depth located in the rows between two trees. Soil solution access tubes with 4 cm diameter and 5 cm long porous cup were installed like watermarks. Samples were collected about every two weeks, after irrigation took place. Trunk perimeter was measured monthly. Among physiological measurements, fruit growth was measured weekly on the tree and at the lab after sampling (six fruits per subelemental plot per week). Photosynthetic active radiation (PAR) was measured three times and predawn and midday leaf water potential, stem water potential and leaf gas exchange four times during the growing season and one time at postharvest. Leaf and fruit samples were taken monthly in order to determine the nutritional status.

On September 4, all fruits from five trees per subtreatment were harvested. Yield, number of fruits, fruit size distribution and individual fruit fresh mass and dry mass per tree were measured. Eighteen fruits samples from the most common fruit size of each subtreatment were taken for qualitative measurements and firmness, color, soluble solids, titratable acidity, starch test and fruit physiological disorders were determined.

Two extra 18 fruits samples were collected to evaluate qualitative changes after four and six months Ultra Low Oxygen (ULO) cold storage.

Evapotranspiration and rain values were obtained from the Catalunya Agroclimatic Station Network weather station located at Raimat (Lleida), five km away from Gimenells.

Results and discussion

After first year data, most of parameters had similar values between treatments and subtreatments and only few of them gave treatment or subtreatment differences. That was a common situation after an initial period of acclimation to new irrigation and fertilization conditions. As a consequence, only most relevant results are explained.

Total applied water and N
The amount of water applied (Figure 1) were obtained using the water balance method. Three distinct curve pattern were distinguished, corresponding to different slopes and in accordance to irrigation treatments establishment. Until treatment change point (mid-July), MED had the highest slope value while from that point to harvest, MDE had the highest one. The rest of
treatment had an intermediate value. MF treatment was jumping because its two weeks irrigation period at a constant dose. MC curve was divergent during the last period due to some irrigation management problems.

![Figure 1. Total water applied](image1)

![Figure 2. Total N applied](image2)

Total N applied (Figure 2) curves were splitted on four groups, corresponding to 0-40-80-200 N treatments respectively. About 20% of total N was applied during postharvest. The stepped shape of N-200 curves was due to extra N applications.

**Physiological aspects**

*Individual fruit growth*

Seasonal pattern of individual fruit diameter measured on the tree gave slight irrigation treatments differences (Figure 3) but, when extreme treatments were considered (D and MF), those differences were relevant. Looking at calculated fruit volume data (Assaf et al., 1982) (Figure 4), the same result was obtained, even magnified because fruit volume is a function of fruit diameter. During the period of expansive fruit growth, just before harvest, treatment D had the highest slope and harvested fruits had the biggest volume.
For fruit fresh- and dry-mass, very similar pattern for all irrigation treatments were obtained with apparently the same values at harvest (results not shown).

For N treatments and subtreatments, any difference was obtained during this experimental year (results not shown).

Leaf water potential

For diurnal leaf water potential on July 6, lowest results corresponded to MF (Figure 5), while MC and D obtained the best values but with slight differences between them and the rest of irrigation treatments. Leaf water potentials from N-0 and N-40 (Figure 6) were apparently higher (less negative) than the ones obtained in N-80 and N-200. One aspect to be pointed out was the fairly low midday leaf water potential values (about -2MPa), close to the reported by (Ebel et al., 1993) when regulated deficit irrigation (RDI) treatments were monitored. All the values obtained had to be compared with future results in order to confirm these tendencies. Proebsting et al. (1984), comparing drip and sprinkler irrigation in “Golden” reported some firmness differences at harvest and after cold storage bud, when leaf water potential was similar, previous differences had been compensated.
Productive aspects

Although there were no statistical differences on individual tree yield and total tree fruit number between irrigation treatments, apparently higher values were obtained from D, MC and MED compared to MDE and MF treatments (Table 1). The same tendency appeared for individual fruit fresh mass, with higher values (statistically different) for D, compared to MF, the extreme irrigation treatment. Kilili et al. (1996b) reported that, although yield figures were similar for irrigation treatments in “Braeburn”, individual fruit fresh mass was lower when no irrigation or initial deficit was applied. For N subtreatments, values were very similar.

For N treatments in drip irrigation, N-200 had the best figures, different from N-80 but without a clear tendency between all of them. Results from Fallahi (1997) for “Redspur Delicious” indicated lower yields from trees receiving 45 g N-tree\(^{-1}\) (80 kg N-ha\(^{-1}\) under our conditions), different from trees that received 180 g N-tree\(^{-1}\) or even more (300 kg N-ha\(^{-1}\) under our conditions)
Table 1. Productive aspects

<table>
<thead>
<tr>
<th>Irrigation treatment</th>
<th>kg·tree⁻¹</th>
<th>Number fruits</th>
<th>Indiv. fruit mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>40.6</td>
<td>217</td>
<td>190 a</td>
</tr>
<tr>
<td>MC</td>
<td>41.6</td>
<td>229</td>
<td>179 ab</td>
</tr>
<tr>
<td>MED</td>
<td>41.3</td>
<td>238</td>
<td>178 ab</td>
</tr>
<tr>
<td>MDE</td>
<td>35.3</td>
<td>200</td>
<td>176 ab</td>
</tr>
<tr>
<td>MF</td>
<td>35.0</td>
<td>206</td>
<td>171 b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N subtreatment</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>38.3</td>
<td>218</td>
<td>178</td>
</tr>
<tr>
<td>200</td>
<td>39.2</td>
<td>218</td>
<td>180</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N treatment (in D)</th>
<th>SS (°Brix)</th>
<th>AC (g. malic acid·l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.3 b</td>
<td>4.6 a</td>
</tr>
<tr>
<td>40</td>
<td>13.1 a</td>
<td>4.5 a</td>
</tr>
<tr>
<td>80</td>
<td>13.0 b</td>
<td>4.4 ab</td>
</tr>
<tr>
<td>200</td>
<td>12.9 ab</td>
<td>4.2 b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N subtreatment</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>13.2</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>13.1</td>
<td>4.3</td>
<td></td>
</tr>
</tbody>
</table>

Qualitative aspects

Only soluble solids and acidity are reported (Table 2). Although N treatments show statistical differences, we had very similar data in this study, and no clear tendency was seen. Similar values were obtained for irrigation treatments. However, when withholding irrigation was applied at the end of the season, better values of soluble solids, firmness and color were obtained (Kilili et al., 1996b). The rest of qualitative parameters gave similar results. Focussing on firmness, one of the most studied aspect, Assaf et al. (1975); Erf & Proctor (1989) obtained higher firmness levels in “Golden” under low soil water content during the whole fruit growing season, without affecting fruit size but yield. Kilili et al. (1996a) obtained firmer fruits at harvest and after cold storage under dry conditions or when withholding irrigation was applied at the end of the growing season, compared to a control (well irrigated) or a withholding irrigation at the initial stage.

Table 2. Qualitative aspects

<table>
<thead>
<tr>
<th>N treatment (in D)</th>
<th>SS (°Brix)</th>
<th>AC (g. malic acid·l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.3 b</td>
<td>4.6 a</td>
</tr>
<tr>
<td>40</td>
<td>13.1 a</td>
<td>4.5 a</td>
</tr>
<tr>
<td>80</td>
<td>13.0 b</td>
<td>4.4 ab</td>
</tr>
<tr>
<td>200</td>
<td>12.9 ab</td>
<td>4.2 b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N subtreatment</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>13.2</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>13.1</td>
<td>4.3</td>
<td></td>
</tr>
</tbody>
</table>

Future seasons data will be helpful to explain the initial tendencies found and some contradictory results, mainly due to the orchard acclimation to the new irrigation and fertilization conditions during this first year.
References


Timing irrigation by measurement of seasonal fruit growth of apple

Lakatos, T. ¹,  T. Bubán ¹ and O. Krammer ²
¹ Research and Extension Centre for Fruitgrowing, P.O.Box 38, 4244 Újfehértó, Hungary
² Ministry of Foreign Affairs, Centre of International Cooperation (MASHAV), Embassy of
Israel, Fullánk u. 8, 1025 Budapest, Hungary

Abstract: Monitoring of fruit growth rate was carried out to schedule irrigation in apple orchards of
high density planting. Responsiveness of cultivars to the water they received by rainfall and/or
irrigation proved to be different. After all, a temporary decline in fruit growth rate (mm day⁻¹) can be a
guide for timing irrigation. Providing proper amount of irrigation water adequate to the actual ET₀
demand, however, remained a possibility to be checked in further investigations.

Key words: scheduling irrigation, water stress, fruit growth rate, evapotranspiration

Introduction

Concerning environmental physiology, apple draws its inherent productivity e.g. from stress
tolerance, such as good water use efficiency and plasticity of osmotic adjustment (Lakso 1994). Apple production, however, in many countries rely on irrigation and its water use
should be limited to control leaching out nutrients into the ground water and, to reduce costs
of irrigation. Fruit growth rate expressed in volume (ml day⁻¹) proved to be a guide for

This study was undertaken to adapt a simple procedure to be used by the growers as a
tool for scheduling irrigation in apple orchards.

Material and methods

The orchard A planted with 'Idared' and four other cultivars on rootstock M.9 (with spacing
3.8 by 1 m) obtained rainfall monthly 16 to 60 mm as a total of 232 mm (from May to Sept.,
1999) and overhead irrigated by 45 to 90 (total: 190 mm, July - Sept.). Orchard B of very high
density (3.2 by 0.6 m) planted without irrigation system in an other region usually rich in
rainfall distributed rather evenly (e.g. at a range of 93 to 121 mm from May to August, but 31
mm in Sept., 1999). Next year (at Újfehértó) an experimental plot of 'Jonagold Wilmuta' and
'Golden Reinders' on M.9 planted of 3.0 by 1 m were irrigated by a lateral per tree row with
2.0 l h⁻¹ online drippers spaced 0.8, 1.0 and 1.2 m along the lateral in Treatment A, B and C,
resp. Treatment B received an amount of water equivalent to 100% of ET₀ demand, the
amount of irrigation water was determined according to the previous week’s factors of
Penman equation. The level of irrigation calculated in the same way was in A: 120% and C:
80%, (except from 10 July to 29 Aug., the irrigation system was out of work). Measurements
in both year of experiments: seasonal fruit growth in volume (ml fruit⁻¹); growth rate of fruit
(mm day⁻¹) weekly, 5 trees/6 tagged fruits per treatment. Additional measurements in the
experiment at Újfehértó were done as presented in Tab. 1, 2 and 3.
Results and discussion

Changes in water supply were reflected fairly well in fruit growth rate (Fig. 1 and 2), in the orchard B of heavy fruit load, too, in spite of the abundant rainfall there (Lakatos et al. 1999).

Some cultivars proved to be, however, less responsive (Lakatos et al. 1999), like to others experiences (Forshey and Elfving 1989). Fruit size (see fruits larger than 81 and 71 mm) was depending rather on relative yields (kg cm⁻² TCSA) of trees than on the amount of irrigation (Tab. 1 and 2) and, it is also true for shoot growth in terms of total cm m⁻¹ of 2nd-year-old twig (Tab. 3). Probably, the effects expected by treatments of irrigation have been eliminated by the water stress period of 7 weeks (due to the breakdown of the irrigation system).

Table 1. Fruit size distribution and relative yield in trees of apple cv. ‘Wilmuta’ Újfehértó, 2000

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>Percentage of fruits graded by diameter (mm)**</th>
<th>Relative yield kg cm⁻² TCSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;70 10 71-75 32 76-80 46 81-85 12 &gt;85</td>
<td>0.49</td>
</tr>
<tr>
<td>B</td>
<td>3 19 39 33 6 0.61</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>– 16 36 36 12</td>
<td>0.56</td>
</tr>
</tbody>
</table>

* spacing of on-line 2.0 litre h⁻¹ drippers was 80 cm (A), 100 cm (B) and 120 cm (C), resp.
** 12 trees x 10 fruits treatment⁻¹

Table 2. Fruit size distribution and relative yield in trees of apple cv. ‘Golden Reinders’ Újfehértó, 2000

<table>
<thead>
<tr>
<th>Treatments*</th>
<th>Percentage of fruits graded by diameter (mm)**</th>
<th>Relative yield kg cm⁻² TCSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;60 – 26 61-65 45 66-70 29 71-75 0.83</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>– 5 34 36 25</td>
<td>0.64</td>
</tr>
<tr>
<td>C</td>
<td>7 8 37 30 18</td>
<td>0.87</td>
</tr>
</tbody>
</table>

* spacing of on-line 2.0 litre h⁻¹ drippers was 80 cm (A), 100 cm (B) and 120 cm (C), resp.
** 12 trees x 10 fruits treatment⁻¹

Table 3. Vegetative parameters and relative yield in trees of apple cvs. Újfehértó, 2000

<table>
<thead>
<tr>
<th>Cultivars, treatments</th>
<th>Shoot length</th>
<th>Spurs</th>
<th>Relative yield kg cm⁻¹ TCSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>average cm</td>
<td>cm m⁻¹ of 2nd-year-old twig</td>
<td>pieces m⁻¹ of 2nd-year-old twig</td>
</tr>
<tr>
<td>‘Wilmuta’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>44.2</td>
<td>375</td>
<td>16.4 ab</td>
</tr>
<tr>
<td>B</td>
<td>41.0</td>
<td>311</td>
<td>19.4 b</td>
</tr>
<tr>
<td>C</td>
<td>39.0</td>
<td>337</td>
<td>14.8 a</td>
</tr>
<tr>
<td></td>
<td>n. s.</td>
<td>n. s.</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>‘Golden Reinders’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>30.3</td>
<td>183</td>
<td>18.4 ab</td>
</tr>
<tr>
<td>B</td>
<td>31.5</td>
<td>204</td>
<td>21.9 b</td>
</tr>
<tr>
<td>C</td>
<td>30.8</td>
<td>219</td>
<td>16.5 a</td>
</tr>
<tr>
<td></td>
<td>n. s.</td>
<td>n. s.</td>
<td>p&lt;0.1</td>
</tr>
</tbody>
</table>
Figure 1. Seasonal fruit growth (mm) and growth rate of fruit (mm day$^{-1}$) apple cv 'Idared', orchard A, 1999

Figure 2. Rainfall, irrigation, ET$_0$ and fruit growth rate (mm day$^{-1}$) apple cv 'Golden Reinders', Újfehértó, 2000
A lower rate of irrigation decreased the percentage of apple fruits >65 mm, while the total yield t ha⁻¹ was similar as in high rate irrigation (Naor et al. 1995). Total yield and yield of larger fruits as well as relative yield of larger fruits in pear trees increased with irrigation level, but relative yield of larger fruits decreased with increasing crop load (Naor et al. 2000). Fruit weight of apple at harvest was affected by interaction between irrigation treatment and fruit load (Ebel et al. 1995). The fruit weight was less in regulated deficit irrigation regime early in the season (early RDI) than in late RDI treatments (Mills et al. 1996) or, mean fruit weight was not affected by late RDI (Irwing and Drost 1987). According to Mpelasoka et al. (2000) in trees of ‘Braeburn’ the gross yield (kg tree⁻¹), fruit growth rate (mm day⁻¹) and fruit size were less but not significantly even in early RDI. A decrease in harvest fruit weight by mid-season DI was reported by Yao et al. (2000). Due to their growth attributes the stone fruits respond to the water stress peculiarly (Torricellas et al. 2000). A late RDI treatment during the II rapid period of fruit growth caused reduction in size of apricot fruits and, a RDI treatments immediately postharvest (affecting flower bud induction and/or differentiation processes) resulted in less fruit set and yield next year.

Early RDI reduced shoot extension much more than RDI later in the season in apple (Irwing & Drost 1987, Mills et al. 1996) and in pear trees (Marsal et al. 2000). Vegetative growth in early RDI can be less or similar than in control trees (Ebel et al. 1995), although, vegetative growth usually is more responsive to water deficit than fruit growth.

The less sensitivity of fruit growth to water stress compared to vegetative growth (Forshey & Elfving 1989) is founded on physiological relationships (Mills et al. 1996). Nevertheless, the early season relative rate of fruit growth is critical to final fruit size variation regardless of the reason (Lakso et al. 1989). The potential maximum fruit size is set about 50 days after pollination, determined by total fruit cell number, resulting from a temperature responsive cell division growth phase (Stanley et al. 2000). Furthermore, the effect of canopy shade on fruit size occurs primarily in the period of 1–5 weeks after bloom, or reversed: relative growth rate of apple fruitlets can be increased by CO₂ enrichment beginning with 28 days after bloom (Lakso et al. 1989). The main cell division period of pear fruit development takes place at the first 7–8 weeks after full bloom (DAFB), and RDI treatment from 32 to 60 DAFB resulted in smaller harvest fruit size than in control treatment (Marsal et al. 2000). Temperature treatments imposed from 10 to 40 DAFB significantly affected mean fruit expansion rate of apples, however, the harvest fruit weight did not as much as have been expected from the early fruit expansion rates (Warrington et al. 1999). By others (Naor et al. 2000) a severe drought stress, only, might affect cell division and therefore potential fruit size.

The properly regulated irrigation (or even fertigation) does not imply risk concerning the pollution of the ground water, i.e. it can be well involved in the technology of integrated fruit production (IFP). Investigating distribution of nitrogen in the soil to the depth of 60 cm following fertigation in 2 successive seasons, we did not find nitrogen accumulation in the deeper layers of soil Bubán & Lakatos 2000).

References


Herbicide use and the sustainability of soil quality

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Abstract: Persistence in soil is an important property for consideration in the registration and use of pesticides. For example, persistent residual herbicides can cause phytotoxic symptoms in following crops. However, the herbicide paraquat has been widely used for weed control in orchards for many years. Being very strongly sorbed to soil, paraquat is of limited availability to degrader microorganisms and so is rather persistent, but this causes no deleterious biological effects in soil. In other studies, long-term field trials having annual applications of up to five pesticides over a 20-year period have found no deleterious effects on soil fertility as assessed by crop yield, nor any effects on the overall microbiological processes in soil. Persistence of modern pesticides in soil is primarily due to strong sorption therein, which limits availability and likewise also the possibility of adverse effects on microorganisms; persistent but weakly sorbed compounds would not be approved for use due to the risk of groundwater contamination. It is concluded that the current registration procedure of using laboratory measurements of persistence is an appropriate approach, with persistence in soil above set criteria triggering the requirement for more detailed studies to ensure no long-term adverse effects.

Key words: paraquat, sorption, persistence, soil, soil quality

Introduction

Pesticides applied to crops will inevitably have some side effects, either directly or indirectly such as herbicides removing food sources for some insects. These effects will however usually be short term, and often no more significant than an agricultural operation such as ploughing. But the potential longer-term impacts of pesticides, especially those persistent in soil, need to be considered for these are a concern amongst the public. Does such pesticide usage damage soil fertility, lead to the accumulation of unacceptable residue levels in soil or allow pesticide breakdown products to be incorporated into soil organic matter with uncertain long-term consequences? And can such effects lead to the contamination or even pollution of surface- and groundwaters? These aspects are considered in the light both of information now available from long-term field trials and of the present registration requirements.

Registration criteria for pesticide behaviour in soil and water

Soil

In the development of a new pesticide for use in the European Union (EU), breakdown of the pesticide in several soils is measured in laboratory tests. If the disappearance time for half the pesticide (i.e. the DT$_{50}$) $>$60 days at 20°C or DT$_{50}$ $>$90 days at 10°C where this lower temperature is more relevant for the proposed uses, then field studies are triggered. It should be noted the parameter DT$_{50}$ is purely a measured value that says nothing about the loss kinetics, whereas a half-life ($t_{1/2}$) implies that the loss process approximates to first-order kinetics. As soils vary somewhat in their ability to degrade pesticides, then the interpretation of these measurements can itself be somewhat arbitrary if they span the trigger value.
If field studies are triggered, then if DT$_{50}$ > 3 months and DT$_{90}$ > 12 months the compound will not be accepted for use without more testing. Such further tests are required to show no deleterious effects for example in soil organisms including microbial processes. In interpreting persistence in the field, several complicating factors occur such as fluctuations in temperature and soil moisture. These can have an appreciable effect, for a 10°C rise in temperature will typically increase degradation rates by 2- to 3-fold, whereas the drying of topsoil will almost prevent any degradation at all. Thus the use of half-lives or other simple kinetic functions to interpret field data is usually not justified unless they are incorporated into sophisticated simulation models that take into account the changing conditions. This caveat pertains especially to the more persistent compounds that may go through a complete summer/winter cycle.

A final criterion is that further tests are required if non-extractable residues are > 70% with mineralisation to carbon dioxide of < 5% in 100 days in the laboratory tests. This requirement has no scientific basis, as degraded residues of pesticides chemically bound into soil organic matter have never been shown to have subsequent biological effects; furthermore, it takes no account of the rate of application, an important consideration given that pesticide application rates can vary over a range of 100-fold (e.g. from 10 to 1000 or more g ha$^{-1}$).

**Water**

Different criteria apply to allowable concentrations of pesticides in surface waters compared to groundwater. If a use of a pesticide is likely to lead to concentrations in groundwater exceeding the EU limit of 0.1 µg L$^{-1}$, then that use would not be permitted. For new compounds, estimates are made of the probability of this occurring, these usually being derived from computer modelling of movement using realistic application patterns, degradation rates and sorption coefficients.

For surface waters, the avoidance of environmental damage is the sole criterion, even if the outcome is that surface waters used for potable water do exceed the limit of 0.1 g µL$^{-1}$. Such contamination does occur for a small number of widely used herbicides in the U.K., especially those applied in autumn to cereals, though the toxicity to mammals of these compounds is very low such that maximum residue levels in water set on this criterion as in the USA would be much higher than 0.1 µg L$^{-1}$. Returning to the ecotoxicological effects, for a limited number of compounds Environmental Quality Standards (EQS) have now been set; these are the levels at which contamination becomes pollution by having a deleterious effect on aquatic organisms, and permitted uses should not allow the EQS to be exceeded.

**Studies on pesticides persistent in soil**

**Paraquat usage in orchards**

The herbicide paraquat, introduced in the late 1950s, has the unusual property of killing the above-ground green parts of plants but being rapidly deactivated by soil such that sowing can be done within days of application (Summers, 1980). This deactivation is caused by very strong binding of the paraquat dication onto clays, with the cation exchange mechanism being enhanced as the planar molecular is able to intercalate the lamellae of expanding clay lattices. Such strong sorption leads to slow breakdown, but after a few years of annual treatments nonetheless breakdown limits further accumulation in soil (Figure 1).

The estimated breakdown constant was quite small at 0.124 year$^{-1}$ in the U.K. study, with a similar result obtained at a site in Goldsboro, North Carolina, USA. Nonetheless, despite world-wide use in many situations, the persistence of paraquat has not damaged following crops or adversely affected soil quality.
Figure 1. Accumulation pattern of paraquat in soil following repeated annual treatments of 4.48 kg ha\(^{-1}\) at the Weed Research Organisation, Oxford, U.K.

**Effects of long-term pesticide application in soil fertility**

There has been public concern at the possible deleterious effects on soil fertility of the long-term repeated use of pesticides. Such compounds are designed to kill at least one group of organisms and often may have some impact directly or indirectly on others. The possible accumulation of pesticides in soil, or even the ultimate fate of their breakdown products incorporated into soil organic matter, is thus of importance, especially given that pesticides have been routinely used in much of agriculture for 50 years.

Several long-term field trials have investigated these possible effects on soils and soil processes. At Rothamsted, a field experiment was started in 1974 with 32 plots of a clay loam soil receiving annual applications of up to five pesticides over a 20-year period to 1993. Each plot received the same pesticide treatment each year; the compounds were aldicarb, benomyl and chlorfenvinphos (for 20 years) and glyphosate and triadimefon introduced later (14 and 12 years respectively). Application rates were slightly above normal, and yields of spring barley were taken as an indicator of soil fertility (Bromilow et al. 1996). By 1994, no pesticide residues, even of the rather persistent triazole fungicide triadimenol derived by reduction of triadimefon in soil, could be detected. No deleterious effects on soil fertility were observed, with no significant differences in barley yield from 1994-98 across the plots following cessation of the pesticide treatments in 1993 (Bromilow, unpublished results). Furthermore, in 1992, no damaging effects of treatments were observed either on soil respiration (Figure 2) or on microbial biomass carbon (Hart & Brookes, 1996). A similar lack of effect of repeated herbicide treatments has been reported at other sites (Fryer *et al.*, 1980; Smith *et al.* 1991).

**Conclusions**

Modern pesticides, even if persistent in soil, have not caused deleterious effects to soil fertility or microbial processes. Persistence in soil is caused by strong binding of lipophilic or cationic pesticides to soil solids, which reduces availability both for degradation by microorganisms and for uptake by other organisms. Such sorption limits the rate of transfer of pesticide from soil to organism, and modern compounds, unlike the older heavily halogenated insecticides such as DDT, are sufficiently rapidly metabolised that damaging bioaccumulation does not occur. Strong sorption to soil also greatly minimises movement to rivers or
groundwater, the Groundwater Ubiquity Score providing an estimate of the latter (Gustafson, 1989).

Repeated use of pesticides, even of persistent ones such as paraquat and the triazole fungicides that inhibit sterol biosynthesis, over more than 30 years in general agricultural practice has not led to problems with soil fertility. This has also been borne out in detailed long-term field studies done at several sites, though of course these can only cover a small range of the possible pesticide/soil combinations. Soils receive annually amounts of organic compounds from plants that are far in excess of those applied as pesticides, and many of these natural compounds such as alkaloids and phenols are very biologically active. Nonetheless, the soil microorganisms are well adapted over millions of years to utilise such materials as a source of nutrition, and it appears that pesticides are degraded by the same process. Indeed in certain situations, microbial populations have become adapted to use a particular pesticide as a food source, leading to rapid degradation in soil which at times can negate the intended use of the pesticide, e.g. carbofuran applied to maize to control corn rootworm in the USA. Inorganic pesticides containing heavy metals will result in accumulation of the metals in soil with concomitant problems, an example being toxicity to earthworms observed in orchards receiving repeated doses of copper in the fungicide Bordeaux mixture.

Although persistence of modern pesticides has not caused long-term problems, there are many other reasons to moderate the use of pesticides and to integrate their use with agronomic practices, resistant plant varieties and biological control. Where this balance needs to be struck is a matter both of economics and of the viewpoint of the individual farmer. Nonetheless, much of agriculture is dependent on the use of pesticides to some degree, and it is incumbent on us to use them wisely.

![Figure 2. Effect of repeated pesticide treatments over 19 years on soil respiration (comparing 16 plots receiving a particular pesticide annually with the 16 plots not receiving it)](image)

**References**


Flowering ground cover plants for pest management in peach and apple orchards

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Abstract: Four orchards (each 0.5 ha) with peach and apple trees were managed with four levels of plant diversity and two different insecticide schedules. The first orchard was planted with peach and apple monocultures and received a conventional insecticide schedule with 6 to 8 insecticide applications. The second orchard had peach and apple monocultures with flowering ground covers under the trees and received a reduced insecticide schedule with one organophosphate application and several selective insecticide sprays (Bt or spinosad). The third orchard had peach and apple interplanted, no flowering ground cover plants, and the same reduced insecticide schedule. The fourth orchard had peach and apple interplanted, flowering ground covers, and the reduced insecticide schedule. The flowering ground cover plants used were buckwheat (Fagopyrum esculentum), dill (Anethum graveolens), tansy (Phacelia tanacetifolia), and a mixture of wildflowers. The same fungicide application schedule was used in all four orchards. Overall fruit quality was unaffected by the reduced insecticide sprays with flowering plants and interplanting. There was an increase in damage from leafroller (Tortricidae) and second generation plum curculio (Conotrachelus nenuphar) in peach and for codling moth (Cydia pomonella) and first generation plum curculio in apple. The use of this program of pest management is promising but requires further work before it can be commercially applied.

Key Words: diversity, ground cover, interplanting, yield

Introduction

The use of flowering ground covers to enhance biological control in orchards has been studied from Hungary (Jenser et al. 1999) to New Zealand (Stephens et al. 1998) and has been reviewed by (Bugg & Waddington 1994). Most of these studies have shown that the presence of flowering plants does increase the abundance of biological control organisms with a resultant increase in biological control of insect pests (Wyss 1996, Solomon et al. 1999, Jenser et al. 1999, Stephens et al. 1998). An increase in biological control of pests has not been found in all experiments, however (Gruys 1981, Vogt & Weigel 1999). Fewer studies have taken the next step to incorporating flowering plants into integrated fruit production by examining fruit yield and quality. Altieri & Schmidt (1985) did show an decrease in codling moth damage to apples in plots with flowering plants, but they did not include a conventional management check for comparison. Brown & Glenn (1999) showed that an apple orchard using flowering plants to increase biological control and reduced insecticides produced fruit of quality equal to that of a conventionally managed orchard. This orchard however, had a significantly lower yield than the conventional orchard due to competition between the ground covers and apple trees for water and nutrients. This study tests a refinement in the use of ground covers in an attempt to replicate the results of Brown & Glenn (1999) and to manage the ground covers without reducing yield.
Materials and methods

Four orchards were planted to test various levels of plant diversity on the natural control of insect pests on apple (‘Empire’ and ‘Granny Smith’) and peach (‘Loring’). Each orchard was 0.5 ha in size and planted in 1997. The first orchard was planted as a monoculture of apple adjacent to a monoculture of peach managed with conventional pest management, including 6 to 8 broad spectrum insecticides. The second orchard was planted with the apple and peach monocultures but had four species of ground cover plants sown under the trees. The ground covers were planted in a 0.75m strip beginning from 0.75m from the tree out to a grass strip between tree rows. The ground covers used were buckwheat (Fagopyrum esculentum), dill (Anethum graveolens), purple tansy (Phacelia tanacetifolia), and a mixture of native wild flowers. One application of a broad spectrum insecticide was applied at petal fall and then 3 to 5 applications of the selective insecticides Bacillus thuringiensis or spinosad. The third orchard had apple and peach trees interplanted with sweet cherry (‘Emperor Francis’ and ‘Ulster’) and pear (‘Bosc’ and ‘Anjou’). This orchard did not have ground cover plants but was managed with the reduced insecticide schedule. The fourth orchard had the fruit trees interplanted as in the third orchard and had the same ground cover planting as the second orchard and the reduced insecticide schedule. All four orchards had the same fungicide application schedule and mating disruption for oriental fruit moth, Grapholita molesta.

Yield was measured by completely harvesting 20 peach trees and 15 trees of each apple cultivar, randomly selected from each orchard. The weight and number of fruit from each of these trees was measured with an automated fruit grading machine. Fruit quality data was collected on 20 randomly selected fruit from 25 peach and 15 trees of each apple cultivar. Each fruit was visually examined for any insect, disease or physical defect and cut to examine for internal pests. In 1999 there was a light apple crop, and no yield data were collected.

Results and discussion

The yield of peach in 1999 was lowest in the conventionally treated orchard and highest in the two orchards with ground cover planting (Table 1). In 2000, however, the conventional peach orchard had the highest yield of all treatments. In both apple cultivars in 2000, the conventional orchard had greater yields than did the two orchards with ground covers. Empire apples in the low spray/interplanted orchard did have the greatest yield among all apple harvests.

Quality of the apple harvest in both years was low with 18 to 24% culls in the conventionally managed orchard and 18 to 44% culls in the low spray orchards (Table 2). In 1999, insect damage was greater in the conventional orchard than in the test orchards, but there was no significant difference in insect damage among the 4 orchards. In 2000, insect damage was similar for Empire in all except the low spray/ground cover orchard and very high for all Granny Smith apples. Insect damage to Granny Smith in 2000 was mostly due to stink bug (Pentatomidae) in all orchards, ranging from 35% to 49%, and to codling moth (Cydia pomonella) which ranged from 7% in the conventional orchard and 17 to 23% in the reduced spray orchards. The Empire apples in 2000 from the low spray/ground cover orchard had slightly higher codling moth damage and more damage from first generation plum curculio (Conotrachelus nenuphar) than the other orchards. All orchards received the same fungicide spray schedule, but there were differences in the amount of damage due to diseases in 1999 and for Empire in 2000. The greater disease incidence was in the ground cover orchards. It is likely that the ground cover plants grew into the lower portion of the tree crowns and prevented adequate spray coverage of the fruit.
Table 1. Total weight of fruit per tree (kg) averaged over 20 peach and 15 apple of each cultivar randomly selected per orchard.

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Low Spray/ Ground Cover</th>
<th>Low Spray/ Inter-planted</th>
<th>Low Spray/ Ground Cover/ Interplanted</th>
</tr>
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<tbody>
<tr>
<td><strong>Peach, 1999</strong></td>
<td>13.9</td>
<td>21.5</td>
<td>16.3</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Peach, 2000</strong></td>
<td>17.2</td>
<td>8.3</td>
<td>10.8</td>
<td>10.8</td>
</tr>
<tr>
<td><strong>Empire, 2000</strong></td>
<td>9.6</td>
<td>4.9</td>
<td>6.3</td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Granny Smith, 2000</strong></td>
<td>9.5</td>
<td>4.9</td>
<td>6.3</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 2. Apple harvest quality data from orchard diversity study, West Virginia, USA, 1999-2000.

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Low Spray/ Ground Cover</th>
<th>Low Spray/ Inter-planted</th>
<th>Low Spray/ Ground Cover/ Interplanted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Both Cultivars, 1999</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No damage</td>
<td>26</td>
<td>11</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>Cull</td>
<td>18</td>
<td>44</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Insect damage</td>
<td>32</td>
<td>29</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Disease damage</td>
<td>18</td>
<td>30</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td><strong>Empire, 2000</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No damage</td>
<td>64</td>
<td>46</td>
<td>66</td>
<td>52</td>
</tr>
<tr>
<td>Cull</td>
<td>19</td>
<td>34</td>
<td>18</td>
<td>37</td>
</tr>
<tr>
<td>Insect damage</td>
<td>16</td>
<td>31</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Disease damage</td>
<td>21</td>
<td>31</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td><strong>Granny Smith, 2000</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No damage</td>
<td>50</td>
<td>37</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>Cull</td>
<td>24</td>
<td>34</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Insect damage</td>
<td>46</td>
<td>59</td>
<td>56</td>
<td>63</td>
</tr>
<tr>
<td>Disease damage</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Highest quality peach fruit was harvested from the conventionally managed orchard in both years (Table 3). In 1999, there were no significant differences among orchards in any insect damage category. The biggest difference in 1999 was in the amount of peach scab (*Cladosporium carpophilum*), which ranged from 17% in the conventional and low spray/ground cover/interplanted orchards to a high of 85% in the low spray/interplanted orchard. In 2000, the conventional orchard had less insect damage than the reduced spray orchards, with damage from second generation plum curculio and leafrollers (Tortricidae) making up most of the difference. The damage from second generation plum curculio can be a serious problem because larvae are found inside the fruit, a major concern for consumers. A primary concern with peach was a potential increase in damage by stink bugs and Miridae due to the addition of flowering plants. In both years no increase in damage from these pests was observed in the ground cover plots.

The use of flowering plants and interplanting fruit tree species with reduced insecticide use is giving good insect control, but there are a few pests that are causing unacceptable
damage. More selective insect control options need to be used to control these pests. Yields from these experimental orchards are highly variable and, therefore, they do not allow for conclusions about the potential cropping ability of the individual orchard designs. To successfully incorporate the flowering plants, they must be planted farther from the trees to allow for the full cropping potential of the trees.

Table 3. Peach harvest quality data from orchard diversity study, West Virginia, USA, 1999-2000.

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Low Spray/ Ground Cover</th>
<th>Low Spray/ Interplanted</th>
<th>Low Spray/ Ground Cover/ Interplanted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1999</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No damage</td>
<td>54</td>
<td>27</td>
<td>8</td>
<td>51</td>
</tr>
<tr>
<td>Cull</td>
<td>8</td>
<td>20</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>Insect damage</td>
<td>13</td>
<td>19</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>Disease damage</td>
<td>13</td>
<td>51</td>
<td>89</td>
<td>14</td>
</tr>
<tr>
<td><strong>2000</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No damage</td>
<td>77</td>
<td>27</td>
<td>29</td>
<td>67</td>
</tr>
<tr>
<td>Cull</td>
<td>11</td>
<td>49</td>
<td>57</td>
<td>20</td>
</tr>
<tr>
<td>Insect damage</td>
<td>10</td>
<td>24</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Disease damage</td>
<td>5</td>
<td>70</td>
<td>67</td>
<td>10</td>
</tr>
</tbody>
</table>

References


Soil management and weed control in French orchards: towards new approaches governed by the principles of integrated farming

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Abstract: The main soil management technique in French fruit tree farming involves the use of inter-row vegetation associated with the application of herbicides on the row. Taking into account this current situation, the aim of this article is to propose a number of new approaches to improving the management of the flora found in and around French orchards.

Introduction

In France, less attention has been paid to soil management and weed control in orchard farming than that granted in recent years to the same issue in large-scale farming and in wine-producing regions. This is undoubtedly due to a number of specific, intrinsic characteristics:

• orchard farming produces a perennial crop on limited, relatively well-defined plots; as such it only very rarely suffers from the negative effects which can occur in large-scale farming covering a vast surface area which is open to the elements and therefore to a wide range of unexpected consequences,
• the combination of inter-row vegetation management and chemical weed control on the row is a fairly simple practice which tends to reduce erosion phenomena or the appearance of spectacular floral inversion,
• the early adoption of a number of integrated farming techniques has made it possible to draw up rational soil maintenance methods which do not generally cause a significant imbalance over a wide area.

However, there are some clear opportunities for improving soil management in relation to specific weeds and to optimising control systems for integrated production in orchards.

Soil management in fruit production today

In 1999, French orchards covered a surface area of 140000 hectares. Top fruits are the leading product with 74000 ha, followed by peaches (27000 ha), plums (20000 ha) and apricots (18000 ha).

The most commonly-used soil management technique involves inter-row sodding coupled with the use of herbicides on the rows of trees themselves. This method, which is used in 95% of orchards, has been given further support by the development of trickle irrigation systems which use less water, but which require the ground to be clean and also limit the possibilities of using machine tools and of weed-burning.

More than 70% of growers claim to make rational use of herbicides. Most give priority to foliar herbicides, primarily glyphosate or sulphosate (45% of surfaces), followed by glufosinate (22%), paraquat or diquat (18%), amitrole or herbicidal phenoxyacetic acids. Soil-
applied herbicides (diuron, simazine ...) are only used on approximately 25% of surfaces. 50% of orchards are the subject of two herbicide treatments a year, 30% just once a year and 15% three times a year, the last of these treatments generally being applied locally on specific problem areas. The rising costs of labour, energy and the use of machines are offset by the downward trend in herbicide prices, which helps to encourage growers to continue in this way.

The objectives of practices which are currently recommended in integrated production (Gendrier et al., 1999) are as follows:

- to encourage tree development in order to increase yield and to improve fruit quality,
- to make work in the field easier,
- to limit soil erosion.

In order to achieve these objectives, it is necessary:

- to maintain and improve the structure and depth of the soil,
- to preserve the fauna and microflora contained in the soil,
- to improve soil fertility.

These objectives, and the means of achieving them, which have been adopted by a large number of growers, can be made even more effective by incorporating new approaches which have recently come to light as solutions to specific problems or as the result of studies carried out in other tree-crop systems.

For a global soil management concept involving the use of herbicides

The absence of direct biological weed control methods, as well as the strong trends outlined above, highlights the need to promote reflection on a number of different points which are described in detail below.

Weed control in rows of trees in orchards: a concept which has to be refined

a) Understanding and awareness of weed species

Being open, orchards often have an extremely wide variety of botanical species. Fruit growers however, despite their often high level of technical knowledge, are frequently surprisingly unaware of the different botanical species which grow wild in their orchards. Apart from the “majors” such as “couch grass” (including Elymus repens, Cynodon dactylon, and to some extent Sorghum halepense), bindweed (Convolvulus sp.) or certain strong summer weeds (Amaranthus sp., Chenopodium sp.), the different plants are just seen as members of a large “weed family”, without distinguishing the more or less damaging nature of its different members. This relative lack of understanding and awareness constitutes a real obstacle to the development and implementation of new approaches capable of providing a more effective management of wild herbaceous plants.

b) Advantages and limitations of current control methods

Twenty years ago, fruit producers were looking for long-term total weed control, involving the use of herbicides with a persistent action. Today, the use of contact or systemic active ingredients, which do not have a long-term root action, leads to a need to tolerate the presence of weeds during periods where there is no danger to crop development, i.e. from the harvest to bud-bursting periods. In this way, anti-erosion benefits can be obtained for a large part of the season and the negative impacts of year-round bare soil on the biological activity of the underlying soil can be avoided. To date, however, little work has been carried out on the establishment of tolerable vegetation management thresholds which take into account the
species present in orchards. It is estimated however that low-development, horizontal-branching species do not pose a threat so long as sufficient water is available.

Compared with large-scale farming and grapevine production, orchards are clearly less prone to invasions of new, harmful weeds or to long-term establishment of resistant, highly-competitive populations. This satisfactory situation is undoubtedly due to the temporary action of chemical weed control, to the narrow weeded zones which maintain a certain pressure from the natural flora, and, most important of all, the rotation of large-scale foliage-applied herbicides belonging to different chemical families. A close eye should nevertheless be kept on local development of certain deep-rooted species (such as *Rumex* sp., *Plantago* sp. ...), which are extremely demanding in terms of water supply at certain moments of their life cycle.

Mulching-based control methods are still subject to debate owing to the fact that they have a tendency to encourage the development of rodent infestations. Growers are generally loath to use rodenticides to deal with a problem which most currently-used practices manage to prevent.

c) Some development areas

- French experiments with controlled natural floral growth in grapevine production (e.g.: work carried out by the COLUMA “ENM” group) have shown that it is possible, by making rational use of foliage-applied herbicides, to encourage maximum growth of non-competitive species (e.g.: *Poa annua*, *Veronica* sp. ...). Furthermore, this can be done during periods where these plants help to encourage the infiltration of water and to prevent soil erosion. It would clearly be useful to extend the scope of these trials to include fruit production.

- Trials of systems for treating set-aside cover with low doses of foliage-applied herbicides (Bernard & Verdier, 1995), and other trials using sulphosate (Bernard & al., 1995), have also indicated the possibility of reducing the biovolume of herbaceous cover using non-destructive methods and of limiting the bolting of weed species. On set-aside, these methods, which are now covered by a specific registration category, are recognised as being preferable to machine grinding, in order to preserve birds and field mammals. The financial and environmental advantages of rationalising weed control in fruit tree farming are therefore certainly worthy of further study.

- A greater awareness of the benefits and drawbacks of certain weeds could lead to the development of selective weed control strategies, the objective being to encourage the growth of certain weed species which have been established as being useful.

**Management of orchard-based botanical diversity**

In the context of integrated farming, it is difficult to focus solely on those wild weeds found around tree-bases without also examining the role played by plant life between rows, on headland and in hedgerows.

An ongoing debate revolves around the inter-row presence of nectar-producing plants. Many growers encourage such plants, considering them to attract greater numbers of pollinators into the orchard. Many technicians, on the other hand, are less enthusiastic, owing to the fact that they represent competition during blossoming and also provide refuge to certain pests, e.g. Thrips.

In large-scale farming and grapevine production there is currently a strong movement in France to give real consideration to field edges, owing to their benefits in terms of erosion and large-area pollution and also to their contribution to botanical diversity and the preservation
of beneficials, soil fauna and game (Camus & al, 1999). Even though there are currently considerable efforts being made to regenerate or replant hedgerows in central and western France and also in the Beauce region, orchard farming is not as yet reaping all of the benefits to be obtained from nationwide studies on hedgerows, despite the fact that many relevant works have been published in French since the beginning of the 1990s. The use of composite hedges for bordering pear orchards troubled by *Psylla piri* has been thoroughly researched (e.g. Simon et al., 1998) but is not yet common practice. During the ongoing renovation of hedgerows, the decision-makers would be well-advised to give preference to plant species which play host to the most useful beneficials, rather than focusing solely on aesthetic concerns, neglecting the essential issue of plant protection.

These new considerations concerning the choice of plant species for orchard edges should logically lead to further progress in the following areas:

- selection criteria for the choice of plant species between tree rows,
- consideration of the role played by weed species in order to decide which to encourage and which to get rid of, both between rows and on the rows themselves.

A greater awareness of the strengths of these plants will lead, sooner or later, to the development of new methods for improving the overall management of the herbaceous cover of the orchard.

The choice of herbicides for orchards

Compared to large-scale farming, there are a number of specificities in orchard farming as far as the use of herbicides is concerned:

- for the crop: a number of cases of phytotoxicity via root absorption have been reported in the past on young plantations on permeable soil; today however, product registration has done away with this phenomenon by forbidding the use of such herbicides before the appearance of the 4th leaf. The possibility of phytotoxicity linked to drift is often taken into account by fruit growers, but there is still a great deal of progress to be made in regulating spray nozzles for local applications. This type of equipment is generally less well-designed than the large trailed sprayers used in protection against pests and diseases. Occasional accidents have also been reported with systemic herbicides on young plants and on central axis peach trees which are close to the ground. The use of foliage-applied contact herbicides should therefore be preferred in such situations.

- for the user: compared to other crops, relatively few herbicide applications are made in orchard farming. Furthermore, local directed spraying under fruit-tree canopy, which prevents drift and reduces user exposure during treatment. Recommendations for the preparation of mixtures are similar to those given for other types of crop.

- for water protection: the use of foliage-applied products reduces the risk of water pollution. Precautions for the use of root products containing ureas or triazines are exactly the same as for other crops. Weed control strategies which focus on the tree rows themselves significantly reduce the quantities of product applied per hectare. Furthermore, inter-row vegetation management reduces rain flow, thus confining active ingredients within the plot.

- for earthworms and beneficials: the herbicides used present no particular risk to earthworm populations. For beneficial arthropods, the main impact would appear to be temporary habitat disruption owing to the disappearance of plant cover at the foot of trees. However, the limitation of weed-controlled areas and the presence of wide grassy strips between rows offer excellent recolonization possibilities; furthermore, the reduced
use of persistent herbicides encourages the summer and autumnal growth of weeds thus showing considerable consideration for the arthropod army.

As a final point, it should also be noted that the ongoing European re-registration procedure should lead in the near future to a reduction in the number of active substances available, and therefore a more limited choice of solutions for controlling specific weed species.

Conclusion

Although the herbicide strategies currently used in orchard farming already offer sound guarantees in terms of user safety and environmental care, there are a number of excellent development areas for improving existing methods. In our opinion, awareness of these potential advantages is still too low in the field of orchard farming, where there is still a great deal of room for improvement as far as soil management is concerned.

References

Towards insecticide free apple orchards in Quebec

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In recent years, growers, consumers and politicians have become interested in biological control as a pest management strategy because of the negative effects of pesticides on ground water contamination, worker safety, species diversity and pest resurgences in crops. Meanwhile, resistance to pesticides continues to develop in key pest species, and regulations along with accelerated costs of pesticides increasingly restrict when and where pesticides can be applied.

Enhancing the use of biological control in agriculture, is an awesome challenge. We have some of the information that can and should be used immediately. We also need additional research, and more resources to meet the challenge, as well as the recognition that there are limits to what can be achieved let us say by 2005.

To date most of the programs described as IPM are based on refining a scenario best described as supervised chemical control. In other words, biocontrol techniques (predators, parasitoids, male confusion, male sterility, mass trapping etc) replace a pesticide whenever possible. The weakness of this approach is that you will eventually come to a level where you can’t reduce the number of pesticide applications anymore. And if there are changes in the availability of a single pesticide, the program would fall on its face. The literature is full of such programs and several were presented in this symposium. I also have such a program in Quebec, encompassing 600 hectares or so where no acaricides have been used for the last 5 years and only 2.5 insecticide treatments are carried out per season. The alternative is to use biological control based on habitat management as described by Mark Brown earlier today. And there are few examples in the literature (Altieri & Schmidt 1985; Bugg & Waddington 1994; Wyss 1996; Brown et al. 1997; Solomon et al. 1998; Vogt & Weigel 1998; Rieux et al 1999). It is based on the basic principles of preservation and augmentation (Debach 1964).

In our study a 1 ha plot of ‘McIntosh’ apples were divided into 3 subplots and each subplot had its subplot of companion plants. The entire plot was sandwiched between a forest on the West side and treated trees on the East side. The North side had a traditional IPM plot and the South side was prairie grass. The companion plants (Tanacetum vulgare, Chrysanthemum maximum, Aster tongolensis, and Achillea millefolium) were planted in rows about 1 meter apart, the approximate width of a rotary cultivator. Weeds were managed by passing the cultivator three to four times per season. The trees were 15 years old when we began the study. Thus, the Habitat management program was imposed on a plot that was already in full production. This was important for we wanted to know how long it would take to build up the predator/parasitoid fauna to an effective biocontrol force. We also had two check plots of similar size that received the same 7 to 8 treatments of fungicides (captan, myclobutanil and metiram). The only difference between the check plots was that check plot # 2 was adjacent to a forest (refuge) on the South and East sides. The activity of pests was determined by examining 1500 apples/plot/ season and calculating the percentage of damaged...
and undamaged fruit. The key pests were: The tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois); plum curculio, *Conotrachelus nenuphar* (Herbst); and apple maggot, *Rhagoletis pomonella* (Walsh). In conventional IPM orchards a single treatment is necessary for each of these 3 different species. Sometimes the apple maggot may require 2 treatments. The Lepidoptera were subdivided into 2 groups spring Lepidoptera that included obliquebanded leafroller, *Choristoneura rosaceana* (Harris) and greenfruitworm *Lithophane antennata* (Walker); summer Lepidoptera that included 2nd generation obliquebanded leafroller; redbanded leafroller, *Argyrotaenia velutinana* (Walker), and lesser appleworm, *Grapholitha prunivora* (Walsh). We noted that the damage decreased systematically in the companion and the check plot #1 and it increased in check plot #2. The increase in damage of the 2nd check plot was because in the past, insects had been chemically controlled in that plot and as the effect of the treatments wore off, the pest level increased. Whereas, check plot #1 had been a neglected plot for at least 4 years prior to the study and a certain balance had reached between the pests and the predator / parasitoid fauna. Needless to say, there was also an influx of predators and parasitoids from the refuge. The percentage of undamaged fruit jumped from 4.8% in the first year in the companion plant plot to 91.7% five years later. In check plot #1 the percentage of clean fruit jumped from 32.1% to 67.5% and in check plot # 2 it decreased from 7.8% to 0% for the same five year interval.

Hymenoptera and Diptera were also monitored. This was done by placing six yellow pans in each of the companion plant sub-plots, the check plot #1 and a Malaise trap at the centre of the companion and check plot #1. Within four years the Ichemunidea density increased 3.7 folds, the Chalcidoidea 5.5 folds, the Proctotrupoidae 4.1 folds the Tachinidae 2.6 folds in the companion plots and it increased in check plot #1 4.2 folds, 4.1 folds, 6.9 folds and 2.4 folds for these super families presented in the same order. Incidentally, from 1995 to 1997 inclusive the companion and check plot #1 were treated with azinphosmethyl (850 g a.i / ha) at fruit set.

In conclusion this study shows that we can use habitat management as a template and modify it to become an IPM program. Commercially acceptable control cannot be achieved immediately, therefore, such a program should be initiated as soon as the trees are transplanted. Refuges as a source of parasitoids / predators are essential and without such refuges the establishment of biocontrol agents would be even harder. Since, the program is not based on the availability of any particular insecticide/acaricide it offers a lot of flexibility to the investigators.

References


Horticultural performance, soil quality, and orchard profitability of integrated, organic, and conventional apple production systems

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Abstract: The objectives of this study are to assess the effects of integrated, organic, and conventional apple (Malus x domestica Borkh. ‘Golden Delicious’) production systems on horticultural performance, soil quality, and orchard profitability. The 1.7 hectare study site is part of a 20 hectare commercial orchard in Washington state, USA, and is comprised of four replicate plots of each of the three treatments planted in 1994. Organic soil management practices have included additions of composted poultry manure and bark mulches and the use of mechanical tillage for weed control. Conventional soil management practices have included synthetic fertilizers and the use of herbicides for weed control in all years. The integrated treatment has utilized a combination of organic and conventional practices. Tree growth has been similar for all three treatments following a slight growth lag in the organic trees in the first year of orchard establishment. Fruit yield was slightly higher in the organic treatment in 1997 and 1998 than yields in the integrated and conventional treatments, which were similar. However, size of organic fruit in 1998 was significantly smaller than integrated and conventional fruit. Higher fruit densities per tree and typically drier soils in the organic treatment may be responsible for the significantly smaller organic fruit. Generally, organic fruit was as firmer or firmer than fruit from the other systems and had lower nitrogen content. Assessment of soil quality in 1998 and 1999 indicated that the integrated and organic production systems maintained higher soil quality than did the conventional system (Glover et al., 2000b). All three systems were not profitable until 1999. In comparison to the conventional system, higher production costs for the integrated and organic systems in 1994 and organic system in 1995 were largely due to differences in weed control practices.

Key words: costs, firmness, fruit, Malus x domestica, nitrogen, returns, storage, yield

Introduction

As orchard production in Washington state has intensified to meet market demands over the past decades, environmental concerns associated with conventional management practices have also increased (Williamson, 1998). These concerns have led to heightened interest in developing environmentally sound management practices.

Integrated and organic apple production systems offer alternative practices that address environmental concerns (Conacher et al., 1998; National Research Council, 1989). Organic management practices exclude synthetic chemical pesticide and fertilizer inputs and use naturally derived products as defined by organic certification programs. Integrated farming systems, successfully adopted in some of the major apple growing regions of Europe (Sansavini, 1997), utilize methods of conventional and organic production systems in an attempt to optimize both environmental quality and economic profit. Other studies have found that alternative production practices may improve soil quality as compared to conventional...
practices (Glover et al., 2000a, b; Gunapala et al., 1998; Reganold et al., 1987, 1993; Swezey et al., 1998). The purpose of our study was to compare the horticultural performance, soil quality, and orchard profitability of integrated, organic, and conventional apple production systems.

**Materials and methods**

Four 0.14 ha replicate plots of integrated, organic, and conventional production systems were planted in May 1994 in a randomized complete block design on a commercial apple (*Malus x domestica* Borkh. ‘Golden Delicious’/M.9) orchard in the Yakima Valley of Washington state, USA (latitude 46°30’N). Each plot contains four rows trained to a two wire trellis system. Trees were planted at a spacing of 1.2 m between trees and 3 m between rows (2240 trees/ha). A 2 m wide weed free strip in the tree rows was maintained for all systems according to weed management practices described later. The alleyways consist of mown turf grass. The 200 mm of annual precipitation at the site is supplemented with an under tree sprinkler irrigation system. Soil in the study area is of a sandy loam texture.

**Table 1. Nutrient and weed management practices of integrated, organic, and conventional apple production systems.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Integrated Nutrient Management</th>
<th>Organic Nutrient Management</th>
<th>Conventional Nutrient Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>50:50&lt;sup&gt;z&lt;/sup&gt;</td>
<td>Poultry compost&lt;sup&gt;z&lt;/sup&gt;</td>
<td>Ca(NO&lt;sub&gt;3&lt;/sub&gt;)&lt;sub&gt;2&lt;/sub&gt;&lt;sup&gt;z&lt;/sup&gt;</td>
</tr>
<tr>
<td>1995</td>
<td>50:50&lt;sup&gt;z&lt;/sup&gt;, 3-18-18&lt;sup&gt;y&lt;/sup&gt;, urea&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Poultry compost&lt;sup&gt;z&lt;/sup&gt;</td>
<td>Ca(NO&lt;sub&gt;3&lt;/sub&gt;)&lt;sub&gt;2&lt;/sub&gt;, 3-18-18&lt;sup&gt;y&lt;/sup&gt;, urea&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>1996</td>
<td>3-18-18, Ca, B, Zn, SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Ca, B, Zn, SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;y&lt;/sup&gt;</td>
<td>3-18-18, Ca, B, Zn, SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>1997</td>
<td>3-18-18, Ca, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Ca&lt;sup&gt;y&lt;/sup&gt;</td>
<td>3-18-18, Ca, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>1998</td>
<td>3-18-18, Ca, B, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Ca, B&lt;sup&gt;y&lt;/sup&gt;</td>
<td>3-18-18, Ca, B, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>1999</td>
<td>3-18-18, Ca, B, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
<td>Ca, B&lt;sup&gt;y&lt;/sup&gt;</td>
<td>3-18-18, Ca, B, Zn&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Integrated Weed Management</th>
<th>Organic Weed Management</th>
<th>Conventional Weed Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>Bark mulch, glyphosate</td>
<td>Bark mulch</td>
<td>Glyphosate</td>
</tr>
<tr>
<td>1995</td>
<td>Bark mulch, glyphosate</td>
<td>Bark mulch</td>
<td>Glyphosate</td>
</tr>
<tr>
<td>1996</td>
<td>Glyphosate</td>
<td>Woven fabric mulch</td>
<td>Glyphosate, simazine</td>
</tr>
<tr>
<td>1997</td>
<td>Glyphosate</td>
<td>Woven fabric mulch</td>
<td>Glyphosate, simazine</td>
</tr>
<tr>
<td>1998</td>
<td>Glyphosate</td>
<td>Cultivation</td>
<td>Glyphosate, simazine</td>
</tr>
<tr>
<td>1999</td>
<td>Glyphosate</td>
<td>Cultivation</td>
<td>Glyphosate, simazine</td>
</tr>
</tbody>
</table>

<sup>z</sup>Ground application totally 29 kg N/ha. <sup>y</sup>Foliar applications

Organic production practices included bark mulch and landscape fabric for weed control in 1994-96 and cultivation in the 1997-99 growing seasons (Table 1). Nutrients for the organic system were supplied in the form of composted poultry manure and as organically certified foliar sprays. Certified biological pest control methods were also used in the organic system. Conventional production practices included synthetic soil and foliar fertilizer
applications and chemical control of weeds. The integrated production system included some practices from the organic and conventional production systems that were deemed to be profitable and environmentally sound. Nutrients for the integrated system were supplied partly as composted poultry manure and partly as synthetic fertilizer. Pest management practices were identical in both the integrated and conventional systems, and included pheromone mating disruption to control codling moth (*Cydia pomonella*). Flower and fruit thinning was by hand in the organic system and with chemicals in the conventional and integrated systems.

Unit tree growth was estimated each year during the dormant season as trunk cross sectional area (TCSA) measured 20 cm above the graft union. Yields and fruit size (average mass) were recorded at harvest in 1995-1999. Crop densities were calculated as number of fruit per TCSA of each tree. Fruit firmness was analyzed according to standard procedures (Apple Maturity Program Handbook, 1986) at harvest and after three and six months of controlled atmosphere (CA), refrigerated storage in 1999. For plant tissue analyses, random pooled samples of mid shoot leaves and uniformly sized fruit were collected from each plot annually in midsummer (leaves) or three weeks prior to expected harvest (fruit). Leaf and fruit mineral contents were determined according to standard methods (Gavlak et al., 1994).

Soil samples for measurement of physical, chemical, and biological properties and calculation of the soil quality index were taken from 0-7.5 cm and 7.5-15 cm depths from each of the designated plots as previously reported (Glover et al., 2000a, b). These samples, and those taken prior to implementation of the treatment production systems, were collected each May midway between trees within the tree rows. Analyses of the pre treatment soil samples revealed no differences in physical, chemical, or biological soil properties among plots at planting (Hopkins-Clark, 1995). To minimize edge effects, all horticultural and soil measurements and samples were taken from the interior of the middle two rows of each plot.

Gross receipts were calculated using farmgate prices paid by packing houses to farmers for apples sold at harvest or after storage. Prices for the specific size, grade, and firmness of ‘Golden Delicious’ organic and conventional apples from our study were based on prices from *Washington Growers Clearing House Bulletins* and fruit packing houses in Washington State. Receipts for the organic system were estimated using prices for conventionally produced fruit in the first three years (1994-1996), the number of years necessary to transition from conventional to certified organic. The farmgate price premium used for fresh and processed organic apples in 1997-1999 averaged 50% above conventional market prices. Receipts for the integrated system were estimated using prices for conventionally produced fruit, since unlike organic fruit there was no price premium for integrated fruit. Total costs included non harvest variable costs (fertilizers, pesticides, fuel, labor, and water), harvest variable costs (picking, grading, packing, and storage), and fixed costs (machinery, interest, and taxes). Net returns were calculated as gross receipts minus total costs. Projected returns for 2000 and beyond were estimated from average fruit sizes (1998-1999) and yields (1997-1999) for each treatment, assuming a 15% cullage rate for all three treatments and a 50% price premium for organic fruit.

**Results and discussion**

Tree growth was similar in all three systems, except that trees in the organic system were slightly smaller than trees in both the integrated and conventional systems in 1995 and than trees in the integrated system in 1996 (Table 2). During these first two years, the tree rows in the organic plots were mulched with bark chips, which in other research has been found to have either no effect on or to increase apple tree growth or to increase (Marsh et al., 1996;
Merwin et al., 1994; Swezey et al., 1998). Growth of weeds through the mulch may have accounted for reduced tree growth in the organic plots in our study.

Table 2. Horticultural performance of integrated, organic, and conventional apple production systems.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Trunk cross sectional area (cm²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated</td>
<td>2.3 b²</td>
<td>28.0 b</td>
<td>69.1 ab</td>
<td>65.8 ab</td>
<td>69.0 a</td>
</tr>
<tr>
<td>Organic</td>
<td>2.2 b</td>
<td>21.1 c</td>
<td>75.9 a</td>
<td>74.9 a</td>
<td>51.2 b</td>
</tr>
<tr>
<td>Conventional</td>
<td>12.0 a</td>
<td>18.5 ab</td>
<td>25.2 a</td>
<td>25.4 a</td>
<td>30.7 a</td>
</tr>
</tbody>
</table>

|                   | Fruit yields (metric tons/ha) |         |         |         |         |
| Integrated        | 2.3 b   | 28.0 b  | 69.1 ab | 65.8 ab | 69.0 a  |
| Organic           | 2.2 b   | 21.1 c  | 75.9 a  | 74.9 a  | 51.2 b  |
| Conventional      | 7.0 a   | 38.8 a  | 63.3 b  | 63.8 b  | 70.8 a  |

|                   | Mean fruit mass (g) |         |         |         |         |
| Integrated        | 238 a   | 197 a   | 184 a   | 220 a   | 193 a   |
| Organic           | 230 a   | 183 b   | 171 a   | 181 b   | 172 b   |
| Conventional      | 238 a   | 185 b   | 182 a   | 221 a   | 197 a   |

|                   | Crop density (fruit number/cm² TCSA) |         |         |         |         |
| Integrated        | 0.38 b  | 3.27 b  | 6.99 a  | 5.54 b  | 6.63 a  |
| Organic           | 0.48 b  | 3.05 b  | 8.22 a  | 7.46 a  | 5.65 b  |
| Conventional      | 1.21 a  | 5.15 b  | 6.98 a  | 5.56 b  | 7.07 a  |

²Mean separation within years by protected LSD at the 5% level.

Table 3. Fruit flesh firmness (N) of three apple production systems in 1999 immediately after harvest or after removal from three and six months controlled atmosphere (CA) storage, and seven days at 20°C in air after harvest or removal from storage.

<table>
<thead>
<tr>
<th>Time</th>
<th>Integrated</th>
<th>Organic</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Day²</td>
<td>65.4 c²</td>
<td>70.6 a</td>
<td>68.5 b</td>
</tr>
<tr>
<td>7 Days²</td>
<td>64.8 b</td>
<td>66.9 a</td>
<td>65.5 ab</td>
</tr>
<tr>
<td>3 Months CA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Day²</td>
<td>57.0 c</td>
<td>60.7 a</td>
<td>59.0 b</td>
</tr>
<tr>
<td>7 Days²</td>
<td>57.3 a</td>
<td>58.0 a</td>
<td>57.0 a</td>
</tr>
<tr>
<td>6 Months CA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Day²</td>
<td>55.1 a</td>
<td>54.8 a</td>
<td>52.4 b</td>
</tr>
<tr>
<td>7 Days²</td>
<td>54.7 ab</td>
<td>56.4 a</td>
<td>53.4 b</td>
</tr>
</tbody>
</table>

²Day following harvest or removal from storage, or 7 days later at 20°C in air.
³Mean separation within rows by protected LSD at the 5% level.
Differences in annual yields among the three systems were inconsistent (Table 2). Cumulative yields were not significantly different among the three systems (234, 225, and 244 metric tons/ha for integrated, organic, and conventional systems, respectively). Integrated fruit was the largest in 1996 and organic fruit was the smallest in 1998 and 1999 (Table 2). Crop densities were highest in the conventional system in 1995 and 1996, highest in the organic system in 1998, and lowest in the organic system in 1999 (Table 2). Swezey et al. (1998) measured as high or higher yields, but smaller fruit, in an organic apple production system as in the conventional system. In our study, smaller fruit size sometimes can be explained by higher crop densities in the production system with the smallest fruit. Swezey et al. (1998) consistently found greater fruit numbers on the organic trees to be associated with smaller fruit from this system. However, in our study in 1999, the organic trees had the lowest crop density, even though the fruit from this system was the smallest. Drier soils in the organic system in 1998 and 1999 (data not shown), as well as the less effective thinning methods available in organic systems, also may have contributed to the smaller fruit size in this system. The integrated system always had as larger or larger fruit than fruit from the other systems (Table 2). Although there were some differences in leaf nutrient contents among the three systems (data not shown), analyses indicated satisfactory levels of nutrients (Dow, 1980; Gavlak et al., 1994).

Post harvest evaluation of fruit firmness in 1999 indicated that the organic fruit were as firm or firmer than either integrated or conventional fruit the day following harvest or removal from three or six months CA storage, or after seven days at 20°C in air (Table 3). DeEll et al. (1992) found no differences in firmness between organically or conventionally grown fruit, but they did not evaluate stored fruit. The greater firmness of organic apples in our study may be associated with the lower nitrogen content of the cortical tissue in these fruit (0.3% dry weight for organic fruit versus 0.4% for integrated and conventional fruit); however, DeEll et al. (1992, 1993) did not find a relationship between fruit nitrogen content and firmness of organic and conventional apples. Nevertheless, others have reported reductions in fruit firmness and storage potential due to excess fruit nitrogen (Hipps et al., 1989; Ystaas et al., 1991). Analyses of other fruit mineral nutrients indicated inconsistent differences among the systems (data not shown).

Soil quality was significantly better in the integrated and organic systems than in the conventional system, because these production systems were better able to accommodate water entry into the soil and to resist surface structure degradation (Table 4). The organic matter added to the integrated and organic systems as compost and mulch in 1994 and 1995 (Table 1). Organic matter has a profound impact on soil quality, enhancing soil structure and fertility and increasing water infiltration and storage (Brady et al., 1999).

The organic production system had higher production costs in 1995 and 1997, but lower production costs in 1999 (Table 5). The three systems did not show a net annual profit until 1999, but the organic system lost less money than either the conventional or integrated systems in 1997 and 1998. The breakeven point, when cumulative net returns equal cumulative costs, is projected to be in 2002 (9 years after planting) for the organic system, but in 2008 for the conventional system and in 2010 for the integrated system. The earlier breakeven point and thus higher profitability of the organic system was due to the price premiums received for organic fruit, whether sold fresh or for processing. The later breakeven point and thus lower profitability of the integrated system was due to high production costs in the first year because of the additional costs of compost and mulch. Swezey et al. (1998) found higher total costs for an organic system than for a conventional system, due to higher costs for labor, field power, materials, and interest. Nevertheless, they reported that the organic system had higher net returns than the conventional system due to the price premiums
for organic fruit. Our total costs in 1999 (at full production) were much higher than those they reported, probably because of the added costs of weed control, fruit thinning, and tree training in our high density system. Nevertheless, net returns in 1999 for our organic system are similar to those reported by Swezey et al. (1998).

Table 4. Soil quality index ratings for integrated, organic, and conventional apple production systems in 1998 and 1999. A total soil quality index of 1.0 represents optimal soil conditions.

<table>
<thead>
<tr>
<th>Soil quality functions</th>
<th>Integrated</th>
<th>Organic</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodate water entry^</td>
<td>0.23 a^</td>
<td>0.21 a</td>
<td>0.16 b</td>
</tr>
<tr>
<td>Facilitate water movement &amp; availability</td>
<td>0.24 a</td>
<td>0.21 b</td>
<td>0.21 b</td>
</tr>
<tr>
<td>Resist surface structure degradation</td>
<td>0.24 a</td>
<td>0.23 ab</td>
<td>0.19 a</td>
</tr>
<tr>
<td>Sustain fruit quality &amp; productivity</td>
<td>0.21 b</td>
<td>0.24 a</td>
<td>0.23 ab</td>
</tr>
<tr>
<td>Soil Quality Index Rating (total)</td>
<td>0.92 a</td>
<td>0.88 a</td>
<td>0.78 b</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodate water entry</td>
<td>0.20 ab</td>
<td>0.21 a</td>
<td>0.16 b</td>
</tr>
<tr>
<td>Facilitate water movement &amp; availability</td>
<td>0.20 a</td>
<td>0.19 a</td>
<td>0.18 a</td>
</tr>
<tr>
<td>Resist surface structure degradation</td>
<td>0.21 a</td>
<td>0.21 a</td>
<td>0.15 b</td>
</tr>
<tr>
<td>Sustain fruit quality &amp; productivity</td>
<td>0.21 a</td>
<td>0.22 a</td>
<td>0.21 a</td>
</tr>
<tr>
<td>Soil Quality Index Rating (total)</td>
<td>0.81 a</td>
<td>0.83 a</td>
<td>0.70 b</td>
</tr>
</tbody>
</table>

^Soil quality functions were each assigned equal weights of 0.25 and were calculated based on soil indicator properties analyzed and normalized to a maximum of 1.0.

Table 5. Total costs and net returns of integrated (Int), organic (Org), and conventional (Con) apple production systems.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total costs ($US/ha)</th>
<th>Net returns ($US/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Int</td>
<td>Org</td>
</tr>
<tr>
<td>1994</td>
<td>23740^</td>
<td>23486</td>
</tr>
<tr>
<td>1995</td>
<td>9381 b</td>
<td>12242 a</td>
</tr>
<tr>
<td>1996</td>
<td>12074 a</td>
<td>11608 b</td>
</tr>
<tr>
<td>1997</td>
<td>15947 b</td>
<td>17788 a</td>
</tr>
<tr>
<td>1998</td>
<td>17906 a</td>
<td>19074 a</td>
</tr>
<tr>
<td>1999</td>
<td>20011 ab</td>
<td>18714 b</td>
</tr>
</tbody>
</table>

^No statistics were generated for 1994 because costs were the same for each replicate.

^Mean separation for total costs or net returns within rows was by protected LSD at the 5% level.

In 1995-1997, all fruit produced from the three systems was sold for processing because it was downgraded due to skin russetting. The low landscape position of the experimental site
in the orchard resulted in early season cool, humid conditions that contributed to fruit russetting. In 1998 and 1999, marketable fruit not graded as Washington Extra Fancy or Fancy was sold for processing.

Our results show that integrated and organic apple production systems are better for the soil than a conventional production system, but only the organic fruit showed improvements in fruit quality. Clearly, the organic system is the most profitable because it breaks even earlier. In the U.S. this is due to the economic incentives (price premiums) that value the external benefits to the environment that the organic system provides. At this time, no comparable economic incentives are available for integrated fruit.

Acknowledgments

We thank the farmers A. and E. Dolph for the use of their farm and Dr. J.R. Powers for conducting the sensory panel evaluations. We gratefully acknowledge funding from the U.S.D.A. Agricultural Systems Program.

References


Effects of treatments with strong electrolysed water and an organic extract with minerals on fruit quality of mandarins – a field trial

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Abstract: Satsuma mandarin trees were sprayed with electrolysed strong acidic water, an organic extract with minerals and a mixture of both. pH of juice was lower in fruits of the combined treatment.

Key words: citrus, wood vinegar, brown sugar, electrolysed water, acidity

Introduction

Electrolysed acid water is known for its fungicidal effects and there are some examples of its successful use, mainly against fungi on the plant surface like powdery mildew. It is also said, that spraying with a mixture of wood vinegar and brown sugar enhances inner quality. Treatment with electrolysed water is a relatively new method, whereas the use of organic extracts has a long history.

Material and methods

Strong electrolysed water
Tap water enriched with a salt solution, here KCl, is electrolysed. In this experiment waters have been generated. Acidic electrolysed water was used.

Table 1: Characteristics of electrolysed water

<table>
<thead>
<tr>
<th>Strong acidic electrolysed water</th>
<th>Strong alkaline electrolysed water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &lt; 2.5</td>
<td>pH &gt; 10.5</td>
</tr>
<tr>
<td>ORP &gt; 1050 mV</td>
<td>ORP &lt; -800mV</td>
</tr>
<tr>
<td>total chlorine: ca. 25 ppm</td>
<td></td>
</tr>
</tbody>
</table>

Wood Vinegar and brown sugar mixture
The mixture consists of a fermented fluid of brown sugar, water, soybeans and enzymes, wood vinegar and is enriched with several minerals.

Experimental design
Four scaffold branches of four Citrus unshiu cv “Aoshima” trees have been used. Four treatments were conducted at every tree, choosing four branches of different direction for each treatment, the trees representing the four replications. The branches were sprayed twice, two and four weeks before harvest.
Treatments were:
1. Spraying with acidic electrolysed water
2. Spraying with a mixture of wood vinegar, brown sugar, minerals
3. Spraying with the mixture of 2, but diluting with acidic electrolysed water instead of tap water. Concentration of the extract is the same as in 2.
4. Untreated control

After harvest, Brix and pH of the mandarin juice were measured.

**Results and discussion**

No differences concerning plant or fruit diseases could be observed. Average soluble solids contents were about 10.4 to 10.7 Brix for the four treatments and there were no statistically significant differences. pH of juice was lowest in the combined treatment with acidic water and the wood vinegar / brown sugar mixture (Figure 1).

In order to verify the effect and to separate several factor’s influences, more research will be necessary.

![Figure 1: Influence of spraying electrolyzed water and extracts on pH of juice](image)

**Acknowledgements**

Thanks to Yoshinori Hayatoh and Hayatoh Orchard, Yugawara..

**References**


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Volume rate adjustment in apple trellising in the Upper Valley of Río Negro, Argentina

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2 Cátedra de Mecanización Agraría, Universidad Nacional del Comahue, Argentina

Abstract: The model known as TRV has been widely spread in Río Negro, Argentina, as a way to determine the volume rate in l/ha adjusted to the characteristics of the apple trees. This model was adjusted in orchards with free training systems; for this reason, there is no regional information available to back up its use in trellis training systems. The aim of this task was to set the adequate volume rate in a trellis trained orchard, through the determination of the effectiveness of Cydia pomonella (L.) (Lepidoptera: Tortricidae) control, and the deposit of a fluorescent dye. The treatments were: 1) 2400 l/ha; 2) 1730 l/ha; 3) 2100 l/ha (calculated by the TRV concept). The aspects evaluated were the effectiveness of C. pomonella control with an application of Azinphos Methyl (90 g/hl), and the uniformity of the distribution with a fluorescent dye (fluorescein sodium 10 g/hl). In both cases, by keeping the concentration steady, the dose was increased with the volume rate. In all treatments, a higher amount of deposits of the fluorescent dye could be observed in the external side of the tree, in comparison with the internal side in areas close to the sprayer, C. pomonella control and amounts of residues of the fluorescent dye were independent of the volume rate. This topic higher than those calculated through the TRV concept (2100 l/ha.) did not increase the effectiveness of C. pomonella control; on the contrary, they increased costs and environmental pollution. The TRV concept proved its capability to calculate the volume rate in apple fruit trees with trellis training systems.

Key words: application rate, tree-row-volume, orchard sprayers

Introduction

Errors in dosage that may entail phytotoxicity problems, death of beneficial fauna, increase residues in harvest fruit or, on the contrary, lead to poor pest control and risk of appearance of resistant forms, are nowadays definitely unacceptable.

The model known as TRV has been widely used in the Rio Negro Valley region, in Argentina, as a way to determine the volume rate in l/ha, adjusted to the characteristics of the crop (Cichon & Magdalena, 1992).

The limitations of the equipment for a correct application, together with other physical, biological or environmental variables, affect the effectiveness of the treatment. Even though the TRV method does not consider them, it is an excellent tool for growers (Sutton et al, 1984).

When defining the application rate, special attention must be given to the upper and inner part of the canopy, since locations closer to the sprayer machine do not generally show any problems in the amount of deposits. (Travis et al, 1987 a, Travis et al, 1987 b, Magdalena et al, 1996.)

The aim of this trial was to set the adequate volume rate in a trellis orchard, through the determination of the efficacy of Cydia pomonella (L) control.
Materials and methods

The field experiment was carried out in an apple orchard, with Chañar 28 trees, planted at 4 x 4 m, and trained as a trellising. The trees were 4.5 m high and 2.2 m wide. Based on the TRV method (Magdalena et al, 1995) the rate of application resulted in 2,100 l/ha.

Spraying equipment was an air blast sprayer with an axial fan. The pressure applied was 2,068.50 kPa (300 PSI) and the advance speed was 4.7 km/h. Both factors were kept steady for all the treatments, so as to avoid new variation sources.

Three treatments with three replications were considered for this trial:

1) 2,400 l/ha  
2) 1,730 l/ha  
3) 2,100 l/ha

The product used was Azinphos Methyl, with a concentration of 90 cm³/hl for all the treatments, resulting in a different dosage, depending on the volume rate applied.

To carry out this experiment, nozzles and swirl plates were replaced. Atmospheric conditions – Temperature: 15°C; Relative humidity: 80% and Calm wind.

The efficacy of *C. pomonella* control was evaluated with an application of Azinphos Methyl (90 g/hl). The biological trial used as response variables the pest mortality rate on the 7th and 15th day. At the same time, uniformity of coverage was also evaluated, using as a response variable the deposits of a fluorescent tracer dye (Natrisol Sodium) applied at 10 g/hl per leaf surface unit.

Both assessments were carried out simultaneously; for this reason, the tracer dye and the pesticide were diluted in the same tank. Compatibility of both reagents had been previously tested.

Fifteen leaves were collected from each plant (block) at three different heights (I: 1.5 m; II: 3 m; III: 4.5 m) and from the outside and inner part of the canopy (sub-blocks).

The samples were washed with distilled water to remove the deposits of the fluorescent tracer dye. The concentration of the tracer dye was measured with a fluorimeter, and the leaf surface was determined with an optical foliar surface meter. Deposits were expressed in µg/cm².

For the biological trial, five fruits were harvested per sub-block, on the 7th and 15th day after the application, at two different heights (1.5 y 4 m) and from the inner and outside part of the canopy, with a total of 20 fruits per plant (block). In the laboratory, the samples were inoculated with two *Cydia pomonella* (L) neonate larvae. The presence of living larvae was evaluated four days after inoculation. Mortality percentage was calculated using the Abbot formula.

Results and discussion

Distribution

As shown in Figure 1, at height I treatments are not significantly different among them, although deposits found in the outside part of the canopy were greater than those found in inner locations.

In numerous trials on the subject, it has been observed that in areas of the tree closer to the sprayer machine the concentration of deposits is higher (Travis et al, 1987a; Travis et al, 1987b; Magdalena et al, 1996).

At height II, a higher level of deposits was detected in treatment I (2,400 l/ha), followed by treatment 3 (2,100 l/ha). However, no differences were detected at different depths of the canopy in any of the treatments.
Figure 1. Distribution of deposits in the canopy at three heights (bottom 1.5 m; middle 3 m; upper 4.5 m) and two depths (outer and inner)

At the upper part of the tree, differences were also found, with the similar trend observed at height II, although at this part of the canopy, deposits found in the external part were significantly higher than those found in inner locations.

Higher volume treatments (1 and 3) show better uniformity in the distribution of deposits in all the portions of the tree, while lower volume treatments (2) show a decrease in the distribution of deposits when increasing height.
**Insecticide efficacy of the treatments**

One week after the application, no significant differences were detected among the treatments, in any portion of the canopy.

Fifteen days after the application, differences were detected among treatments and at different depths in the canopy. Higher volume treatments – either higher than the TRV method or adjusted by the TRV method – are similar, resulting in a better pest control than treatments with volume rate below TRV. (Table 1). The reason for this is probably the more uniform coverage obtained from treatments 1 and 3.

The absence of differences in pest control in treatments with higher volumes probes that it is unnecessary to increase the application rate over the value calculated through the TRV concept.

On the other hand, treatments with application volumes below the TRV method show a lower efficacy in the upper part of the canopy, 15 days after the application.

The results probe that higher concentrations of deposits do not always entail better pest control. Increasing the efficiency of distribution would result in savings in agrochemicals, without reducing efficacy of control.

![Figure 2. Effectiveness of Azinphos Methyl on C. pomonella control 15 days after the application.](image)

Table 1: Efficacy of *C. pomonella* control 15 days after application.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mortality %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>76.39 a</td>
</tr>
<tr>
<td>1</td>
<td>73.36 a</td>
</tr>
<tr>
<td>2</td>
<td>56.78 b</td>
</tr>
</tbody>
</table>

**Conclusions**

In areas closer to the sprayer machine, pest control and the amount of residues are independent of the volume rate.
The TRV concept confirms its capability to calculate the volume rate in pome fruit trees. Higher application rates do not increase the efficacy of *C. pomonella* control, but contribute to an increase in costs and environmental pollution.

**References**


Label concept for untreated fruits

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Abstract: A novel concept is proposed which encourages farmers to produce untreated fruits. All cultural and biological measures would be applied to minimize the need of treatments. In some years and in some orchards, the conditions could permit omission of all treatments, or at least treatments between bloom and harvest. Fruit growers should benefit from this luck and sell this product with a special label. The largest obstacle to implementation of this idea is the probability of overcoming resistance of apple varieties to apple scab and possible secondary pests and diseases.

Key words: future, integrated fruit production, pesticides

Integrated Fruit Production (IFP) in Switzerland has become a victim of its own success. The number of treatments are reduced, more selective pesticides are used and cultural practices are better adapted; Swiss fruit production has become more ecological. Because more than 85% of Swiss fruits are produced according to IFP guidelines, IFP has become the norm.

“How can I make a difference on the market?” some fruit growers are certainly asking. Many consumers are untouched by the relatively complex message of IFP and don’t follow the philosophy of organic farming. They simply demand “food without pesticides”. In this context, it is permitted to dream and to try new approaches. A group of pioneers could rise to the challenge and produce untreated fruits and sell it with a new UTF label.

It is not necessary to fundamentally change the way fruits are produced. The grower would continue to treat if required, but if he has the luck in one orchard to end a season without treatment, he should profit from the high demand of this product. If all cultural and biological measures at hand are applied, it could, under optimal conditions be possible to omit all treatments. However, this type of apple production necessarily has some requirements such as use of scab resistant varieties, biological control of spider mites, mating disruption of codling moth, and varieties not requiring chemical fruit thinning.

To improve the chance of success, the no treatment constraint could be relaxed and limited to no treatment between bloom and harvest. To prevent residue problems only fast degrading products should be used before bloom. For example, a management strategy against apple pests and diseases could be:

Pests:
- Codling moth: mating disruption, attract and kill, virus
- Summer fruit tortrix: treatment before bloom, virus
- Anthonomus: treatment before bloom/accept
- Rosy apple aphid: treatment before bloom
- Scales: winter treatment
- Spider mites: biological control, winter treatment
- Sawfly, small fruit tortrix, woolly apple aphid: treat/accept
Diseases:
- Dry climate
- Scab: resistant varieties
- Mildew: resistant varieties/accept
- Monilia, storage diseases: accept

Even if all these problems are resolved, particular conditions favorable to pest and disease development, unforeseeable problems, or problems due to human errors could require treatments during the growing season. In this case the label UTF would be denied, but the harvest could be sold through traditional IFP channels. Obviously, all previous treatments would have to comply with IFP requirements.

Inspection of UTF compliance would mostly be based on residue testing during the season. This approach promises to be simpler and more reliable than current IFP inspections based on agricultural practice diaries.

These propositions certainly are followed by difficult questions. Does there exist a durable anti-resistance strategy to protect apple varieties resistant against apple scab? Will secondary pests and diseases make new treatments necessary? What is the probability of producing untreated fruits? Will the market compensate the grower’s efforts with a higher price?

An important weakness of UTF would be the unpredictability of its harvest, which is unacceptable for supermarkets. It is therefore in the beginning necessarily limited to a small market. Baby food producers would be interested in UTF. Their residue requirements are very strict and they accept more freely harvest fluctuations.

Nevertheless, UTF would also have its strengths. It would be based on recent progress in chemistry and transgenics. The coexistence of UTF and IFP (or organic farming) on the same farm would be possible. The message to consumers would be simple and credible: untreated fruits. Not even organic farming can make this claim.

May these thoughts contribute to the debate on the future of IFP!