DEVELOPMENT OF AN IMPROVED SPRAY TIMING SYSTEM FOR PROCESS PEACH IN HAWKE'S BAY

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ABSTRACT

Weather-based spraying was compared with cover-replacement spraying for control of brown rot and peach rust on 19 process peach orchards from 1990-95. During this time 7-19 brown rot and 11-22 peach rust infection periods occurred per season. By timing sprays to infection periods the number of sprays per season was reduced from 8.4 to 6.7 for brown rot and from 6.3 to 5.3 for peach rust, without reducing control. Infection period forecasts were 88% accurate for blossom blight, 66% for peach rust and 84% for fruit rot. Fungicide usage in 113 peach orchards since 1990 suggests that the industry has partially adopted weather-responsive spraying and would benefit from wider uptake.

Keywords: peaches, disease management, brown rot, peach rust, spray timing

INTRODUCTION

A disease management system (DMS) for brown rot (BR, *Monilinia fructicola* (Wint.) Honey) blossom blight of peach in Hawke's Bay (Manktelow and Tate 1991) was tested in the field over two seasons and shown to improve spray timing and reduce fungicide inputs without compromising disease control (Tate and Manktelow 1992). This was made possible by the development of a system for predicting infection periods (IPs) during spring months (Tate 1993), which enabled spray timing to be coupled to IPs (Tate *et al.* 1994). Since 1992, similar spray timing for peach rust (PR, *Tranzschelia discolor* (Fuckel.)Tranz. & Litv.) control has also been investigated. This paper summarises research data and experience gained since 1990 in the development of an improved spray timing system for both diseases in process peach.

MATERIALS AND METHODS

Experimental design

In the 1990-1992 seasons a single commercial Golden Queen (GQ) peach orchard was split into two large blocks to compare standard spray timing (calendar and growth-stage based) and responsive spraying (infection period based) (Tate and Manktelow 1992). In 1992-93 two orchards on responsive programmes were compared with ten others on standard programmes. In 1993-94, 10 matched pairs (tree age, size, spacing, training) of orchards spanning the Heretaunga Plains were used to compare these programmes. In 1994-95, five orchards on responsive programmes for BR and PR suppression were compared with five other orchards on standard programmes.

In each trial orchard, large blocks (7-21 rows of trees) were used to eliminate airblast spray-drift effects. Growth stage timing, inoculum and disease levels for each block were assessed in 5-15, well-separated monitoring trees spread along the centre row.

Fungicides and spray timing

Fungicides used were those recommended for fresh export peaches and included thiram, chlorothalonil (Bravo), cyproconazole (Alto), bitertanol (Baycor), flusilazol (Nustar) and difenoconozole (Score) for BR blossom blight, wettable sulphur (eg. Kumulus) and triforine (Saprol) for PR, and iprodione (Rovral) and triforine (Saprol) for BR fruit rot suppression. All were applied at standard label rates in high volume airblast applications (1000-2500 litres/ha).

Standard spraying followed 5-7 day spray intervals over flowering for BR blossom blight control, 3-4 weekly spraying from October to mid-February for PR control, and weekly preharvest sprays plus 1-2 sprays between picks, for BR fruit rot control.

Responsive spraying focused on pre-infection application of protectant fungicides. Growers on responsive programmes had telephone access to daily IP forecasts (Tate 1993) and were faxed spray warnings and weather situation prognosis maps. If an IP occurred that was not forecast growers were warned to apply a post-infection spray when eradication was feasible.

Monitoring tree growth stage, fungus inoculum, IPs, disease and weather

For each monitored tree, percentage of open flowers were estimated at 3-4 day intervals over bloom and sources of *M. fructicola* and *T. discolor* inoculum searched for to assist in spray timing. Diseases (BR and PR) and number of sprays applied were also recorded to assist in spraying decisions and to assess results.

Leaf wetness duration, rainfall and temperature were continuously logged at five automatic weather stations sited 1-3 km from each trial site and downloaded daily by telephone. BR and PR IPs were identified immediately after they occurred by computerised infection models. Each infection monitor graphically summarised the previous weeks' weather factors and IP risk levels. The infection models were derived from published infection criteria (respectively Weaver 1950; Anon. 1990). The brown rot model appeared to provide conservative but reliable records of IPs. Validation work (unpublished) indicated no missed IPs but occasional IPs where no disease developed, indicating either excessive model sensitivity or a lack of inoculum. The PR model (based on prune rust criteria) appeared to be much too sensitive, recording most rainfalls as IPs in the absence of any new infections. For this reason only medium to high risk IPs were used in spray timing and assessment of results.

IP monitoring enabled immediate post-infection spraying in the responsive blocks if 1) an IP was missed, 2) existing fungicide cover was considered inadequate and 3) eradication was possible. Blossom infections could be eradicated with triazole fungicides if they had not advanced beyond the flower filaments, and PR infections by triforine within a day or two. Eradication was not considered possible for BR infections in maturing fruit, and IP-responsive growers tended towards standard spray timing during preharvest in the earlier seasons.

RESULTS AND DISCUSSION

Weather, tree phenology and IP incidence from 1990 to 1995

Hawke's Bay weather initially became wetter and cooler from spring 1990 to autumn 1993, then progressively drier and warmer to autumn 1995 (Table 1). For example, while only one IP occurred during bloom in 1990, it rained every day during bloom in 1992, producing eight BR IPs. In addition, one screen frost occurred during bloom 1990, compared with seven in 1992 and three in 1994. While August to December during 1992-1993 was extremely wet and cool, the same period in 1994 recorded below average rainfall and higher daily temperatures, resulting in a serious drought.

Tree phenology varied between the seasons; first GQ blossoms opened from mid-August to early September, and first harvest occurred from 23 February to 10 March. The bloom and harvest periods usually spanned about 30 days each, but in the wet spring of 1992, bloom spanned a 45 day period. IP numbers varied over the seasons, with a range of 1-12 BR IPs recorded over bloom and 4-7 during preharvest (Table 1), while 11-22 medium to high risk PR IPs were recorded from between November and mid-February (Table 2).

Infection period forecasting, spray usage and disease development

Brown rot (BR): Over the five seasons, 41% of rainfall events during bloom initiated IPs, compared with 67% from 3 weeks preharvest to final pick (Table 1). This increase was due to higher temperatures at harvest, resulting in a greater potential for brief rainfalls to produce IPs. Numbers of IPs over the seasons ranged from 1-12 during bloom, and 4-7 from 3 weeks preharvest to final pick, with 6.8 and 5.8

respectively on average. Half of those at bloom and two thirds at pre-harvest required pre-infection sprays. Some additional IPs associated with dewfall were recorded. These were not predicted, but all occurred over the green fruit stage where they would be of little significance.

Forecasting accuracy for key IPs was 88% for bloom and 84% from 3 weeks preharvest to final pick (Table 1). Average lead-time for pre-infection spraying was 1.5 days over bloom and 1.3 days over harvest (range of 0.5-3 days for both). On average less than one false-positive (IP did not occur) or false-negative (missed IP) forecast was made each season.

TABLE 1: Brown rot (BR) infection period (IP) frequency, forecast accuracy, number of sprays applied and BR incidence over five seasons.

Variable	Growth stage/ spray timing	Seasons 1990-1	1991-2	1992-3	1993-4	1994-5	Means
No. of rainfalls	Bloom	6	9	36	16	17	16.8
	Harvest[1]	6	6	9	10	13	8.8
mm rain	Bloom to harvest	307	398	678	283	203	374
No. IPs recorded	Bloom	2	6	8	7	12	6.8
	Harvest	6	4	5	7	7	5.8
No. key IPs[2]	Bloom	2	4	4	3	4	3.4
	Harvest	3	3	4	5	4	3.8
No. these predicted	Bloom	1[3]	4	4	3	3	3.0
	Harvest	3	3	3	4	3	3.2
No. false negatives	Bloom	0	0	2[4]	0	1	0.6
	Harvest	0	0	1	2	1	0.8
No. false positives	Bloom	0	0	2	1	0	0.6
	Harvest	0	1	0	0	0	0.2
Mean days lead time	Bloom	ND[5]	ND	1.3	1.6	1.7	1.5
	Harvest	ND	ND	1.0	1.0	2.0	1.3
Total BR sprays	Standard	8	10	9	6.5	5.8	8.4
	Responsive	5	8	8	5.8	4.0	6.7
% BR/tree 1st pick[6]	Standard	0.1(0.0)	3.5(0.5)	0.9(0.1)	0.1(0.0)	0.2(0.1)	1.0(0.6)
	Responsive	0.5(0.2)	4.2(0.5)	0.8(0.1)	0.1(0.0)	0.3(0.1)	1.2(0.7)
% BR/tree last pick	Standard	0.5	12.1	ND	0.14	0.7	3.4
	Responsive	0.9	11.9	ND	0.19	0.5	3.4

[1] Refers to the period from 3 weeks preharvest to last pick
[2] Requiring protective sprays. Factors considered were IP severity, growth stage, inoculum levels, blossom opening, fruit split, rain wash off and fungicide attributes
[3] This trial started 1 week after first blossom opened and the first IP had already occurred
[4] Both were marginal IPs initiated by a shower in early evening
[5] ND = not determined
[6] Data in brackets are standard errors

On average 6.7 responsive BR sprays were applied each season compared to 8.4 standard sprays, a saving of 1.7 sprays per season (approximately $130/ha). This more than compensated for the slightly higher (0.2%) average BR levels at first harvest in the responsive compared with the standard blocks (a reduction in gross revenue of $25/ha). At final harvest, however, BR levels were similar in both programmes. This indicates that the fewer responsive sprays applied were more effectively timed than the standard sprays.

While our IP forecasts tended to underpredict key BR IPs, this is an advantage in wet seasons as most rainfalls not constituting IPs are disregarded, enabling spray warnings to be focused on key IPs. A disadvantage of underprediction of IPs is that post-infection sprays are necessary to eradicate IPs that are missed. At bloom, blossom filament infections that escape prediction (usually marginal ones caused by overnight showers) are easily eradicated by a DMI fungicide application the next day and at pre-harvest, adding spraying oil to dicarboximides confers some eradicative ability (Tate, unpublished data).

Peach rust (PR): In the first two seasons the PR disease cycle in Hawke's Bay was not well understood and no attempt was made to compare differential spray timings. PR is considered to be an inoculum-driven disease (R. Beresford, pers. comm.), and caution is required in following a weather-based spray programme. Disease monitoring (Tate unpublished) has shown that first appearance of PR uredospores is delayed by several months by DMI bloom sprays, so that the first infections may not occur until December or later. A key requirement for timing the first spray, therefore, is a reliable method for identifying the first appearance of uredospores. In the absence of such a method, most growers apply their first PR spray by early November. This provides an insurance against an early IP being missed, which would be dangerous for an inoculum-driven disease.

TABLE 2: Accuracy of peach rust (PR) infection period (IP) forecasts in relation to spray use and disease development.

Variable	Spray timing treatment	1990-1	1991-2	1992-3	1993-4	1994-5	Means
No. of rainfalls[1]		19	24	37	41	19	28
No. of PR IPs[2]		11	22	14	15	14	15.2
No. requiring sprays		4	5	5	5	5	4.8
No. of these predicted		-	3	3	5	2	3.3
No. of false negatives		-	2	2	0	3	1.8
No. of PR sprays applied[3]	Standard	4	3	7.2[4]	5.7	6.0	6.3
	Responsive	4	3	7.0	6.1	2.8	5.3
% leaf rust	Standard	26.5	tr	ND	tr	tr	-
	Responsive	25.1	tr	ND	tr	tr	-
% fruit rust	Standard	<1	tr	ND	ND	tr	-
	Responsive	<1	tr	ND	ND	ND	-

[1] Occurring during the PR spraying season (early November to mid February)
[2] Medium to high IP risk according to leaf rust infection model (Anonymous, 1990)
[3] Mean for two orchards in 1992-93, ten in 1993-94 and five in 1994-95. Overall means are for 1992-95 seasons only
[4] Mean for 10 orchards; tr = trace (<0.001% PR); ND = non detectable

Over the five seasons, 54% of rainfall periods from early November to mid-February initiated medium to high risk IPs (Table 2). On average 4.8 IPs each season were considered to require pre-infection sprays and 3.3 (66%) were predicted. During the PR season, triforine can be used within a day or two of IPs to eradicate PR infections, providing a similar fallback option for unpredicted PR IPs. However this option can only be sparingly used without increasing selection pressure on DMI-resistant strains of *T. discolor*.

During 1992-95, 6.3 standard sprays were applied on average compared with 5.3 responsive sprays (range of 3-7 for both). As more is understood about the PR disease cycle in Hawke's Bay it is anticipated that further reductions in fungicide use will be achieved.

In 1990-91 the standard-only sprays were not well timed, resulting in significant leaf rust, but fruit rust levels were below the cannery rejection threshold. Over the next four seasons only a trace (<0.001%) or non-detectable leaf rust was recorded in each treatment and no fruit rust was detectable after autumn 1992 in responsive blocks. The absence of PR during 1992-94 was probably due to the higher number of sprays (6-7) applied. During 1993-94, more IP-responsive sprays than standard sprays were applied due to the higher number of rainfalls, while in the drier 1994-95 season, the number of responsive sprays applied was only half that of standard sprays. This reduction did not affect PR levels.

The increased spraying during 1992-94 probably reflects a preoccupation with PR by growers during wet years coupled with an insufficient understanding of the disease. Conversely, we believe the reduced spraying on responsive blocks in 1994-95 reflected grower confidence in the DMS and a better understanding of the disease by these growers.

Increased spraying is to be expected in responsive programmes in wet years, with increased efficiency in disease suppression. Conversely, in dry years reduced fungicide inputs can also be expected without compromising disease suppression. Standard programmes in Hawke's Bay became progressively more weather-based over the 1990-95 period as many growers adopted the weather-responsive spraying approach. This development reduced the contrast obtainable between the two spray timing treatments but also represented an endorsement of weather-responsive spraying.

Fungicide usage since 1990

A survey of spray programmes from an average of 113 growers per season (Table 3) shows that the average number of DMI, sulphur-based and dicarboximide sprays applied per season reflected quite accurately rainfall and IP numbers recorded during each growth period (Tables 1 and 2). Thus BR blossom blight and PR fungicide usage (mainly DMIs and sulphur respectively) increased from 1990 to 1993 then decreased again by 1994-95. Mean DMI and dicarboximide fungicide usage was lower in 1994-95 than in 1990-91 despite more recorded IPs, suggesting a partial adoption by industry of responsive spraying. However, some growers greatly exceeded these means for each fungicide group, indicating that considerable room for improvement exists. Sulphur-based fungicide usage in 1994-95 was higher than in 1990-91, reflecting the higher number of PR IPs. The use of DMI fungicides from 1990 to 1994 exceeded the maximum of three applications per season recommended in the resistance management strategy for stonefruit (Prince *et al.* 1989) and cannot be considered a sustainable practice.

TABLE 3: Mean number[1] of fungicide applications per orchard per season since 1990.

Growing season No. of orchards	1990-91 83	1991-92 114	1992-93 122	1993-94 115	1994-95 132
DMIs	4.3	4.4	4.8	3.3	3.5
sulphur-based	3.8	5.1	6.1	5.6	4.0
dicarboximides[2]	2.3	2.0	1.7	2.2	1.8

[1] Data for each fungicide (group) excludes growers applying zero sprays of that fungicide (group)

[2] Data up to harvest 1994 is estimated (spray programmes as received were incomplete)

Based on the level of BR and PR suppression obtained with fewer sprays in the trial blocks, the process peach and summerfruit industries should benefit by full adoption of weather-responsive spraying as part of a DMS which also emphasises cultural methods such as removal of inoculum sources from trees. Responsible fungicide usage by producers should also assist in promoting the 'clean green' marketing image of the processing and summerfruit industries.

ACKNOWLEDGEMENTS

Computer programming by Andrew Hodson; technical assistance by Larry Morgan and Isabelle Sorenson; the co-operation of John Morton and Chris Simpkin (Rex Graham and Associates Ltd) and the many growers involved in providing trial blocks, following responsive spray programmes and providing spray programmes for analysis is gratefully acknowledged. This work was jointly funded by J.Wattie Foods Ltd, the New Zealand Fruitgrowers Federation (Summerfruit Sector) and the Crown.

REFERENCES

Anonymous, 1990. Prune rust infection prediction service. Technical Manual. Biological and Chemical Research Institute, New South Wales Agriculture and Fisheries. 59 pp.

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

Manktelow, D.W., and Tate, K.G., 1991. Development of disease management systems (DMS) for Hawkes Bay pip and stone fruit production. *Proc. 44th N.Z. Weed and Pest Control Conf.:* 216-219.

Prince, R.W., Moore, M.S., and Wearing, C.H., 1989. The New Zealand committee on pesticide resistance 1989 summary. *Proc. 42nd Weed and Pest Control Conf.:* 278-292.

Tate, K.G., and Manktelow, D.W., 1992. Field evaluation of a disease management system for peach brown rot in Hawkes Bay. *Proc. 45th N.Z. Plant Protection Conf.:* 129-135.

Tate, K.G., 1993. Infection-period prediction for improved orchard disease management in Hawkes Bay. *Proc. Annual Convention 1993, N.Z. Institute of Horticultural Science:* 33 (Abstract).

Tate, K.G., Wood, P.J., and Manktelow, D.W., 1994. Pre- versus post-infection spraying for control of wet weather diseases in horticulture. *Proc. Annual Convention 1994, N.Z. Institute of Horticultural Science:* 29 (Abstract).

Weaver, L.O., 1950. Effect of temperature and relative humidity on occurrence of blossom blight of stone fruit. *Phytopathology 40*: 1136-1153.