Organic Fruit Production in Humid Climates of Europe: Bottlenecks and New Approaches in Disease and Pest Control

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Keywords: apple, cherry, organic, cultivar, scab, brown rot

Abstract

The organic market has grown exponentially in Europe during the last ten years. However, the organic fruit industry has shown the lowest growth rates (1-5% market share) compared to other commodities. One major reason is the high production risk due to high disease and pest pressure in humid climates. Key pests and diseases in apple and pear include scab, sooty blotch, and fire blight as well as rosy apple aphid, pear sucker, and codling moth. In cherry, damages due to brown rot (*Monilinia)* and the cherry fruit fly make organic production almost unfeasible. In an ideal organic system, all possible measures that lead to improved stability of the system must be implemented. In fruit production, such measures include (i) use of resistant varieties (scab), (ii) active promotion of predators (rosy apple aphid), (iii) sanitation (cherry monilinia), (iv) microclimate management (planting density, covering trees), and (v) strengthening the plant self-defence system (e.g. building up of soil fertility, bio-dynamic preparations). At present, most organic orchards have been designed for conventional production and, therefore, lack most stabilising components. In consequence, organic fruit production still depends largely on direct pest and disease control methods. These include traditional pesticides such as copper, sulphur, and lime sulphur, pyrethrin, oil and soap preparations. More recently, new pest control compounds and techniques have been developed including neem products, granulosis virus, and mating disruption. New tools for disease control are less spectacular and focus on the replacement of copper (e.g. with clay powders and resistance inducers). The introduction of new equipment, materials, and Decision Support Systems (DSS) will further improve yield stability. However, other limiting factors such as weed competition, crop load regulation, and conventional market demands need innovative solutions.

INTRODUCTION

The organic market has grown exponentially in Europe during the last decade. However, organic fruit production has not kept pace with market growth despite the growing interest of consumers (Hamm et al., 2002). Pest and disease management, including the management of 'novel' noxious organisms such as fire blight, is the key bottleneck hindering growth of the organic fruit industry in Europe's humid climates. As a result of the high production risks conventional fruit growers are hesitant to convert their farms to organic production. Further bottlenecks include increasingly strict standards for exterior fruit quality and the growing difficulty in development and registration of pesticides acceptable for organic farming (Tamm, 2000).

This paper aims to identify some key pests and diseases in organic apple (*Malus x domestica)*, pear *(Pyrus communis)*, and cherry *(Prunus avium)* production and to discuss the current control strategies as well as the potential of novel techniques.

Bottlenecks and Current Crop Protection Strategies

Crop protection materials that are compatible with organic standards tend to be less efficient than modern synthetic pesticides. Formulas approved for organic production are often efficient at low disease pressure, but may be much less efficient under high

Proc. XXVI IHC – Sustainability of Horticultural Systems
Eds. L. Bertschinger and J.D. Anderson
Acta Hort. 638, ISHS 2004
Publication supported by Can. Int. Dev. Agency (CIDA)

disease pressure when compared to conventional materials (Tamm, 2000). The functional relationship between efficacy and disease pressure shows a massive gap between synthetic pesticides and those available for organic production in high pressure situations (Fig. 1). In consequence, all techniques that lead to a reduction of disease/pest pressure should be exploited. Such techniques include sanitation, avoidance, variety choice and mixtures, intercropping, soil management, and refined indirect and direct crop protection techniques. The applicability of preventive control strategies depends on the host/noxious organism combination and often finds its practical limits due to costs and/or tradition. Key pests and diseases, current control strategies, and efficacy of the controls are listed in Table 1.

Apple Production

1. Apple Scab (*Venturia inaequalis*): Stabilisation of the agro-ecosystem is considered the single most important strategy to prevent massive outbreaks of pests or diseases (Altieri, 1994; Wyss & Tamm, 1996). In apple production, the use of scab resistant varieties has become a realistic option, since novel varieties that meet the requirements of growers, processors and consumers are available. However, the time needed for the introduction of novel varieties to the market as well as the high investments needed for replanting are prohibitive for a rapid replacement of susceptible varieties on individual farms. Furthermore, conventional farms are most often planted with highly susceptible standard varieties. In consequence, strategies for scab control on highly susceptible varieties are needed to ensure economically viable apple production. The use of scab resistant varieties on organic farms has lead to much less intensive spray programs. However, pathogens of secondary importance such as sooty blotch may increase and may cause serious crop losses in some regions. The occurrence of ‘new’ pests and diseases such as fire blight may eliminate all benefits of a scab resistant variety.

Susceptible apple cultivars have to be protected by fungicide sprays against scab. Traditionally, copper sprays are used in spring until near bloom. After bloom, sulphur or lime sulphur is used to control scab during warm periods. For more than a decade, the development of alternatives to copper and sulphur has been a leading goal for both public and industry researchers. So far, acidified clay preparations (in combination with sulphur) are the only alternatives with proven efficacy. Other novel substances on the market are often not efficient enough to provide adequate protection against scab (Fig. 2). Novel techniques include the use of DSS such as RIMpro to improve the timing of sprays. The removal of leaves has been shown to reduce the primary inoculum and contributes to a significant reduction of disease pressure. However, this approach is not yet widely used, as the technical problems are not yet sufficiently solved.

2. Powdery Mildew (*Podosphaera leucotricha*) is sufficiently controlled by the regular scab control provided if sulphur is included. Scab-resistant varieties are often prone to powdery mildew attack. In consequence, a minimal spraying program may be necessary.

3. Fire Blight (*Erwinia amylovora*) causes high damages throughout Europe. As antibiotics such as streptomycin are not allowed in European organic farming, alternatives have been studied. So far, acidified clay preparations and commercialized antagonists such as *Bacillus subtilis* are available for fire blight control.

4. Sooty Blotch and Fly Speck (*complex of causal organisms)* have dramatically increased in the last decade. The most prominent outbreaks occur in orchards with scab-resistant varieties. Coconut soap and lime sulphur have shown efficacy against this disease complex and coconut soap is allowed in several countries for sooty blotch control. However, there have been reports of insufficient efficacy of coconut soap. Investigations in Germany and Switzerland showed that timing of sprays (Fuchs et al., 2002) and, even more important, the quality of the application is crucial for sooty blotch control. Coconut soap (1%) applied by knapsack sprayer was highly efficient whereas almost no protection was achieved when applied at the same time and rate by regular farmer spraying equipment. Further inquiries suggest that modern application equipment is often not designed to deliver the high amounts of water necessary for a good wetting of the fruit.

Results from variety trials suggest that the susceptibility differs substantially between cultivars. Therefore, selection of varieties should probably also include sooty blotch susceptibility.

5. Rosy Apple Aphid (*Dysaphis plantaginea*) is one of the most important pests, which may be prohibitive to organic apple production if not controlled. The introduction of wild flower strips does increase predator populations and, as a result, substantially decrease the number of rosy apple aphids (Fig. 4) (Wyss, 1995; Wyss, 1997). In practice, wild flower strips are implemented along orchard borders in order to limit mouse habitat. Under high pressure conditions, the increased predator populations may not sufficiently control the rosy aphid. In this case neem seed extract based insecticides are currently used in several countries to control rosy aphid populations. Recent research suggests that improved control can be obtained by insecticide application in autumn.

Other **aphids** do not often cause serious damage. However, if populations exceed an economic threshold, pyrethrin, rotenone, or fatty acid preparations are applied.

6. Codling Moth (*Cydia pomella*) **and Winter Moth** (*Operophthera brumata*) would cause very important crop losses if not controlled. Treatment with granulosis virus products, alone or in combination with mating disruption, allows for a highly efficient and selective control of the codling moth. In some European countries *Bacillus thuringiensis* is used to treat the codling moth. Recently, however, codling moth populations display prolonged flight periods requiring repeated sprays for sufficient control. *B. thuringiensis* products are frequently used to efficiently control the winter moth in spring.

7. Apple Saw Fly (*Hoplocampa testudinae*) may cause serious damage depending on region and year. Apple saw fly is efficiently controlled by quassia extract although the efficacy is not always sufficient for control. The crucial point for an efficient control is the very exact timing of the quassia application just after blossom.

8. Apple Blossom Weevil (*Anthonomus pomorum*) causes locally serious problems in high intensity orchards. Currently, pyrethrin and rotenone are used for control, despite the deleterious side effects of these products. However, rotenone is not widely used anymore Recent research programs show that spinosad based products may represent an improved alternative, providing better efficacy and lower environmental impact. However, registration of spinosad in organic apple production is still pending.

Pear Production

1. Pear Scab (*Venturia pyrina*) causes dramatic losses on pears in some areas of Europe. As pear scab is active at low temperatures, only copper treatments give adequate protection.

2. Psyllids (*Psylla pyri, P. pyricola, P. pyrisuga*) are prohibitive for pear production in some regions in Europe. So far, pyrethrin has been used for psyllid control although the efficacy is unsatisfactory. Recent research suggests that kaolin based preparations may give superior pest control.

Cherry Production

1. Cherry Brown Rot (*Monilinia laxa, M. fructigena*) causes dramatic losses in European cherry production (Tamm, 1995). In some regions organic cherry production is almost impossible because all attempts to control Monilinia with fungicide applications have failed. However, sanitation (i.e. removal of overwintering fruit mummies) may decrease the primary inoculum and the subsequent spread of the epidemic substantially (Fig. 5). Avoiding wet conditions which are conducive to infection is a very efficient approach to prevent fruit rot. Recent research suggests that covering trees by means of plastic tents may almost completely prevent fruit rot and split due to rainfall. The use of robust varieties is a valid alternative provided that consumer preferences (fruit size and firmness) are acknowledged.

2. Cherry Fruit Fly (*Rhagoletis cerasi*) is the single most important pest of cherry and may cause total crop loss in some years. Presently there is no direct control available for organic production. Traps have been used to decrease fly populations but this technique has proven to be insufficient under high population pressure. Novel approaches include improved attractiveness of traps, the ‘attract and kill’ approach, and biocontrol solutions (nematodes). However, none of the new techniques has been registered so far.

CONCLUSIONS

The use of available preventive techniques e.g. variety selection, functional biodiversity, or sanitation that stabilize the agro-ecosystem is a prerequisite for successful organic fruit production. Alternative pesticides cannot replace the use of such preventive methods since the efficacy rates of these compounds will often be low when pest/disease pressure is high.

In organic farming, the use of pesticides is regulated by both, governmental and non-governmental entities. Approved pesticide material lists are available in the annexes of guidelines for organic farming including the International Federation of Organic Movements (IFOAM) Basic Standards or the EU-Regulation 2092/91 (EU, 1991). Within Europe, criteria for registration of materials is not standard at the national level and this has led to differences in availability of compounds between individual countries. Copper, for instance, may not be used in Scandinavian countries and the Netherlands while other countries allow restricted amounts of copper per year. Granulosis virus products are registered in all countries, except Denmark and Sweden. In addition to this, more and more hurdles for registration at the EU and national levels, make it difficult for companies to develop and commercialise novel crop protection products for minor crops and for the still relatively small organic sector.

Apart from traditional and novel pests and diseases, man-made hurdles will increase the farmer’s dependency on efficient crop protection strategies. Such hurdles include (i) the increasing demand for exterior quality, (ii) prohibition of traditionally used crop protection compounds, and (iii) the increasing difficulty to register novel and safer compounds.

ACKNOWLEDGEMENTS

We thank Dr. David Granatstein for his useful comments and the help in improving the English of the manuscript. We also thank our colleagues in the EUGROF (European Group of Researchers in Organic Fruit Growing for providing insights in organic production systems throughout Europe. Much of the experimental field work presented in this paper have been conducted in commercial farms. We wish to thank Christoph Meili, Ernst Bader, and Daniel Pfander.

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Tables

Table 1. Importance of pests and diseases and current crop protection strategies in organic farming in humid climates.

Crop	Pest/disease	Importance	Current strategy	Efficacy of current strategy	Losses on farm	Novel strategies
Apple	Scab	xxxxx	resistant varieties, copper, sulphur, lime sulphur, acidified clay preparations	xxxx	x-xxxxx	DSS based spraying
	Powdery mildew	xx	sulphur	xxx	xx	
	Fire blight	x -xxxxx	acidified clay preparations, biocontrol agents	x-xxx	x-xxxxx	
	Sooty blotch, Fly speck	xxxx	coconut soap, lime sulphur	xxx	x-xxxxx	
	Rosy apple aphid	xxxxx	wildflower? weed strip-management, neem seed extract	xxxxx	x	application in autumn
	Codling moth	xxxxx	mating disruption, granulosis virus, *B. thuringiensis*	xxxx	x	
	Winter moth	xxx	*B. thuringiensis*	xxxx	x-xx	
	Apple sawfly	xxx	quassia	xxx	xxx	
	Apple blossom weevil	xxx	pyrethrin, rotenone	xx	x-xxx	spinosad
	Aphids	xx	pyrethrin, rotenone, fatty acids	xxx	xx	
Pear	Scab	x-xxxx	copper, sulphur, lime sulphur	xxx	xx	
	Psyllids	x-xxxxx	pyrethrum	xx	xx-xxxx	kaolin
Cherry	Monilinia rot	xxxx	sanitation, coverage	x-xxxxx	x-xxxxx	
	Cherry fruit fly	xxxxx	traps	xx	x-xxxxx	attract & kill nematodes? spinosad?

Figures

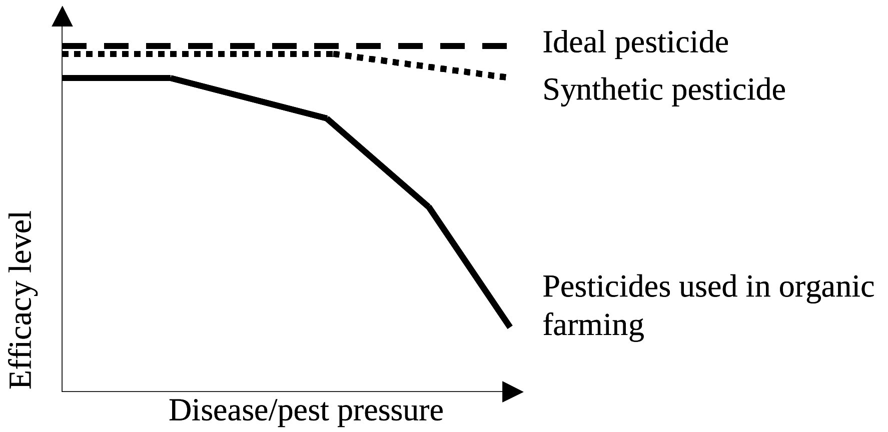

Fig. 1. Interaction between efficacy and disease/pest pressure. Pesticides approved for organic farming are often less efficient at high disease/pest pressure. The difference between synthetic pesticides and pesticides for organic farming results in a 'efficacy gap' at high disease/pest pressure.

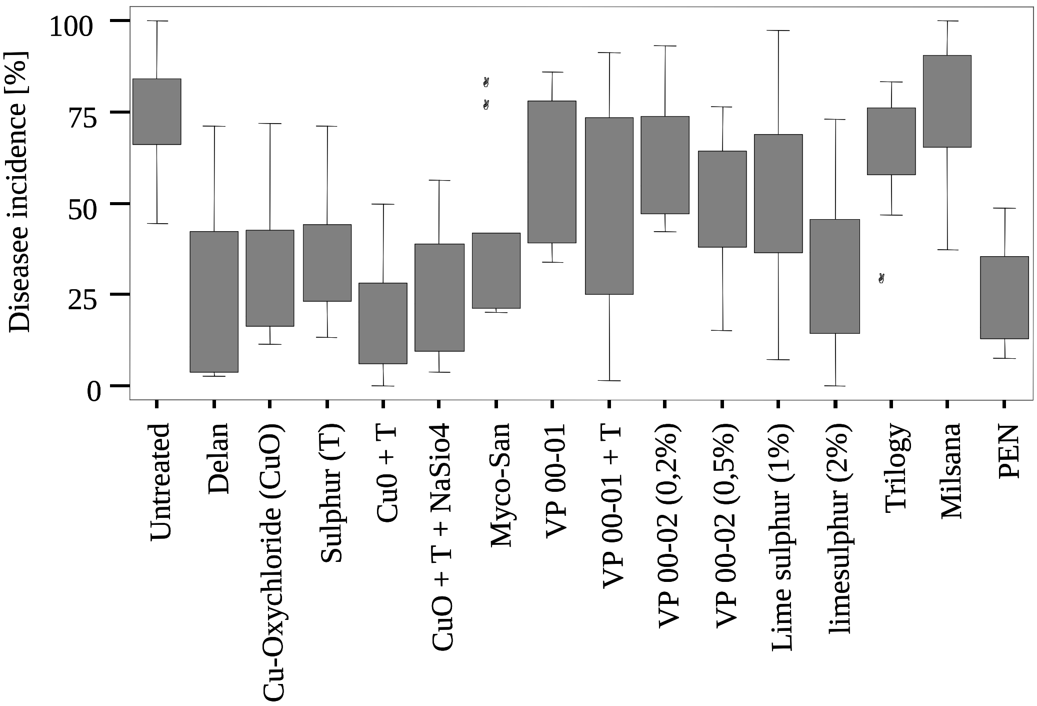

Fig. 2. Fungicide trials against apple scab (*V. inaequalis*) in Frick, Switzerland 2000. Sulphur, copper and combinations thereof control scab whereas novel commercial preparations are often insufficient under high disease pressure.

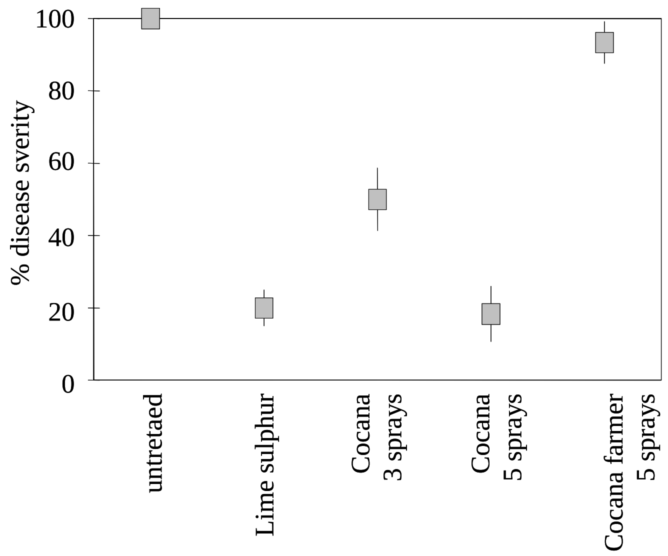

Fig. 3. Sooty blotch control in Swiss organic orchards (2002). Low spraying intensity (3 applications) was compared to high intensity (5 sprays). Coconut soap (Cocana) and lime sulphur both reduced sooty blotch severity significantly. The experimental treatments were applied with knapsack-sprayer, whereas the farmer was applying at the same time and rate by means of commercial spraying equipment.

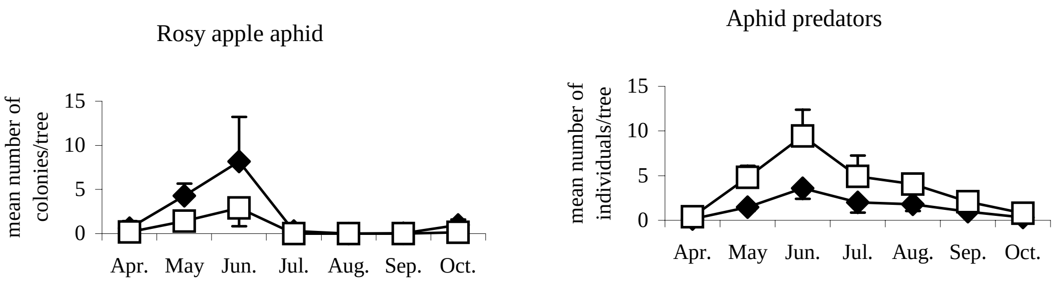

Fig. 4. Introduction of wild flower strips decreases rosy aphid populations as a consequence of promoted predator populations. In the strip-managed part of the orchard (white symbols) significantly less aphids but more predators were observed than in the control part (black symbols).

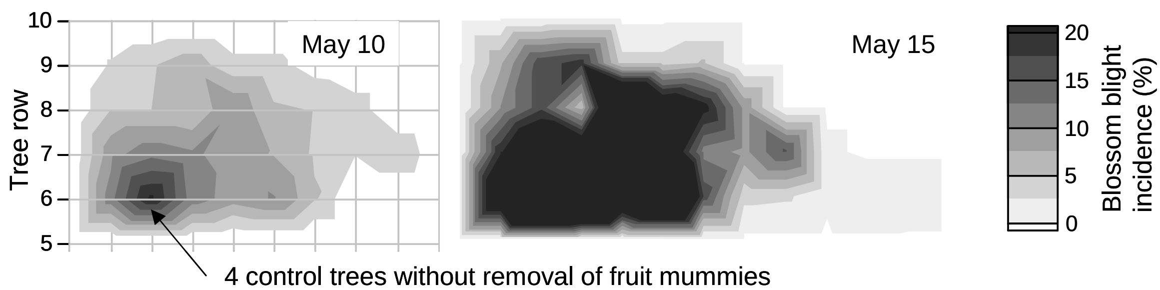

Fig. 5. Epidemic of *Monilinia laxa* on blossoms in a sweet cherry orchard in Switzerland. The epidemic starts and spreads from control trees which have not been submitted to thorough cleaning and complete removal of fruit mummies during winter.