PHYTOTOXICITY TO KIWIFRUIT OF OIL SPRAYED AFTER FLOWERING

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SUMMARY

The risk of phytotoxic damage to kiwifruit by a mineral oil was evaluated. Single sprays of 1%, 2%, and 4% oil were applied at three different periods during the growing season, and under different conditions of humidity and temperature. Currently 1% is recommended for field use. Fruit were damaged when sprays were applied during a sensitive period, particularly in early January. Slow drying conditions and high concentrations of oil increased both the amount and severity of damage. The oil was used safely in early December and in February.
Keywords: kiwifruit, mineral oil, phytotoxicity.

INTRODUCTION

As attitudes to pesticide use and residues change, so too must the methods used by New Zealand kiwifruit growers to produce their crop. The days of calendar spraying with organophosphates are numbered as the international demand for low or no residue fruit increases. The options for pest management must be extended to include effective alternatives that do not leave undesirable residues.

Such alternatives (eg. *Bacillus thuringiensis*) are already available to control leafrollers, so that the problem lies with finding a complementary means of combatting the other major pests, the armoured scales, principally greedy scale *Hemiberlesia rapax* and latania scale *H. lataniae*.

Mineral oils do not leave unacceptable residues and are known to be effective in controlling scale insects on many fruit crops. However, a series of trials in the early 1970s showed that kiwifruit could be damaged by oil sprayed onto growing or dormant vines (Ford 1971; Sale 1972). Fear of phytotoxic damage has since prevented the use of oils on kiwifruit.

Later, after field damage had occurred, Green (1988) showed that kiwifruit were susceptible to fruit russetting when the organophosphate chlorpyrifos was sprayed onto fruit during a period of rapid expansion.

Experience with other crops, especially citrus, has shown that susceptibility to damage from oils is influenced by the type of oil used (Chapman *et al.* 1962), the weather conditions when the spray is applied, and the concentration of oil used (Grossman 1990). Plants under moisture stress can also be more at risk of damage (Grossman 1990).

Ultrafine oil, highly refined with a narrow distillation range, has been developed in the USA for use on sensitive glasshouse crops, and so we thought that such an oil had potential for use on kiwifruit. Our research was designed to determine the risk of this oil damaging the kiwifruit when used at different periods in the growing season, and under different conditions of temperature and humidity.

METHODS

The trial was carried out at the Te Puke Research Orchard in a previously unsprayed block of kiwifruit, cv. Hayward, trained on a T-bar structure. The block was not irrigated, but adequate rainfall during the trial period ensured that the vines were not suffering from moisture stress (88.8 mm in December, 173 mm in January).

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Two test periods were used for the main part of the trial; 15-16 December, 1991, and 8-10 January, 1992. The dates were chosen to coincide with the period of fruit susceptibility to damage from the insecticide chlorpyrifos (Green 1988).

Three concentrations of oil (Sunspray Ultrafine at 1%, 2% and 4%), were compared to an unsprayed control. Single sprays were applied at three separate times during each test period. Times were chosen with different temperatures, relative humidities and cloud cover, to give either fast or slow drying conditions (Table 1). Air temperature and humidity were measured using probes placed beneath the canopy in the region of the fruit. These probes (thermistor and Vaisala types for temperature and humidity respectively) monitored conditions every 15 minutes from 2 days before the first application to 3 days after the final application. Each single vine plot was sprayed only once and for each application time there were four replicates in a randomised block design. The sprays were applied to runoff (approximately 6 litres per vine) using a handgun from a small-plot sprayer.

The trial was extended by adding a third test period, February 10-13, 1992, in response to the results obtained from January applications. Treatments were as before, but there were only two replicates in a randomised block design. This extension was carried out in a neighbouring block of vines which, in addition, received blanket sprays of 1% oil on the following dates; 11-12-91, 16-1-92, 4-2-92, and 13-3-92.

Assessment for phytotoxicity involved visually inspecting whole vines and fruit for any darkening or marking of fruit or leaves, especially black speckling on the fruit. This was done daily for the 5 days immediately after spraying, and thereafter periodically to detect injury not immediately apparent.

Eight weeks after each test period, random samples of 100 fruit were picked from each plot sprayed in that period and scored for severity of damage using five categories:-

1. Nil — No visible damage
2. Light — A few light coloured speckles spread over < 1 cm^2 and generally confined to stamen end of fruit.
3. Moderate — Black speckles spread over 1-3 cm^2 at stamen end of fruit and/or on side.
4. Heavy — Extensive speckling merging to blackening at stamen end of fruit. Some speckling also present on side of fruit.
5. Severe — Extensive speckling merging to blackening at stamen end of fruit and side of fruit.

Fruit in the heavy and severe categories are unacceptable for export.

Analyses of variance and Duncan's Multiple Range tests were done on angular transformed data of total damage using the computer programme M-Stat (Michigan State University). However the figures tabled are means calculated from raw percentages. The severity categories were scored (category 1 = 0, 2 = 1, 3 = 2, 4 = 4, and 5 = 6) and the scores analysed in a two-way anova.

RESULTS

The average weather conditions during each application are shown in Table 1. These confirm that in each test period two sprays were applied when conditions would give slow drying and one when drying would be fast.

No damage to fruit or leaves was observed on any of the vines sprayed in December.

For 5 days after the January applications no damage was apparent. However, at the next inspection 10 days later, phytotoxicity was noticeable. This damage was restricted to the fruit and showed up as a dark speckling merging to blackening in the worst cases. The percentage of fruit damaged increased with the concentration of oil used, regardless of the weather conditions at application (Table 2). Six times as much fruit was damaged with 4% oil as with the 1% oil. Analysis showed that the mean total number damaged for each concentration was significantly different from every other concentration ($P < 0.05$).

TABLE 1: Application times and the average weather conditions during each period.

Date	Spraying time	Temperature (°C)	Humidity (%RH)	Cloud cover	Drying rate
		Test Period 1			
16.12.91	06.10 - 06.55	11.0	84.9	80%	slow
16.12.91	13.15 - 13.55	20.2	38.8	30%	fast
16.12.91	20.15 - 20.55	12.1	81.3	95%	slow
		Test Period 2			
8.1.92	14.25 - 15.15	25.5	55.2	30%	fast
8.1.92	20.00 - 20.50	19.0	74.8	30%	slow
10.1.92	05.50 - 06.35	13.8	88.1	0	slow
		Test Period 3			
10.2.92	15.20 - 16.00	26.1	54.0	10%	fast
10.2.92	20.20 - 20.50	19.7	74.0	0	slow
13.2.92	06.15 - 06.45	10.2	95.0	0	slow

TABLE 2: The percentage of fruit damaged, and the severity of damage, on kiwifruit sprayed with oil in January.

Damage Category	Unsprayed control	Concentration of oil 1%	2%	4%
Nil	100	91	71	46
Light		8	10	7
Moderate		1	13	12
Heavy			6	28
Severe				7

The treatments with the highest incidence of damage also had the greatest proportion of damage in the "heavy" and "severe" categories. In the 4% treatment 35% of the fruit were rendered unacceptable for export, compared with no unacceptable fruit in either the 1% treatment or the unsprayed control. Oil at 2% gave unacceptable damage on 6% of the fruit.

The weather conditions during and after application in January also affected the amount and severity of damage. Application 3, applied in the morning when the average temperature was 13.8°C and the relative humidity was 88.1%, resulted in most damage. This spray caused marking on 40% of the fruit, half of which were unacceptable for export. Oil was also applied under slow drying conditions in the evening (Application 2; 19°C, 74.8%RH). Slightly fewer fruit were damaged by this spray than by Application 3 - 32% damaged and 16% lost from export - but the difference was not significant.

Spraying oil under fast drying conditions (Application 1) caused damage on 20% of the fruit, but only 4% would have been automatically rejected from export. This result was significantly lower than for Applications 2 and 3 only for the 4% concentration of oil ($P<0.05$). There was thus an interaction between spraying under fast or slow drying conditions in January and the concentration of oil used. This was confirmed by the two-way analysis of damage scores ($P=0.01$ for interaction).

Three weeks after the February test period minor damage was observed on some vines. For this test period the concentration of oil used significantly altered the percentage of fruit damaged, but not the severity (Table 3). Of the total damage recorded, 92% was light and 8% moderate. No fruit suffered heavy or severe damage. In the unsprayed control, 2% of the fruit had light damage showing that a trace of the damage in all treatments was actually due to one or more of the oil sprays applied to the whole block.

TABLE 3: The percentage of fruit damaged and the severity of damage on kiwifruit sprayed with oil in February.

Damage category	Unsprayed control	Concentration of oil 1%	2%	4%
Nil	98	92	82	77
Light	2	8	17	20
Moderate			1	3

The percentages of fruit damaged using 4% and 2% oil were significantly higher than in the unsprayed control (P<0.05). The 1% treatment was significantly different only from the 4% treatment (P<0.05).

Analysis of the damage from each application time in February showed that differences between the morning, afternoon, and evening sprays were not significant (P<0.05).

DISCUSSION

The results showed that there is a period when kiwifruit are highly susceptible to damage from sprays of this mineral oil. In the December tests, 7 days after flowering had finished, there was no damage even with a 4% spray. However, considerable fruit marking was caused in January, especially by the 4% and 2% rates; while in February damage was much less and of a minor nature only.

Thus the sensitive period does not begin at fruit set, but only after an interval of at least 7 days after petal fall. It is largely finished 8 weeks later, in early February.

Sensitivity to damage would appear to follow the truncated normal curve described by Green (1988) for chlorpyrifos damage. Applying oil at high rates during the sensitive period will almost certainly cause damage to fruit, although damage will not be apparent for 2 to 3 weeks. After January fruit will be largely resistant to phytotoxicity. Not spraying during the sensitive period is unlikely to compromise scale control because scale does not move on to the fruit until late January or early February (M.G. Hill, pers. comm.).

The risk of damage during the sensitive period increased when drying was slow. Although precise measurements of drying time were not made, when the vines were still wet 2.5 - 3 hours after spraying began, the proportion of fruit damaged and the severity of damage were both increased. By comparison, if the spray was dry within about 30 minutes there was significantly less damage.

Another factor influencing the risk of damage was the concentration of oil applied. The 1% concentration did not cause damage that would have resulted in fruit being rejected from export, even when applied during the sensitive period. This concentration is currently being recommended for use. At higher rates the incidence and severity of damage increased. The 4% rate, which caused the worst damage, is unlikely to ever be used in a commercial situation because of the cost. It was included expressly to test the margin of safety before damage would occur, and the results obtained using this rate have helped determine what environmental factors trigger damage.

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REFERENCES

Chapman, P.J., Lienk, S.E., Avens, A.W. and White, R.W., 1962. Selection of a plant spray oil combining full pesticidal efficiency with minimum plant injury hazards. *J. Econ. Ent. 55*: 737 - 744.

Ford, I., 1971. Control of greedy scale on chinese gooseberries. *The Orchardist of N.Z. 44*: 97-99.

Green, A., 1988. Kiwifruit have their tender moments. *N.Z. Kiwifruit. 50*: 6-7.

Grossman, J., 1990. Horticultural oils: New summer uses on ornamental plant pests. *The IPM Practitioner 12*: 1-10.

Sale, P.R. 1972. Oil and chinese gooseberries do not agree. *The Orchardist of N.Z. 45*: 30 - 31.