USE OF FORECAST AND MONITORED WEATHER INFORMATION FOR TIMING APPLE BLACK SPOT FUNGICIDE APPLICATIONS IN CANTERBURY

D.W. MANKTELOW¹, R.M. BERESFORD², M.J. SALINGER³,
P.E. BRUCE³ and R.E. GAUNT¹.

¹Department of Biochemistry and Microbiology, Lincoln College

²Plant Diseases Division, DSIR, Private Bag, Christchurch

³NZ. Meteorological Service, P.O. Box 722, Wellington

SUMMARY

Fungicide use for control of apple black spot (*Venturia inaequalis* (Cooke) Winter) was evaluated in a trial with apple cvs. Granny Smith and Oregon Red Delicious. Four treatments were used: 1) a standard calendar-based programme; 2) fungicides with protectant activity applied after forecast infection periods (FIP) and fungicides with eradicant activity applied after monitored infection periods (MIP); 3) fungicides with eradicant activity applied after MIP; 4) fungicides with protectant activity applied after FIP. Disease incidence on fruit in all treatments of both cultivars was low (< 1.5%) and commercially acceptable. Lowest disease incidence occurred in treatments combining protectant and eradicant activities. Infection period monitoring and forecasting helps indicate infection risks, and permits informed decisions on the need for fungicides, and the type of fungicide to use.

INTRODUCTION

Black spot, caused by *Venturia inaequalis* (Cooke) Winter, is a serious disease of apples in New Zealand. Many spray programmes to control this disease are calendar-based to give continuous protectant cover, with additional eradicant treatments after perceived infection periods. Fungicide applications attempt to prevent primary infection from ascospores, which are typically present from bud break to early December (Brook 1976). A two year survey of five mid Canterbury orchards showed that on average 14 black spot fungicide applications were made each season, with 11 applications between bud break and the end of December (Manktelow unpublished).

Fungicide use affects disease control, production costs, market acceptability of fruit, integrated mite control, pathogen insensitivity to fungicides and fruit russet. Black spot control should improve with increased fungicide use, but the other criteria are favoured by reductions in use. Fungicide applications may be reduced when their timing is related to weather monitoring (Ellis *et al* 1984), but there has been little research in New Zealand into such rationalization. This paper reports an experiment using forecast and/or monitored weather for timing black spot fungicide applications in Canterbury.

MATERIALS AND METHODS

Four black spot fungicide programmes (treatments) were applied to the apple cvs. Oregon Red Delicious (highly susceptible to black spot) and Granny Smith (moderately susceptible) in a randomised block design with four replicates. Fungicide treatments (Fig. 1) were: 1) a standard calendar-based spray programme (no reference to formal forecasting or monitoring of infection periods); 2) fungicides with protectant activity applied after forecast infection periods (FIP) and fungicides with eradicant activity applied after monitored infection periods (MIP); 3) fungicides with eradicant activity applied after MIP; 4) fungicides with protectant activity applied after FIP. During the primary infection season Treatment 1 was based on 7-10 day applications for protectant cover with applications for eradicant action after wet weather. All chemicals were

Proc. 42nd N.Z. Weed and Pest Control Conf.

Fig. 1: Fungicide applications (1 = dodine; 2 = myclobutanil; 3 = metiram; 4 = mancozeb) and monitored infection periods (vertical lines) for apple black spot experiment. ◀ x ▶ Represents a fungicide application and its estimated eradicant (◀) and protectant (▶) activity periods: ▲ indicates rainfall > 2.5 mm.

applied at recommended rates. Fungicides used were dodine (Dodine 80F) or myclobutanil (Sythane 40W) for eradicant activity, and metiram (Polyram 2000) or mancozeb (Dithane M45) for protectant activity (Fig. 1). Trees were sprayed to runoff with a twin surface boom sprayer, at 2000 litres/ha at full leaf. Protectant and eradication activity durations for each fungicide used were estimated on the basis of manufacturers' claims and suggested application intervals, but protectant activity was assumed to end after rainfall of greater than 2.5 mm (Fig. 1).

The experiment was conducted in the 1988-89 season at the Lincoln College Horticultural Research Area on Lincoln canopy trained trees, which had severe black spot the previous season. Growth stages at day 1 (1/9/88) were 50% bud break in Oregon Red Delicious, and 50% silver tip in Granny Smith.

Temperature and wetness were monitored with a CR21 electronic data logger, using an electrical resistance surface wetness sensor and thermistor temperature probe (Campbell Scientific Inc.) placed in the crop canopy. Monitored infection periods were identified from this data using the criteria for "light" infection defined by Mills and Laplante (1954). Beresford *et al* (1989) describe how these criteria were applied. Forecast infection risk was predicted 1-5 days in advance by the New Zealand Meteorological Service, from day 1 (1/9/88) to day 122 (31/12/89).

After day 125 (3/1/89), when ascospore release had declined to an undetectable level (Beresford unpublished), four additional black spot fungicide applications were made. The first, on day 132, used captan on Treatments 1 and 4, and dodine on Treatments 2 and 3. This maintained the different protectant and eradicant emphasis in

these treatments. Three more applications (one of captan, two of dodine) were made to all treatments. Black spot spraying ceased after day 161 (8/2/89).

Black spot on leaves was assessed on five sample dates (days 49, 80, 106, 146 and at harvest, day 195 for Oregon Red Delicious, day 224 for Granny Smith). Incidence was recorded on upper and lower leaf surfaces in 50 terminal and 50 lateral (Abbot 1984) leaf clusters per plot. Incidence of fruit infection was assessed non-destructively three times on random samples of 250 fruit per plot. At harvest black spot incidence and export russet gradings (Anon. 1988) were recorded on 300 fruit per plot from Granny Smith and 400 from Oregon Red Delicious.

RESULTS

The primary infection season in 1988, 1 September-31 December (Beresford *et al* 1989), was unusually dry (rainfall 31% of normal), and black spot was generally not severe in Canterbury orchards. Eleven infection periods were monitored in the trial block between days 1 and 125. Disease on under-surfaces of leaves developed later in the season than on upper-surfaces and Granny Smith had less disease than Oregon Red Delicious (Fig. 2).

Fig. 2: Percentage black spot incidence in lateral leaf clusters for two apple cultivars for five sample dates. A and C = leaf upper-surfaces; B and D = leaf under-surfaces.

The treatments all gave similar relative disease control on fruit and leaf surfaces for both cultivars. Analyses of variance (arcsine transformed data) were carried out for sample dates 2, 3, 4 and 5 in Oregon Red Delicious and 4 and 5 in Granny Smith (Table 1). Early samples were excluded from analyses because they contained too many zero values. Treatment 4 (protectant only) gave the least disease control. Treatments 1 (standard orchard), 2 (protectant plus eradicant) and 3 (eradicant only) were similar, and significantly ($P < 0.05$) better than Treatment 4 for all analyses, except in Oregon Red Delicious upper leaf surface, where Treatments 3 and 4 were not significantly different. Fruit disease in Granny Smith was of low incidence (mean 0.05%) with no detectable treatment differences. For Oregon Red Delicious mean disease incidence on

TABLE 1: Mean percent black spot incidence on top and bottom surfaces of lateral leaf cluster samples.

	Treatment	Oregon Red Delicious ^x		Granny Smith ^y	
		Top	Bottom	Top	Bottom
1.	Standard orchard	5.1 a (1.2) ^z	2.6 a (0.4)	4.0 a (0.9)	1.0 a (0.1)
2.	Protectant + eradicant	5.5 a (1.5)	1.6 a (0.2)	2.8 a (0.5)	2.3 a (0.3)
3.	Eradicant only	9.9 b (3.9)	5.4 a (1.5)	4.1 a (0.8)	1.9 a (0.4)
4.	Protectant only	12.5 b (5.4)	11.2 b (5.9)	7.6 b (2.3)	5.0 b (1.3)

^x Mean for sample dates 2, 3, 4, 5 (see Fig. 2)

^y Mean for sample dates 4 and 5.

^z Arcsine $\sqrt{y}$ transformed data, mean percent cluster incidence in brackets. Means within columns followed by the same letter do not differ at $P = 0.05$ (Waller and Duncan's Multiple range test).

fruit was 0.82% for Treatment 1, 0.75% for Treatment 2, 1.30% for Treatment 3 and 1.23% for Treatment 4. Treatments 1 and 2, 3 and 4, and 1 and 4 were each not significantly different ($P > 0.05$). All treatments provided commercially acceptable disease control. There were no significant treatment effects on russet within cultivars, but Granny Smith had more russet (mean 8.4%) than Oregon Red Delicious (mean 0.8%).

The efficiency of each treatment in relation to the occurrence of MIP was assessed on the basis of estimated fungicide activity durations (Fig. 1). Treatment 4 (protectants applied in response to FIP), which provided least disease control, received only four fungicide applications, and missed nine infection periods. Treatment 3 (eradicants applied after MIP) received seven applications and missed one infection period, and provided better disease control than Treatment 4. Best disease control was achieved by Treatments 2 (protectant plus eradicant), which received ten applications and missed one infection period, and 1 (standard calendar-based), which received nine applications and missed six infection periods.

Chemical costs per hectare for each treatment to day 125 were \$398 for Treatment 1, \$549 for Treatment 2, \$372 for Treatment 3 and \$177 for Treatment 4 (1988 N.Z. Fruitgrower's Federation Ltd prices for applications of 2000 litres/ha).

DISCUSSION

This trial was conducted in a season with dry spring weather which limited both the amount of disease which developed and the magnitude of treatment effects. It is therefore difficult to determine all the implications of using weather information to time fungicide applications for apple black spot control. However, the results give valuable insight into alternatives to calendar-based spray programmes and indicate directions for further research.

In Canterbury low temperatures limit the number of early season infection periods (Beresford *et al* 1989), so fungicide timing in relation to MIP may allow early season fungicide use to be reduced in comparison with calendar-scheduled applications. This was shown in the experiment, where the standard calendar-based treatment applied three unnecessary applications before any infection periods were detected. Treatment 1 (calendar-based) was the programme used by the Lincoln College Research Orchard, but was not a full calendar schedule because of the dry spring and low perceived disease risk. A full schedule would have required at least eleven applications to day 125.

The spray programmes that gave the best disease control were those that included both protectant and eradicant fungicides (Treatments 1 and 2). Treatment 1, in which six infection periods were missed, was expected to have more disease than Treatment 2, in which only one infection period was missed. However, there were no differences in

leaf or fruit disease between the two. The lack of disease differences may be attributed to longer durations of protectant fungicide activity than expected, and hence there may have been protection for infection periods that were presumed missed. Additionally, some of the disease in these treatments may have resulted from infection occurring outside the monitored infection periods, and not controlled by the protectant or eradicant applications. It is likely that infection occurred outside the monitored infection periods because observations of the leaf canopy showed that patches of wet leaves were sometimes present when the sensor was dry. This implies that the infection period criteria used cannot be regarded as absolute indicators of when infection will or will not occur. Infection period criteria should aim to identify periods when infection occurs and not lead to unnecessary "insurance spraying".

Protectant treatments scheduled on FIP failed to provide cover for at least five monitored infection periods, indicating that the forecasts were not accurate enough. The use of forecast weather information appears best suited to predicting when fungicide treatment is not required (Beresford *et al* 1989).

The large difference in disease between the two cultivars in this study suggests that more resistant cultivars may be exposed to larger numbers of infection periods than susceptible cultivars and still maintain an acceptable level of disease. Therefore, rationalisation of fungicide use should include consideration of cultivar susceptibility in addition to weather information.

The range of chemical costs for the different treatments to day 125 indicates how the types and numbers of fungicides applied can influence production costs. Although reduced fungicide use may provide easily identified cost savings, a 1% decrease in export yield as a result of disease would cost the grower between \$300 and \$900 per hectare (\$0.5-1.0/kg and total yield of 60-90 tonnes/ha). Costs of potential crop losses are the most significant cost consideration in fungicide use.

A rational use of fungicides is to apply a combined protectant and eradicant treatment in response to MIP. Combined treatments provide reachback eradication of infection and protectant cover for future undetected infection periods. With this method for scheduling fungicides, applications for protectant action would only be made when risk of infection was established, and application intervals would extend beyond those of a typical calendar schedule if infection risks were low. Applications for eradicant action would only be made if an infection period occurred and protectant cover was expected to be inadequate. This system should not result in any more applications than currently used, and may, in seasons not conducive for disease, result in fewer applications. Thus infection period monitoring could provide information that would permit rational and objective decisions on fungicide use for black spot control.

ACKNOWLEDGEMENTS

K.S. Boyd-Wilson and S. Ebdon for technical assistance and A.R. Wallace, Applied Mathematics Division, DSIR, for statistical advice and assistance.

REFERENCES

- Abbot, D.L., 1984. The Apple Tree. Physiology and Management. Grower Books, London. 90pp.
- Anon., 1988. Grading Standards for Export Fruit. New Zealand Apple and Pear Marketing Board.
- Beresford, R.M., Salinger, M.J., Bruce, P.E. and Brook, P.J., 1989. Frequency of infection periods for *Venturia inaequalis* in New Zealand and implications for fungicide use. *Proc. 42nd N.Z. Weed and Pest Control Conf.*: In press.
- Brook, P.J., 1976. Seasonal pattern of maturation of *Venturia inaequalis* ascospores in New Zealand. *N.Z.J. Agric. Res.* 19: 103-109.
- Ellis, M.A., Madden, L.V. and Wilson, L.L., 1984. Evaluation of an electronic apple scab predictor for scheduling fungicides with curative activity. *Plant Disease* 68: 1055-57.
- Mills, W.D. and Laplante, A.A., 1954. Diseases and insects in the orchard. *Cornell Extension Bulletin No. 711*: 20-28.