THE CHALLENGES OF DEVELOPING IPM PROGRAMMES FOR SOFT FRUIT CROPS THAT ELIMINATE REPORTABLE PESTICIDE RESIDUES

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(Received October 13, 2005/Accepted November 29, 2005)

A B S T R A C T

Soft fruit crops are highly susceptible to a wide range of damaging pests and diseases. Thus, adequate yields of fruit of acceptable quality cannot be produced and the crops cannot be grown profitably unless these pests and diseases are efficiently controlled. Soft fruit producers rely on pesticides for this purpose but pesticide applications are often made close to harvest, giving rise to detectable levels of pesticide residues in fruit. >50% of harvested soft fruit contains reportable levels of pesticide residues and many samples contain multiple residues. Unfortunately, pesticides are widely regarded as highly undesirable by consumers and hence the market and in the UK there is an ongoing negative media campaign against them. As a consequence, leading UK retailers are asking their suppliers to reduce their incidence, with the eventual aim of eliminating them, an especially difficult challenge in soft fruit production. In this paper, the pesticide uses that give rise to residues in strawberry and raspberry production are overviewed and important approaches for tackling the problem are presented. These include 1) growing resistant varieties 2) using non-chemical control methods, especially cultural, biological and biotechnological methods 3) developing of new biopesticide products 4) avoiding of use of pesticides except where absolutely necessary by frequent crop monitoring and risk forecasting 5) using of products more intensively earlier or later in the season to minimise need during fruit development and fruiting 6) using of shorter persistence products 7) using of products that have a high reporting limit relative to their dose. 8) reducing the dose of applications closer to harvest 9) increasing the harvest interval 10) training to improve knowledge and expertise of all those involved in decision making. Examples of approaches for two major pests and two diseases of soft fruit are presented.

Key words: integrated protection of pests, soft fruit crops, pesticide residues

INTRODUCTION

The soft fruit crops grown in the UK are all highly susceptible to a wide range of damaging pests and diseases. Adequate yields of fruit of acceptable quality cannot be produced and the crops cannot be grown profitably unless these pests and diseases are efficiently controlled. Efficient weed control is also vital. The UK soft fruit industry relies on pesticides for these purposes. With current methods of crop protection for soft fruit, foliar chemicals for pest and disease control are often applied close to harvest, giving rise to detectable levels of pesticide residues in fruit. Residue levels do not exceed Maximum Residue Levels (MRLs) if Good Agricultural Practice (GAP) is adhered to, but a substantial proportion of soft fruit contains detectable levels of pesticides. Many samples contain multiple residues.

Market specifications for strawberry and raspberry mean that protected cropping in glass or polythene clad structures is now practically compulsory. This has caused some of the problems that growers are now experiencing, especially the severity of mildew attacks and the consequent use of fungicides such as bupirimate (Nimrod) close to harvest to try to maintain freedom from the disease. Protected cropping may also have affected the rate of degradation of residues of pesticides. Furthermore, the registration of many products is based on open field crops and crops grown in the glasshouse rather than under polythene tunnel protection.

Unfortunately, pesticides are widely regarded as highly undesirable by consumers and hence the market. There is an ongoing negative media campaign against them, fuelled by Non Government Organisations. The media firmly have pesticides in their sights. The government's policy of 'naming and shaming' has significantly raised the temperature. The concept of Maximum Residue Levels is often misunderstood. They are generally regarded as safety limits whereas in fact they are the maximum levels likely if Good Agricultural Practice is adhered to. Though public opinion is often poorly informed and the adverse consequences of pesticide use in soft fruit often unfounded or exaggerated, it is difficult to change public opinion against such media campaigns. However, market and consumer concerns do need to be addressed. Our industry is challenged to meet these concerns and needs to tackle the pesticide residues issue and work towards producing fruit without detectable residues.

Thus, pesticides present a difficult dilemma to the UK soft fruit industry. They are essential to production but using them is against the wishes of the market and consumers (Payne and Gibbard, 2005). They want it both ways, the very best quality at the low prices but without pesticide use and do not understand the complex issues involved. The pressure is all passed back down to the producer. This problem is not unique to soft fruit production, but it is a more difficult problem in soft fruit requiring more radical change (Cross and Berrie, 2005).

In this paper, we overview the pesticide uses that give rise to residues in UK strawberry and raspberry production and present some approaches for tackling the problem. First we report on which pesticide residues occur, at least sometimes, in harvested fruit. Then we list the generic approaches to reducing the incidence of pesticide residues followed by a detailed account of methods appropriate for the major crop protection problems faced.

The occurrence of pesticide residues in soft fruit

Retail surveillance by government agencies and routine monitoring of pesticide residues in samples of harvested fruit indicate that a number of pesticides are found at least sometimes at levels above the accepted reporting limits (RL) (Tab. 1). Amounts below the reporting limit are regarded as zero, even though trace amounts might be present which could be measured by a more sensitive method of analysis than the standard methods.

General approaches to reducing the occurrence of detectable levels of pesticide residues in harvested soft fruit

There are a number of well known generic approaches to reducing pesticide residues:

- Grow resistant varieties.
- Use non chemical control methods, especially cultural, biological and biotechnological methods, wherever possible. More attention needs to be devoted to developing and using new biopesticide products which do not leave pesticide residues.
- Avoid use of pesticides except where absolutely necessary. This is done by frequent crop monitoring and risk forecasting.
- Use products more intensively earlier or later in the season (e.g. pre-flowering or post fruiting to minimise problems during fruit development and fruiting).
- Use shorter persistence products.
- Use products that have a high reporting limit relative to their dose. Reduce the dose of applications closer to harvest.
- Increase the harvest interval.
- Improve knowledge and expertise of all those involved in decision making.

These last two approaches are discussed in detail below.

Harvest intervals

The mandatory harvest intervals on pesticide labels are designed to ensure that pesticide residue levels do not exceed Maximum Residue Levels. Longer harvest intervals would be required to guarantee residue levels below the reporting limits. The extent to which the harvest interval of each pesticide product needs to be increased needs to be determined scientifically if possible, based on properly conducted residue decline studies conducted in each target crop. Data for the polythene tunnel and outdoor crops is needed as rates of degradation may be substantially affected by environmental conditions. Some residues data do exist but it is normally kept confidential by the parent companies and in any case was not gathered with the intention of determining zero residue intervals.

As a starting point, a study is needed to gather available residues data, in particular residues decline studies, in collaboration with parent agrochemical companies. Attendant efficacy data also needs to be considered as substantially increasing harvest intervals may have negative consequences for the efficacy of control of the target pest or disease. Examination and statistical analysis of the data may enable the extent to which intervals can be/need to be increased. Conduct of further studies is likely to be prohibitively expensive. Another, supplementary approach is to try to tie in the occurrence of residues from the normal residue monitoring programme with last application dates from growers spray programmes to determine what harvest intervals lead to detectable residues. If the available information is inadequate for sound decision making, then an arbitrary factorial increase could be instigated. Such a study is the starting point of any attempt to tackle the pesticides residues problem and is of the highest priority.

Training

In order to support the improved pest and disease management strategies needed to deliver a significantly reduced occurrence of pesticide residues, a higher level of knowledge and expertise is needed by growers and their staff. Practical courses on the recognition and management of major soft fruit pests and diseases would be valuable.

Example: Powdery Mildew

Many strawberry varieties grown currently in the UK for their fruit quality are susceptible to strawberry powdery mildew and Glen Ample and Joan Squire are highly susceptible to raspberry powdery mildew. These two diseases are very similar and may even be caused by the same fungal strains. Furthermore, the protected environment of polythene tunnels is very favourable to these diseases which are a severe, somewhat intractable problem. The early stages of mildew infection, though readily seen with the aid of a hand lens by the trained eye, often go unnoticed by growers who only recognise symptoms of severe, established infection when it is often too late to take effective action. Practical training courses on the recognition of mildew for growers and advisors would be valuable.

The fungicides mainly used for controlling powdery mildew include bupirimate, myclobutanil and fenpropimorph. To avoid the occurrence of detectable residues of these fungicides, the harvest intervals of all of these products need to be increased (see above). Growers would then be advised to put much more effort into early season control.

Reducing residues of mildew fungicides

Reducing inoculum sources: Understanding the means of overwintering is key to devising sustainable methods of control with minimal fungicide use. The amount of primary inoculum in the spring drives the growing season mildew epidemic on foliage, flowers and fruits. In mild winters, strawberry powdery mildew overwinters mainly as the sexual state as cleistothecia on leaves. Autumn inspection of strawberry crops will identify those crops requiring early mildew control the following season. Removing old leaves in spring would also reduce overwintering cleistothecia. The epidemiology of raspberry mildew is poorly understood. It may overwinter as cleistothecia on canes or debris and, or as mycelium in buds. On apple, powdery mildew overwinters in buds and dormant season sprays of surfactants alone or in a mixture with fungicides have proved effective in greatly reducing overwintering inoculum which makes control of the disease in the growing season more effective. Chemical and physical methods of reducing overwintering inoculum need to be investigated.

Environmental manipulation: It may be feasible to regulate tunnel environment to manage disease by manipulating tunnel ventilation and canopy structure. Unfortunately, manipulation of the tunnel environment to reduce Botrytis is likely to result in more favourable conditions for mildew.

Fungicides: If cleistothecia are present, fungicide programmes need to be started early, at the onset of growth in spring, and tightly maintained until the end of flowering. During fruit development, materials with a lower risk of residues should be chosen and harvest intervals should be increased (see above). Spraying mildew fungicides close to harvest is certain to result in detectable residues. Potassium bicarbonate has recently been approved for use and is showing good eradicant activity against powdery mildew. Other chemicals need to be evaluated and, if effective, possibly included in an integrated programme for mildew control.

Table 1. Pesticides found, at least sometimes, as residues in soft fruits at levels above Reporting Limits

Active substance	Product Example	Target	H.I. Days*	Max individual dose [g ai/ha]	MRL [mg/kg]		Reporting limit [RL][mg/kg]	
					Strawb.	Rasp.	Strawb.	Rasp.
Azoxystrobin	Amistar	mildew blackspot	3 & 7	250	2	3	<0.05	<0.01
Bupirimate	Nimrod	mildew	1	350	no MRL	no MRL	<0.02	<0.01
Chlorothalonil	Bravo 500	botrytis blackspot	14 & 3	3000	3	10	<0.02	<0.01
Chlorpyrifos	Lorsban	many pests	7	750	0.2	0.5	<0.05	<0.01
Fenpropimorph	Corbel	mildew blackspot	14	750	1	1		<0.01
Fenhexamid	Teldor	botrytis	1	750	5	10	<0.05	<0.05
Iprodione	Rovral WP	botrytis	1	765	10	5	<0.05	<0.01
Myclobutanil	Systhane	mildew	3	90	1	0.02†		<0.01
Pirimicarb	Aphox	aphids	3	280	0.5‡	0.5‡		<0.01
Pyrimethanil	Scala	botrytis	1	800	no MRL	no MRL	<0.02	<0.01
Tolylfluanid	Elvaron Multi	botrytis blackspot cane diseases	14	1717	3‡	no MRL	<0.02	<0.05
Tolylfluanid + fenhexamid	Talat	botrytis blackspot cane diseases	14	1000 500	As above for individual active substances			

Note this is not an exhaustive list. Information collated from PSD surveillance (Anon., 2004ab) and producer residues monitoring. †MRL set to limit of detection; ‡ Codex MRL

*Where two values are given in this column the first is for strawberry, the second for raspberry

Example: Botrytis

In the growing season, Botrytis conidia, initially from overwintering sources of inoculum, infect strawberry and raspberry flowers. In raspberry, the infection is initially symptomless only becoming apparent as fruits ripen. Currently, fungicides are mainly protectant and are applied throughout the flowering period (which can be protracted) to protect new flowers as they open and thus are applied when fruits are ripening, resulting in residues. The fungicides recommended for controlling Botrytis include iprodione (Rovral), chlorothalonil (Brave, Repulse etc.), pyrimethanil (Scala), fenhexamid (Teldor), mepanipyrim (Frupica) tolylfluanid (Elvaron Multi) and thiram. To avoid the occurrence of detectable residues of these fungicides, the harvest intervals of many of these products will need to be increased, in some cases substantially (see above). Growers would then be advised to put much more effort into alternative approaches to control.

Botrytis development in strawberries and raspberries depends on initial inoculum and specific environment conditions during flowering when infection occurs. The initial inoculum level drives the epidemic but the rate of increase and spread depends on environmental conditions. Reducing the inoculum and making environmental conditions unfavourable for infection are two important alternative cultural approaches to minimise dependence on fungicides.

Botrytis inoculum mainly originates from within the plantation. In strawberries, the main source of inoculum is dead leaf litter and old mummified fruits from the previous season. In raspberries, lesions develop on fruiting canes that result from leaf infection the previous season. Strawberries and raspberries now mainly have to be grown under protection to meet the requirements of major multiple retailers. The tunnel environment is believed to be much less favourable for Botrytis. Many raspberry growers have already reduced their spray programmes on protected crops, especially those who grow under glass, some of whom use no fungicides during flowering for Botrytis control. Others have reduced numbers of spray rounds and rates of use. They rely on effective ventilation, temperature and canopy management. The same approaches need to be developed for polythene tunnel crops of strawberries and raspberries and spray programmes adapted for this new growing environment. The Botrytis risk forecasting model, Botem, developed by East Malling Research could be used to indicate high periods of risk to better target fungicide sprays.

Reducing residues of Botrytis fungicides

Inoculum sources: The removal of old plant tissue and debris from the crop on the resumption of growth in the spring, helps to reduce the level of inoculum which over-winters in the crop, thus reducing the risk of infection. Further research is needed to develop new technology to improve the removal of the debris from the field or to develop methods to suppress Botrytis sporulation on plant debris. For raspberry, the temporal dynamics of cane infection *via* leaves and the importance of cane botrytis as a source of fruit infection need to be determined by identifying the active sporulation periods of sclerotia and other inoculum sources.

Environmental manipulation: The tunnel environment needs to be kept below thresholds favourable for disease by manipulating tunnel ventilation and canopy structure to increase airflow, thereby influencing humidity and temperature within the crop canopy. Improved tunnel venting systems need to be developed to allow growers to react more quickly to environmental changes

Control agents: Alternative fungicides and other chemicals need to be evaluated for botrytis control. There are several chemicals which are reported to increase fruit resistance to rotting which, if effective, could be included in an integrated programme. Biocontrol should also be evaluated but despite much research in other countries, biocontrol of Botrytis has been unreliable.

Example: Strawberry blossom weevil

Many strawberry growers apply chlorpyrifos as a routine before flowering against strawberry blossom weevil adults. Ideally, sprays should be made early during flower stem extension before significant damage is done.

Reducing residues from insecticides applied for strawberry blossom weevil

Spraying only crops where economic damage is likely: Strawberry blossom weevil flower severing damage is only likely to be significant where the number of flower buds present is low and where loss is likely to limit the plants yield potential. Established crops often have excessive numbers of flowers and significant damage can be tolerated without economic loss.

Pest monitoring: Populations of strawberry blossom weevil adults should be monitored regularly in spring to determine whether damaging numbers are present. A sex/aggregation pheromone is available commercially from International Pheromone Systems, Units 10-15 Meadow Lane, Meadow Lane Industrial Estate, Ellesmere Port, Cheshire CH65 4TY (Tel: +44 (0) 151-357 2655; email: ips_ltd@btconnect.com). A leaflet is supplied with the lures explaining how they can be used in pheromone traps to monitor adults. Approximate thresholds have been developed. The pheromone traps give an early warning of weevil immigration.

Alternative insecticides: Thiacloprid (Calypso) now has a SOLA for use in strawberry and is likely to give good control of strawberry blossom weevil though its efficacy in comparison with chlorpyrifos has not been determined. Unfortunately, thiacloprid is a moderately persistent insecticide and there may be no reduction in risk of detectable residues. Use of spinosad (Tracer) which has a favourable safety profile and which is known to be active against some adult beetle species, needs to be investigated.

Example: Aphids

Several species of aphid infest strawberry and raspberry causing direct plant and sometimes fruit damage but also transmitting virus diseases. Contamination of harvested fruits by aphids, a potential problem especially on raspberry, is totally unacceptable to supermarkets. Unfortunately, most of the current major raspberry varieties (Glen Ample, Tulameen and Joan Squire have at best only partial resistance to large raspberry aphid. On Glen ample, virus infection transmitted by large raspberry aphid can occur rapidly with devastating consequences leading to premature loss of plantations due to leaf spot virus.

Currently, aphids and to a lesser degree the viruses they transmit, are controlled with aphicide sprays when aphids are seen in spring. Pirimicarb (Aphox) and chlorpyrifos are frequently used products and both are found as pesticide residues (Table 1). Residues occur mainly when aphicides are applied to developing fruitlets.

Reducing residues from insecticides applied for aphids

Pest monitoring: Crops should be inspected for the presence of aphids and during fruit development, sprays only applied where necessary.

Adjustment of spray timing: Aphid problems are so common on strawberry and raspberry that early season routine application of an aphicide, before biocontrol agents are introduced, is justified. The control of the aphids with aphicide sprays in the autumn so that damaging populations do not develop the following spring is a tactic that has worked well in apple and blackcurrant and needs to be investigated in strawberry and raspberry.

Non-chemical methods: For protected crops, regular introductions of commercially available biocontrol agents could be made in spring and summer, reducing, perhaps eliminating, the need for sprays during fruit development..

Conclusions

Many ways of reducing the incidence of detectable levels of pesticide residues have been identified above. The highest and most urgent priority is to appraise information on pesticide residues to determine the extent to which harvest intervals need to be increased on a scientific basis. More training is needed to improve the expertise of growers and advisors in pest and disease management. Practices are best implemented gradually, through the Assured Produce Scheme. This process has already started but much more radical change will be needed to greatly reduce the incidence of detectable residues. A vigorous research and development programme to investigate alternative control strategies needs to be pursued. Many items for research have been highlighted above and these need to be carefully considered and prioritised and a programme of research instigated. High priority research projects not currently in progress include:

Acknowledgements. Advice and help from Richard Harnden, K G Fruits Ltd, and from Scott Raffle and Janet Allen ADAS, UK in preparation of this paper is gratefully acknowledged.

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PRZESŁANIE DLA ROZWOJU INTEGROWANYCH METOD PRODUKCJI JAKO CZYNNIKA ELIMINUJĄCEGO POZOSTAŁOŚCI ŚRODKÓW OCHRONY ROŚLIN W OWOCACH JAGODOWYCH

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STRESZCZENIE

Krzewy jagodowe są grupą roślin sadowniczych atakowaną przez różne gatunki agrofagów. Efektywne ich zwalczanie warunkuje więc uzyskanie odpowiednio wysokich plonów wysokiej jakości owoców, co decyduje o opłacalności produkcji. Aby cel taki został osiągnięty, producenci owoców jagodowych wykorzystują głównie metody chemiczne. Nierzadko środki ochrony roślin stosowane są w okresie przedzbiorczym, przez co poziom pozostałości pestycydów w owocach wzrasta. W ponad 50% próbek zbieranych owoców jagodowych stwierdza się pozostałości środków ochrony roślin. Często w jednej próbce wykrywa się kilka substancji biologicznie czynnych. Taka sytuacją wzbudza ostry sprzeciw ze strony konsumentów, czego wyrazem są liczne kampanie w mediach. W rezultacie, główni detaliści Wielkiej Brytanii, zmuszeni są wymagać od swoich dostawców, aby udział owoców, w których wykrywa się pozostałości środków ochrony roślin, był znacznie zredukowany. Ostatecznym celem, dotyczącym w szczególności owoców jagodowych, jest całkowite wyeliminowanie pozostałości środków ochrony roślin z owocach.

Niniejsza publikacja jest przeglądem najważniejszych problemów związanych z ochroną chemiczną plantacji truskawek i malin, które prowadzą do wzrostu poziomu pozostałości środków ochrony roślin w owocach. Analizowane są także różne możliwości rozwiązania tych problemów. Wśród nich znalazły się: 1) uprawa odmian odpornych, 2) zastosowanie niechemicznych metod ochrony, w szczególności metod agrotechnicznych, biologicznych i biotechnologicznych, 3) stosowanie nowych biopreparatów, 4) redukcja zużycia środków, 5) intensywniejsza ochrona na początku sezonu na korzyść ograniczenia liczby zabiegów w okresie wzrostu i rozwoju owoców, 6) stosowanie środków ochrony roślin o szybszej dynamice rozkładu, 7) redukcja dawek preparatów w okresie przedzbiorczym, 8) przedłużenie okresu zbioru owoców, 10) szkolenia z zakresu ochrony roślin. Omówione zastały również możliwości wykorzystania powyższych metod w odniesieniu do dwóch szkodników oraz dwóch chorób truskawek i malin.

Słowa kluczowe: integrowane zwalczanie szkodników, krzewy jagodowe, pozostałości środków ochrony roślin