DISEASE MANAGEMENT IN HAWKE'S BAY APPLE ORCHARDS CONVERTING TO ORGANIC PRODUCTION

K.G. TATE[1], D.W. MANKTELOW[2],
J.T. WALKER[2] and H. STIEFEL[3]

[1]*Crop Health Services, P.O. Box 2153 Stortford Lodge, Hastings*
[2]*HortResearch, Hawke's Bay Research Centre, Private Bag 1401, Havelock North*
[3]*Agriculture New Zealand, Private Bag 9024, Hastings*

ABSTRACT

Disease control achieved by 10 apple growers converting to organics during the 1997-98 and 1998-99 seasons is reported. Two orchards experienced black spot outbreaks each season, while the remainder averaged 0.5% spotted fruit. Powdery mildew was severe in 1997-98 but acceptable in 1998-99. Fruit rots after cool-storage averaged 0-11% for different varieties in 1997-98 and 0-30% in 1998-99. Fungicide applications averaged 11.6 in 1997-98 and 18.4 in 1998-99, which was a net increase in chemical use. Copper use was below 3 kg/ha/year. The most-used spray programme was a green-tip copper, three pre-bloom lime-sulphurs, sulphur/copper bloom sprays and sulphur or sulphur/copper sprays thereafter. Results showed that acceptable disease control is achievable in "organic" orchards, but summer and core rots remain a concern.

Keywords: organic production, apples, disease management, *Venturia inaequalis, Podosphaera leucotricha.*

INTRODUCTION

In the wake of food safety scares, such as dioxins in dairy products, and negative consumer reactions to genetically modified foods, there has been an increasing global consumer demand for "safe food". Rightly or wrongly there is a consumer perception that food produced under an organic standard such as Bio-Gro™ (Anon. 1998) is "safe" and organic produce can command price premiums over that from "conventional" production systems.

In the absence of commercially acceptable disease resistant cultivars, control of apple black spot and powdery mildew diseases has been a major barrier to commercially viable organic apple production. Organic production standards severely restrict the types and quantities of plant protection products that can be used by growers (Anon. 1998; Beresford *et. al.* 1991). The main fungicides available to growers are cupric hydroxide (restricted to a maximum of three kilograms of elemental copper per hectare per season), sulphur and lime sulphur. However, when using such products growers are forced to strike a balance between achieving effective disease control without inducing unacceptable fruit russet or other adverse phytotoxic or tree health effects.

In August 1997 Hawke's Bay had two apple orchards in transition towards full Bio-Gro™ certification (Anon. 1998). Following a workshop in September 1997 on the potential for organic apple production, eight new apple growers commenced organic conversion. In 1999-00 this had increased to over 40 growers, with production of transitional and certified export fruit in excess of 400,000 cartons, and income projections significantly higher than those achieved for conventionally produced fruit (K.G. Tate, unpubl. data). This rapid adoption of organic production techniques was assisted by a two year Technology for Business Growth technology transfer programme, which was established in 1997 by the exporter Freshco (The Fresh Fruit Company of New Zealand Ltd) to help growers with organic pest and disease management. This paper documents the disease management practices and outcomes for 10 growers over the 1997-98 and 1998-99 seasons, during conversion from conventional to organic production.

MATERIALS AND METHODS

During 1997-98 and 1998-99, all apple varieties on each of the 10 Hawke's Bay orchards either "in conversion" (first season), "in transition" (second season) or fully Bio-Gro™ certified (organic) were monitored for black spot (*Venturia inaequalis*), powdery mildew (*Podosphaeria leucotricha*) and fire blight (*Erwinia amylovora*) incidence. All orchards had blocks of Gala or Royal Gala apples and most had blocks of Braeburn and/or Fuji. Other cultivars examined included Cox's Orange, Red Delicious, Pacific Rose and Granny Smith. The number of cultivar blocks sampled were 33 in 1997 and 57 in 1998. Powdery mildew and black spot incidence were monitored using sampling protocols established in New Zealand for Integrated Fruit Production (Anon. 1999). Sampling was undertaken at the end of spring growth (November-December) and again prior to harvest. Powdery mildew and black spot incidence were recorded on all the leaves from 50 shoots per block, and black spot incidence was recorded on 1000 fruit from 10 trees per block. Black spot incidence in 2000 fruit samples per block was also recorded during harvest. Two cartons of packed fruit per block were cool-stored for six weeks, assessed for market defects then assessed again after one week at ambient temperatures.

Weather factors were monitored at 10 Hawke's Bay weather stations (Beresford and Spink 1992) and black spot infection periods identified using MetWatch computer software (Anon. 2000).

RESULTS

Weather related disease risks

September-October 1997 was wet and relatively cool, with conditions favourable for primary black spot infection (Table 1). Drought conditions then prevailed until leaf fall, with February being particularly warm, and conditions were favourable for powdery mildew development. In 1998, the September-October period was dry and warm, favouring powdery mildew and fire blight. Spring weather conditions in 1998 were less conducive to black spot infection than those in 1997. However, extended wet periods in January 1999 were more conducive for black spot (pepper spot) and summer rot infections than those experienced in 1998.

TABLE 1: The date of black spot infection periods as recorded by MetWatch monitor from ten weather station sites located in Hawke's Bay. Dates in bold type indicate widespread infection periods while dates in brackets indicate that the infection period did not occur at all sites.

Season	September	October	November	December	January	February
1997-98	**3, 11-12, 23-25, 29-30 (5, 8, 19)**	**5, 15, 19**	**16-17**	(21)	**(21-22)**	24
1998-99	**6 (30)**	**10, 11-12**	**2-3,** 16, 21-22, 26-27, **28-30**	**2-5,** 18	2, 14, 15, (17-18), 19, **22-23**, (24-26) 31	11

Fungicide spray programs

Fungicide programmes at each block were dominated by various combinations of cupric hydroxide (copper, as Kocide DF or Blue Shield), sulphur (as Kumulus) and lime sulphur sprays (Table 2). Spray application volumes ranged from 200 to 3000 litres/ha. Most sprays were protective, applied either by air-blast sprayer or helicopter. Many growers timed their sprays to precede infection periods and occasional post-infection lime sulphur sprays were applied after significant wet periods.

In 1997-98, fungicide use fell into one of the following patterns:

1) Copper and sulphur mixtures in September or September/October, then lime sulphurs.
2) Mainly copper, interspersed with sulphur or copper and sulphur mixtures.
3) Mainly lime sulphur, interspersed with occasional copper and sulphur mixtures or copper only.
4) Lime sulphur in September, switching to copper and sulphur mixtures, then back to lime sulphur.

Fungicide use patterns and resulting disease levels were reported to the growers in August 1998 and most adopted the following programme for 1998-99:

1) Copper and sulphur (Kocide plus Kumulus at 32 g and 180 g/100 litres respectively) at green tip (early September).
2) Lime sulphur for the next three sprays at 4 litres, 2 litres and 1 litre/100 litres respectively.
3) A copper and sulphur cover programme over flowering.
4) Copper and sulphur or lime sulphur at 0.8-1 litres/100 litres after fruit set (late October) as required.

TABLE 2: Fungicide use on 10 "organic" apple orchards[1] in Hawke's Bay during 1997-98 and 1998-99.

	No. fungicide sprays.		No. sprays applied			kg ai/ha/season		
Orchard	Total	As mixes	Cu	S	LS	Cu[2]	S	LS
1997-98 Season								
A	9	4	4	4	5	0.6	7.2	7.5
B	10	1	1	1	9	0.2	2.9	72.3
C	11	2	2	2	9	1.4	1.6	90.0
D	11	1	1	2	9	0.6	5.2	42.0
E	15	11	11	11	4	2.4	24.0	9.0
F	10	3	3	4	6	0.7	5.8	24.0
G	12	1	3	2	8	1.5	1.0	24.0
H[3]	-	-	-	-	-	-	-	-
I	17	2	0	9	10	1.8	13.7	37.0
J	9	7	7	7	2	1.4	13.9	7.4
Mean	11.6	3.6	3.6	4.7	6.9	1.2	8.4	32.8
1998-99 Season								
A	11	8	7	7	5	0.6	8.4	4.2
B	21	7	6	6	16	1.5	15.6	53.4
C	21	7	6	6	16	1.2	11.4	59.2
D	17	14	8	13	10	1.6	24.7	37.0
E	25	12	12	12	13	2.4	34.4	48.0
F	12	4	3	3	10	0.4	4.3	24.0
G	14	10	9	8	7	2.0	16.7	72.0
H	22	7	10	7	13	2.1	14.7	39.0
I	22	6	8	8	12	2.0	18.9	23.7
J	19	9	8	8	12	1.6	20.0	40.5
Mean	18.4	8.4	7.7	7.8	11.4	1.5	16.9	40.1

[1]Data not available from all orchards each season.
[2]Copper (Cu) expressed as elemental copper, S = sulphur, LS = lime sulphur.
[3]Apple crop abandoned after bloom due to severe black spot outbreak (wrong fungicide choice).

Disease incidence

In both seasons, most orchards achieved black spot control comparable to average levels under conventional production (D.W. Manktelow, unpubl. data), but major black spot epidemics occurred on two different orchards each season (Table 3). In

1997-98 approximately 70% fruit spotting occurred in two orchards due to wrong product choice. In 1998-99 smaller outbreaks were caused by spray timing error, for example the early spring infection period was missed. Black spot incidence in bin samples was comparable to that in pre-harvest samples, except in blocks with high disease levels where significant field grading had occurred (data not presented). Powdery mildew incidence by harvest 1998 was unacceptably high on most blocks. Lowest mildew levels were observed on blocks that received three lime sulphur sprays from early-September. By harvest 1999, mildew incidence was appreciably lower than in 1998. Variations in disease levels between orchards observed in the spring samples (data not presented) were consistent with those observed in the preharvest samples (Table 3). This confirmed the need for intensive fungicide spraying during spring to protect young, susceptible leaves and fruitlets.

Fire blight was absent on most blocks in spring 1997, despite infection periods on 13-14 and 30-31 October. Timing of October copper sprays, based on fire blight warnings, was considered to be acceptable. In spring 1998, fire blight was largely absent from blocks that received several copper sprays during October, despite a widespread outbreak in the region (K.G. Tate, unpubl. data).

TABLE 3: Average pre-harvest black spot and powdery mildew incidence on 10 "organic" apple orchards in Hawke's Bay during 1997-98 and 1998-99.

Orchard	No. of cultivar blocks sampled[1]		Fruit black spot incidence %		Leaf black spot incidence %		Leaf powdery mildew incidence %	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
A	1	2	1.6	1.4	0.3	2.3	6.3	4.9
B	4	8	1.7	13.4	1.3	5.3	19.6	3.3
C	3	5	0.9	3.1	0.0	0.6	15.8	3.1
D	4	8	0.2	0.2	0.4	0.3	38.6	7.3
E	4	9	0.2	0.9	0.2	0.0	43.0	10.4
F	4	6	0.3	0.9	1.5	0.1	45.4	16.7
G	3	7	24.0	0.3	11.6	0.1	54.5	15.4
H	2	3	27.2	0.3	15.6	0.0	20.5	6.4
I	4	7	0.1	0.3	1.4	0.0	23.5	1.9
J	4	2	0.1	0.0	0.3	0.0	31.8	9.6
Overall mean			5.6	2.1	3.3	0.9	29.9	7.9
Mean for incidence of <2%			0.6	0.5	0.7	0.1		

[1]Total number of blocks of all cultivars sampled in each orchard (total for 1997-98=33 and 1998-99=57).

Leaf spotting and fruit russet

In November 1998, necrotic spotting of Braeburn foliage appeared a week after spraying lime sulphur and sulphur (0.7% + 125 g/100 litres Kumulus) prior to high day temperatures (ca 29°C in shade). Similar symptoms were also observed after spraying copper and sulphur in slow drying conditions or before high air temperatures.

Data on fruit russet was not collected as part of this project. While Braeburn and Pacific Rose fruit were observed to suffer from russet problems, fruit finish on other varieties did not appear to be compromised by organic fungicide programmes.

Storage rots

There was no detectable development of black spot on 55% and 50% of samples in storage each season respectively. The maximum incidence observed was 3% on Granny Smith in 1998-99. Incidence of surface rots was 0-11% in 1997-98 and 2-5% in 1998-99. The pathogens involved with surface rots were mostly *Gloeosporium* sp. (ripe spot) on Royal Gala and Red Delicious with some *Penicillium* sp. (blue mould) and *Botrytis cinerea*. Core rots (*Eutypa, Alternaria, Fusarium* and *Pleospora spp*) and mouldy core incidence averaged <1% except in Fuji (6% in 1998 and 11% in 1999) and Red Delicious (30% in 1999).

DISCUSSION

Powdery mildew incidence was high on conversion orchards in 1997, producing significant inoculum pressure in spring 1998, but mildew wasn't a serious problem in 1998. This could be due to the large increase in early-season lime-sulphur use in 1998 (Table 2). Lime-sulphur is an effective powdery mildew control and may exhibit some eradicant activity in combination with sulphur (Cunningham 1935; Atkinson *et al.* 1956). Other mildew-suppressing factors include pruning out of infected wood and tree devigouration. This was considered to be the result of understorey competition and copper and sulphur sprays. Trees generally appeared healthy by harvest 1999, lacking the excessive, mildewed sucker growth of the previous year.

The black spot problems on four different orchards over the two seasons were caused by wrong product selection and inaccurate spray timing during spring. However both orchards affected in 1998 returned relatively clean crops in 1999, demonstrating the potential effectiveness of organic control options. The generally lower levels of black spot at harvest 1999 were associated with both drier spring conditions and more intensive spraying over this period (Table 2).

Fire blight was observed to be less a problem on most organic compared with conventional orchards in both years. The programme of low-rate, timely copper sprays was considered responsible. Cupric hydroxide rates of 25-50 g Cu/100 litres are known to suppress *E. amylovora* bacteria (S.C. Gouk, pers. comm.). A build-up of copper residues from several spring applications at low rates may account for the relative absence of fire blight on organic blocks.

High summer rot and wet core rot incidence developed during cool-storage in some varieties. This may reflect the limited fungicide choice and rates available to organic growers and/or poor spray timing. *Eutypa* infection (core rot) probably occurs during October when trees are being intensively sprayed while summer rot and black spot pepper spot presence may reflect poor spray timing during summer rains. The levels of both storage rots and core rots are of concern for organic growers, but biological control of storage rots using bacterial and yeast antagonists is an option (R.A. Hill, pers. comm.).

DeEll and Prange (1993) in a two year comparison of organic and conventional orchards found that organic apples had a higher incidence of storage rots, black spot, russet, senescent breakdown, phosphorous and potassium levels than conventional fruit and lower levels of nitrogen. In a four year comparison, Vossen *et al.* (1994) found that black spot caused 86% more damage in organic than conventional blocks, greatly reducing the yield and market value. However, eradicant spray timing for both programmes appears to have been used which would have severely disadvantaged the organic programme through the lack of an effective eradicant. In our study growers sprayed fungicides pre-emptively whenever possible and spraying intensity was higher.

The 1998-99 fungicide programmes were more intensive than those of 1997-98, averaging 18.4 and 11.6 sprays respectively (Table 2), with a decrease in spray interval from 9.3 days (range 5.4-16.2) to 6.2 (range 4.4-8.7) days (data not shown). Regression analysis of fungicide use and disease incidence (Tables 2 and 3) indicated consistent (non-significant) trends towards lower disease incidence with increasing fungicide applications and decreasing spray intervals (data not shown). These were similar to those observed by Beresford and Manktelow (1994) for fungicide use in conventional production systems.

Copper, sulphur and lime-sulphur use are restricted by Bio-Gro™ organic standards, with a maximum Cu use of 3 kg/ha/season (Anon. 1998). While cupric hydroxide was included in ca 40% of fungicide applications, total Cu use was usually well below the permitted maximum due to the low application rates used (25-30 g Cu/100 litres equivalent) (Table 2). Beresford *et al.* (1991) found that cupric hydroxide mixtures at 125 g Cu/100 litres with sulphur provided good black spot and powdery mildew control but caused severe fruit russet. In subsequent work (Beresford *et al.* 1995) cupric hydroxide at 25 g Cu /100 litres was at the threshold between unacceptable russet and effective black spot control.

Lime-sulphur is toxic to foliage, and high temperatures and/or humidity following copper, sulphur or lime sulphur sprays may cause leaf injury (Cunningham 1935). To avoid russet or leaf spotting, these sprays should be avoided on Braeburn and other sensitive varieties during such conditions or they should be carefully timed in relation to expected conditions. Lime-sulphur plus sulphur at lower rates may be less toxic than either fungicide alone (Atkinson *et al*. 1956) and concentrate spray application is also known to reduce risks of phytotoxicity through faster drying of residues.

CONCLUSIONS

Grower experience during 1997-98 and 1998-99 demonstrated that commercially acceptable disease control can be achieved in apples under organic production in Hawke's Bay. The impact of copper and sulphur use on productivity of some cultivars, such as Braeburn, and potential for increased storage rots remains a concern.

ACKNOWLEDGEMENTS

FreshCo and Technology New Zealand for funding this project; Mary Horner and Sue Dryden for assistance with post-storage monitoring.

REFERENCES

Anon., 1998. Bio-Gro New Zealand: Organic production standards. Bio-Gro New Zealand, Wellington, New Zealand. 96 pp.

Anon., 1999. ENZA-IFP production guide. ENZA New Zealand Ltd, Wellington, New Zealand.

Anon., 2000. HortPlus® MetWatch software description. www.hortplus.com

Atkinson, J.D., Brien, R.M., Chamberlain, E.E., Cottier, W., Dingley, J.M., Jacks, H., Reid, W.D. and Taylor, G.G., 1956. Plant Protection in New Zealand. R. E. Owen, Government Printer, Wellington. 699 pp.

Beresford, R.M., Elmer, P.A.G., Spink, M., Alexander, R.T. and Daly, M.J., 1991 Fungicides for control of black spot and powdery mildew in organic apple production systems. *Proc. 44th N.Z. Weed and Pest Control Conf. :* 86-90.

Beresford R.M. and Manktelow, D.W.L., 1994. Economics of reducing fungicide use by weather-based disease forecasts for control of *Venturia inaequalis* in apples. *N.Z. J Crop Hort. Sci.. 22:* 113-120.

Beresford, R.M. and Spink, M., 1992. A national disease forecasting system for apple black spot (*Venturia inaequalis*) in New Zealand. *Acta Horticulturae 313*: 285-296.

Beresford, R.M., Wearing, C.H., Walker, J.T.S., Spink, M., Marshall, R.R. and White, V., 1995. Copper and slaked lime for the control of powdery mildew in apples. *Proc. 48th N.Z. Plant Prot. Conf. :* 83-88.

Cunningham, G. H., 1935. Plant Protection by the aid of therapeutants. John McIndoe Printer, Dunedin, New Zealand. 243 pp.

DeEll, J.R. and Prange, R.K., 1993. Postharvest physiological disorders, diseases and mineral concentrations of organically and conventionally grown McIntosh and Cortland apples. *Can. J. Plant. Sci. 73:* 223-230.

Vossen, P., Jolly, D., Meyer, F, Varela, L. and Blodgett, S., 1994. Disease, insect pressures make organic production risky in Sonoma County. *Calif. Agric. 48 (6):* 29-36.