Achieving Lower Chemical Inputs in the Apple Industry - Messages for Viticulture

BOB HARDY
Principal Consultant, Specialist Agricultural Services Pty Ltd Sorell, Tasmania

Introduction
Integrated pest management (IPM) is an all-embracing approach to the problem of managing pests. It encompasses important aspects such as recognition of the impact of micro-climate on pest and disease incidence, and where feasible, as is the case with grapes, manipulation of the canopy environment to reduce pest and disease incidence. Management of the pesticides themselves is another crucial aspect.

The Australian apple industry took the historic and challenging step in 1992 of committing its growers to the goal of reducing their use of pesticides by 50% by 1996 and 75% by the year 2000. This goal was seen as achievable within the context of IPM. The precise manner in which it could be achieved was unclear at the time.

The potential of achieving this goal was highlighted in 1992 by an adviser from Kent who spoke of savings in pesticide use in the order of 75% achieved in his area. In that region the key was the adoption of new spray technology based on spinning discs.

In 1993 a research program involving spinning disc technology was launched privately with two Tasmanian apple growers. Its success led to the adoption by the Australian apple industry and the Horticultural Research and Development Corporation has played a major role.

The program treats spray technology as one of the most important components of the IPM approach. Moreover it involves three crucial elements in the effective utilisation of pesticides and new spray technology. These are the relationship between the following: droplet size and the efficient application of sprays, dose rate and pest mortality, and spray interval and the level of pest control.

This paper focuses on the nature and scale of these three factors, which are so frequently ignored but are crucial to the harnessing of the benefits of spray technology in the IPM context.

Background
The apple industry is confronted by a complex of pests and diseases, prominent among which are the lightbrown apple moth, codling moth, woolly apple aphid, European red mite, two spotted mite, powdery mildew and black spot. Pest levels vary considerably between apple varieties, largely as the result of different levels of pest susceptibility which can in part be related to canopy form. Canopy manipulation in apples is undertaken as a means of optimising yield, size and colour of fruit, and to a lesser extent as a means of reducing disease incidence and improving spray coverage.

Most apple-growers use medium volume (1,000 to 2,000 L/ha) airblast sprayers, although there has been a swing in recent years to airshear sprayers and a reduction in volumes to 250 to 500 L/ha.

Commitment to the future—the pesticides charter
To view the recent past as a guide to the future nature of pest management in the apple industry could be misleading. In 1992 under an agreement with the Australian Consumers Association the Australian Apple and Pear Growers Association committed itself to a Pesticides Charter aiming at a 50% reduction in pesticide use by 1996 and a 75% reduction by the year 2000.

The charter has had a major impact on the long term planning of many major growers. In particular it has focussed their attention on a clear goal, i.e. to dramatically reduce their use of pesticides. They are now actively seeking strategies to reach this goal.

Researchers in all states have been stimulated in their efforts to achieve the goal and some innovative approaches are being actively pursued. The use of pheromones for mating disruption, the application of alkaline materials such as hydrated lime for disease control, the greater use of monitoring, the application of new spray technology, and many other approaches are being researched and in some instances applied. In these the Horticultural Research and Development Corporation has played a major role.

Growers have also undertaken their own programs, including the greater use of pest monitoring services and experimentation with lower-than-label rates utilising the new spray equipment.

The context of change
The concept of integrated pest management (IPM) is well recognised within the apple industry and as mentioned it was...
identified as a vital element of the Pesticides Charter, however the actual implementation of IPM has not been well understood. In many instances it has been confused with biological control using parasites and predators alone. Others have not seen it extending beyond the use of predatory mites.

The essential elements of IPM are depicted in Figure 1.

The essential elements of the Integrated Pest Management system

The components of IPM are essentially like the parts to a car. They can be assembled to produce a car, but to use a car you must understand the road rules and to a degree the mechanics of the car. So what are the rules and mechanical principles we must apply when we take the car out of the showroom and onto a busy highway? The prime aspects of effective driving are, apart from steering in the right direction, maintaining alertness, understanding the relationship between effective fuel injection and petrol use, being aware of the relationship between accelerator pressure and velocity, and making appropriate use of the brake. We can also influence the comfort within the car by microclimate manipulation through the operation of the air conditioner.

Nevertheless, of the four prime aspects the first two are paramount. In horticultural terms these translate as follows. First, having a clear direction. In most instances this means reducing pesticide use while maintaining, or reducing, the level of loss due to pests to low levels. The second aspect is maintaining constant awareness of the state of the plants, diseases, insect and mite pests, as well as predators and parasites; in summary, constant and thorough monitoring.

Microclimate control is one aspect in which the grape industry has a distinct advantage compared to most horticultural industries. Major alterations to canopy form can be readily made between seasons and within season the removal of leaves adds a further level of manipulation. These means of manipulation can be used to significantly reduce the incidence of disease and improve the deposition of foliage spray.

Basic operational principles in the management of pesticides

The orchard or vineyard can again be compared to the car in that the basic components are essentially unalterable in the short term. Varieties, soil types, climate, pest pressure, presence of useful insects and mites are basically fixed.

However, as mentioned above, we can greatly alter the way we use our car through tuning, plus knowledge and experience in the use of the accelerator and the brake. We can also alter the environment within the car. In the pest management system the situation is similar. By understanding the basic principles covering the application and action of pesticides, growers can have a great influence over the way they use pesticides and, since pesticides are the expensive short term inputs, it is through them that growers can substantially influence the cost of pest and disease management.

The effective use of pesticides cover three relationships:

1. Droplet size and deposition on the target
2. Dose and mortality
3. Spray interval and the level of pest and disease control.

Droplets size and deposition on the target

Droplets can be categorised in three classes:

- 20 to 60 microns diameter, which readily move in an airstream but are slow to deposit. They are ideal for insects that will fly into them but they make the major contribution to spray drift.

- 80 to 120 microns diameter, which readily move in an airstream but have sufficient mass to impact and readily adhere to near vertical surfaces without shattering.

- 140 to 250 microns diameter which will be carried short distances by high velocity air but on impact with a near vertical surface will shatter and lose much of their mass to ground.

When considering sprayer efficiency the prime factor is the proportion of the total volume in these size classes. Most orchard sprayers produce a wide range of droplet sizes with most of the spray volume in the 140 to 300 micron range and many droplets in the 20 to 60 micron range. Consequently their use results in a high level of wastage through droplet shatter and a high level of spray drift.

Sprayers that use systems such as Micronaire spinning cages and Micron spinning discs have a high level of control of droplet size, and these are referred to as controlled droplet application (CDA) systems. In tree fruit orchards they are operated to produce most droplets in the range of 90 to 110 microns with application rates in the order of 25 to 100 L/ha. Droplet size can also be influenced by the addition of adjuvants such as Codaic to the spray tank.

Droplet size (i.e. droplet diameter) automatically influences the number of droplets for a given spray volume. If we consider the standard airlift sprayer putting out droplets with a mean diameter of 250 microns, with droplets ranging from 40 to 400 microns diameter, the number of droplets within the ideal range 90 to 100 microns can be described as 100 per unit volume. A liquid in a spray tank with a mean diameter of 150 microns would give about 440 droplets in the ideal range per unit volume. In contrast, the spinning disc with a mean diameter of 100 microns would produce 1,550 droplets in the ideal range.

Spray droplets are normally propelled by an airstream and the distribution of air is crucial, but major refinements in air movement can only partly overcome basic deficiencies in droplet size. On the other hand adoption of canopies with a high level of leaf exposure, such as the Scott Henry, greatly increase the evenness of spray deposition.

In summary we can readily influence the crucial factor of droplet size and deposition through selection of the spray applicator, to a lesser degree by using adjuvants and canopy manipulation.

Relationship between pesticide application rate and mortality of pest

It is important when considering pesticide use to separate the concepts of mortality of the pest and pest control. The former refers to the simple short term impact of the pesticide on the death of the target organism, while the latter refers to the longer term impact of the pesticide on the level of infestation or infection.

It is well known that a very low dose rate of pesticide causes very little mortality, and on the other hand a very heavy dose is often no more effective than a moderate amount. Further, excessive applications may lead to resistance to the pesticide.

The relationship between dose and insect mortality for a typical control chemical, whether it is a fungicide, insecticide or herbicide is illustrated in Figure 2. At low dose rates there is virtually no mortality (Figure 2, Region I) because the pest’s natural chemical and physical defences first stop the material entering the organism and then denature the small amount that enters. As dose increases we move into the zone where there is an almost direct relationship between dose and mortality (Region II). As dose increases further the additional mortality declines to the point where further increases in dose have
virtually no impact (Region III).

Numerous trials have shown that under reasonable conditions growers are applying doses that fall well within the latter zone, with as much as 50% of the pesticide applied having virtually no effect on mortality. From the point of view of an adviser with a government body—or of a chemical company—the overdose recommendation, which is often the label rate, is reasonably safe because even the poorest operator will obtain a good kill. The good operator can therefore gain considerably from finding just how far he can drop the rate under his circumstances.

Spray interval and pest disease control

Animal and plant numbers fluctuate not only seasonally according to the life cycle but also in relation to weather conditions, the presence of parasites and predators and the condition of their host plants. Much of the time the numbers of disease infections, or pestiferous insects, or mites, are so low that the benefits of spraying do not appear obvious. In fact, other than a sense of doing something to protect your investment, there are often probably no benefits.

On the other hand when numbers do build up a sense of urgency is often all too apparent. There is a strong temptation to add extra pesticide to the tank. However, as pointed out above, the quantity of pesticide recommended on the label is frequently at the overkill level and hence this is a very unwise strategy, and may well be illegal.

Each pest or disease reproduces and invades new regions of the plant or the crop at a unique rate, so by knowing a little of the pest's behaviour and biology we can define a spray interval that will ensure a pesticide has maximum effect. To illustrate this I shall take the example of house flies breeding in fowl manure. The strategy is based on a computer program from North Carolina and is used in Tasmania.

In fowl houses there are many fly predators which normally keep fly numbers at very low levels. If these predators are not controlling the flies we can use pyrethrum aerosol to kill the adult flies. In our system this pesticide kills few predators because they hide in the manure.

If there is a fly outbreak and we spray each fortnight we find that apart from a decline in fly numbers for about two days we have no long term impact on fly incidence. If we drop the interval to seven days we still have no long term impact, but if we drop the interval to four days the results are dramatic (Figure 3). After two weeks we find a general decline in fly numbers and after four weeks they have disappeared and the predators deal with the survivors.

The situation in the orchard or vineyard probably has many similarities to flies in poultry manure. Diseases and insect pests invade in what seems to be waves related to weather or other conditions that are favourable to them. A series of frequent, well-timed sprays is often the most effective approach.

Pest management in the Tasmanian apple industry—the spray reduction program

The research program I have undertaken in the Tasmanian apple industry was applied to two 2–4 hectare blocks of apples in 1993–94; in 1994–95 it will extend to five apple orchards and cover blocks ranging from 2 to 20 hectares. The program is strictly an integrated approach involving monitoring, new spray technology, and a strong awareness of the principles that relate to droplet size, the relationship between dose rate and mortality and influence of spray interval on pest control.

Droplet size

We are very much aware that the optimum droplet size for spray application to apple trees is 100 microns. Spinning discs and spinning cages both make this possible; we selected discs because they had been used successfully in the UK and were inexpensive and easy to install. Spinning cages allow a wider range of application rates but are more expensive and difficult to install on an existing machine. Our application rate of spray is 55 L/ha. We add Codacide oil (except early in the season) because it aids in generating optimum droplet size, it increases droplet adherence and it reduces pesticide breakdown due to sunlight. In the trials the spinning discs are fitted to standard airblast sprayers.

Rate of pesticide application

Three rates have been trialled: the full label rate through the grower's own sprayer, 50% of label rate through spinning discs and 25% of the label rate through spinning discs. We apply only the grower's spray program of fungicides, insecticides and miticides.
We did not use the full label rate through the spinning discs because in the UK growers normally use 25%, and sometimes 12.5%, of the label rate, and we did not believe we would find the 100% rate any better than 50%. We have mainly applied wettable powder formulations and have had no problems with blocked discs where high quality powders were used.

Spray interval
In 1993-94 we had very low pest pressure in one of our orchards. In the second, the disease pressure was moderately high but we found the fortnightly schedule adequate. However in future when we are faced with a major pest or disease outbreak our response will be to reduce the spraying interval until we have achieved control. A major advantage of ULV spraying is that it greatly reduces the number of times the operator needs to stop to fill the tank on the sprayer. This greatly reduces the overall time required to spray a given orchard and makes the shortening of spray intervals far more feasible.

Conclusions
At this stage the program is essentially a large scale feasibility trial. The system has been proven in Kent and it appears to have the potential to allow the Australian apple industry to achieve its goal of a 75% reduction in pesticide use by the year 2000.

Frequent disease, pest and predator monitoring are crucial aspects of the program. Unlike grapegrowers, apple-growers do not have within their production program the opportunity to readily influence disease incidence through canopy manipulation during the growing season. On that account the project described is focussing primarily on means of improving the effectiveness of spraying. It is a program in which we are combining new spray technology with, on the one hand, our knowledge of the relationship between dose rate and mortality, and, on the other, an understanding of the importance of timing in ensuring effective pest control.

In summary, the program aims to reduce very significantly pesticide use in the apple industry by actively driving the most readily manipulated elements of the integrated pest management approach. The elements over which the grower has the most influence—and this is typical of most pest management programs for tree fruits—involve the application and the management of pesticides; therefore, this program concentrates on these two aspects. The integration of this approach with the winegrape industry's ability to manipulate disease incidence through canopy management appears worthy of serious consideration.