EFFECTS OF PACLOBUTRAZOL ON AVOCADO AND KIWIFRUIT

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SUMMARY

In trials on 4-7 year old avocado (cv. Hass), paclobutrazol applied at 0.2-1.2 g/m² of canopy profile, in a narrow furrow encircling the trunk, reduced shoot lengths by 20-40% and overall tree profile at one site by 50% in 18 months. In pilot trials on 3-5 year old kiwifruit (cv. Hayward) paclobutrazol applied as a soil drench to irrigation dripper zones, and as encircling narrow band treatments, increased the number of potential fruit buds and individual fruit weights and strengthened canes at the base. High rates of 5.0-7.5 g/vine affected fruit shape, size and maturity in the first year of treatment. In the second year after treatment rates of 1.25-5.0 g/vine advanced maturity and increased fruit weights.

INTRODUCTION

Subtropical crops, particularly kiwifruit (*Actinidia deliciosa*) and avocado (*Persea americana*), grown in well drained New Zealand soils tend to produce over-vigorous vegetative growth leading to high pruning costs, high picking costs and often poor fruit set. Paclobutrazol, a synthetic plant growth regulator, inhibits the biosynthesis of gibberellins, thereby reducing cell expansion in developing tissue. This effect restricts vegetative growth, leading to more plant assimilates being redirected into bud development, reproductive tissue and ultimately fruit.

Paclobutrazol has been extensively tested on pome and stonefruit crops worldwide and is currently registered for commercial fruit crop use in eight countries including New Zealand. Here it is registered for use on cherry and apricot crops, and has a limited sales permit for use on peach and nectarine crops.

Published information on the use of paclobutrazol on subtropical fruits in New Zealand has been limited to kiwifruit (Leonard 1986; Davison and Martin 1985; Henzell and Briscoe 1985). Little is known about the effects of plant growth regulators on New Zealand avocados, but Sale (1986) and Pringle (1984) have stated that tree control is necessary for this crop under New Zealand conditions.

Early research work on kiwifruit (Davison and Martin 1985) illustrated difficulties in getting paclobutrazol into the kiwifruit vines by soil application, a simple method proven successful in stonefruit crops (Leonard *et al* 1988). This led to a radio tracer study on kiwifruit at ICI's Jealotts Hill Research Centre in the UK. This trial, which used high rates of 0.05 mg/pot (10 kg/ha), indicated that paclobutrazol as a soil drench could be taken up by kiwifruit, but was not accumulated at the shoot apex in the same concentrations as found in other crops when used at comparable rates (S. Denness — pers. comm.). Relatively high rates were therefore chosen for these pilot trials.

This paper summarises two sets of preliminary trials in the Bay of Plenty and Gisborne investigating the effects of paclobutrazol on avocado and kiwifruit.

MATERIALS AND METHODS

With the exception of one observational trial on kiwifruit using a methanol based formulation designed for trunk injection, the paclobutrazol used in these trials was a 250 grams/litre suspension concentrate (Cultar). The methanol based formulation (Clipper) contained 20.0 g/litre paclobutrazol.

Avocado

Trials 1 and 2 were sited on Katikati black sandy loam based on a volcanic Waihi ash. The trees were 5 and 4 years old respectively and, planted at 270/ha, were growing

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vigorously. Trial 3 was sited at Ormond, Gisborne on Matawhero silt loam. The trees, 7 years old and planted at 200/ha, were nearly meeting in the row at time of treatment.

Dosage rates were determined by a formula (ICI UK.C.H Voon pers. comm.) which uses height $\times$ maximum width to give a profile area. This formula which has worked successfully in South Africa and Australia is one way of determining a dose rate for trees which vary widely in size. Using this method a range of rates 0.2 to 1.2 g/m² of profile which amounted to, from 2.4 to 14.5 g/tree were used. Per tree doses were diluted in 1-5 litres water and poured evenly around a hand grubbed 2 cm deep furrow, encircling the trunk at a 0.5 m radius. The higher water rate was used on dry soils in the autumn application. The treatments were applied in September 1986 in Trial 1, April 1987 in Trial 2 and August 1987 in Trial 3.

In the two Katikati trials, five to ten shoots per tree (40/replicate) and two per tree (10/replicate) at the Gisborne trial, were tagged and measured at treatment. The shoots were well distributed through the canopy. New extension growth was measured on Trial 1 at 99 and 221 days after treatment (DAT) respectively.

Original profile size was compared to later assessments of size. All fruit on treated trees at Katikati were harvested and graded through a commercial packhouse to ascertain export sizes.

Kiwifruit

Three trials (G1, G2, G3) were sited near sea level on Katikati black sandy loam, based on volcanic Waihi ash. The site was contoured, with some vines stressed as a result of soil problems. This site was chosen because of the grower's effective irrigation/fertigation system, ensuring that the feeding roots were well developed under the dripper points. Vines were 3 or 4 years old, intensively planted with male rows on both sides of a female row, to achieve 700 vines/ha, pergola trained.

Two trials (P and T) were on Kaharoa ash soils, a light, deep, free draining volcanic soil typical of the major growing areas in New Zealand. Trial P site was equipped with a sprinkler irrigation system and the paclobutrazol was applied in a 2 cm-deep furrow, drawn in a radius 0.5 m from the stem. Vines were 4 years old, widely spaced at 285 vines/ha, with male rows each side of a female row, and pergola trained. Trial T had a trickle irrigation system, and was on 5 year old pergola trained vines (300/ha).

On four trials (G1, G2, G3, and T), paclobutrazol was applied to the dripper zone, in 1 litre of water, the site having been lightly forked to aid even penetration of the dose. On Trial P, 2 litres of water were used to distribute the dose evenly around the circular furrow and application was followed by 2 hours of sprinkler irrigation. Rates used ranged from 1.25 to 7.5 g/vine (0.75 kg/ha — 5.2 kg/ha). Applications were made in spring 1986 (G1), autumn 1987 (G2, P, T) and spring 1987 (G3).

Rates of 0.7 to 2.1 g/vine were tried in the trunk injection observational trial laid down in Spring 1987, on 3 and 4 year old vines alongside the soil trials at Katikati. An LPG powered gun was used to inject 35 ml doses into 1, 2 or 3 pre-drilled holes in the kiwifruit trunks just above the graft union.

Buds in the first metre of replacement cane were counted in Trials G1 and P. Total buds/vine and per first metre were counted in Trial G2.

Trial G1 treated in spring 1986, was harvested completely in 1988, all fruit graded and samples taken for fruit maturity and fruit shape characteristics. The other four trials were randomly sampled in the field (50-100 fruit per vine), graded at the DSIR Te Puke orchard for export fruit size, and measured for fruit shape characteristics and maturity. Samples for residue analysis were also taken. Fruit maturity was measured using the Brix test to assess percentage soluble solid levels at relative maturity. Trials G3 and T were not measured for buds, only fruit characteristics.

RESULTS

Avocado

The effects of paclobutrazol on growth of avocado in Trial 1, are shown in Table 1. In all three trials soil applications to a shallow 2 cm furrow encircling the trunk at a 0.5 m radius were successful in reducing avocado vegetation growth without the aid of irrigation. The April application in Trial 2 appeared to have a more uniform result than the mid-September application in Trial 1 where a number of vigorous shoots had

'escaped' before the paclobutrazol had entered the tree. Percent reduction in shoot growth in Trial 2 was 55% in the 1.2 g/m² treatment 231 DAT and, in Trial 3 on 7 year old trees was 22% at 0.4 g/m², 126 DAT.

Tree profile comparisons before and after application in Trials 1 and 3 demonstrated paclobutrazol's effect in holding trees to manageable sizes (Table 2).

Yield 18 months after treatment with paclobutrazol at 0.8 g/m² in September 1986 was 17.4 kg/tree compared with 9 kg/tree in the untreated controls. Fruit size was not affected, with all treatments predominantly in the "20" size export grade.

TABLE 1: The effect of paclobutrazol on non-fruiting vegetative shoots of avocado in Trial 1 (Measured 99, 221 and 548 days after treatment)

Treatment g ai/m ²	Average increase in tagged shoots (cm)		% Shoot length increase (cm)		Other shoots (cm)	% Shoot reduction compared to untreated
	99 DAT	221 DAT	99 DAT	221 DAT	548 DAT	548 DAT
Untreated	12.8aA	14.8aA	26.6aA	29.6aA	69.7	—
0.4	9.1AB	8.9bB	19.4bAB	19.1bB	45.4	34.8
0.8	7.6B	7.9bB	17.3bB	17.8bB	39.7	43.0
M.S.D.(5%) =	2.91	2.78	5.72	5.43		
M.S.D.(1%) =	4.40	4.22	8.66	8.22		
C.V.% =	17.09	15.26	15.66	14.16		

TABLE 2: The effect of paclobutrazol on tree profile of avocado (cv Hass)

Treatment (g ai/m ²)	Profile (m ²)		% Increase in Profile (Max height × max width) m ²
	Before	548 DAT	
Trial One (5 year trees)	15.9.86	16.3.88	548 DAT
Untreated	12.9	24.8	92
0.4	12.5	18.1	45
0.8	13.3	21.2	59
Trial Three (7 year trees)	30.8.87	10.1.88	126 DAT
Untreated	23.7	30.2	27
0.2	23.2	27.7	19
0.4	23.8	26.6	20

Kiwifruit

These kiwifruit trials demonstrated that paclobutrazol can be taken up by young vines, 3 to 6 years old, from soil applications using dripper and sprinkler irrigation systems in either spring or autumn. Young vegetative replacement canes were reduced in length, and average diameter, but were strengthened at the base when assessed visually, an advantage predicted by Henzell and Briscoe (1985). Numbers of replacement canes were not affected by paclobutrazol.

The numbers of potential fruiting buds were greatly enhanced, particularly in the first metre of replacement cane from the centre leader (Table 3). The number of buds on fruiting spurs was also increased, when measured 411 days after treatment in Trial P with untreated vines having an average 4.3 spurs and 38 buds, compared to 14.6 spurs and 171 buds following application of 3.0 g/vine.

TABLE 3: Effect of paclobutrazol on the number of potential fruiting buds of kiwifruit

	Treatment g ai/vine	No. of Canes*	Buds range/m	Mean buds /metre**	% Increase in buds over untreated
Trial G1	Untreated	11.8	7-13	8.96	—
Applied Spring 1986.	1.25	10.1	9-20	12.23	36.5
Counted 248 DAT	2.50	10.1	9-18	12.86	43.5
(16.6.87)—Mean of six vines.	5.00	11.0	9-23	13.20	47.3
Trial G2	Untreated	22.4	7-11	8.59	—
Applied Autumn 1987.	2.0	17.6	9-35	11.53	34.2
Counted 217 DAT	3.0	25.8	9-16	11.91	38.6
(22.10.86)—Mean of five vines	5.0	26.0	8-16	13.20	53.6
	7.5	23.8	8-21	14.71	71.2

* Only canes 1.0 m or more in length counted.

** Only buds in the first metre of replacement cane were counted in Trial G1, and total buds per vine and per first metre were counted in trial G2.

TABLE 4: Effect of paclobutrazol on maturity of kiwifruit in the season of treatment (Trial G3) and in the season after treatment (Trial G1) as measured by the Brix test (mean of 45 fruit).

TRIAL G3				TRIAL G1		
Treatment g ai/vine	Low	Brix % High	Mean	Low	Brix % High	Mean
untreated	5.2	7.8	6.32	5.5	7.0	6.25
1.25	5.4	8.0	6.31	6.1	7.5	6.93
2.50	5.0	7.2	5.67	6.1	7.2	6.77
5.00	5.0	6.1	5.54	5.9	8.0	6.77

An assessment of flowering time was made which showed that treated vines flowered 10 to 15 days earlier than untreated vines. In Trial G1 that effect was carried through to harvest in 1988 when treated vines gave a higher Brix test (Table 4). In contrast, relative maturity, based upon Brix tests, appeared to be delayed in the same season as paclobutrazol application in Trial G3 (Table 4). Clearly this aspect needs further investigation. Paclobutrazol at the rates used also influenced size and weight (Table 5). The very high rate of 7.5 g/vine reduced size on some low vigour vines in Trials P and T.

With fruit weight and size apparently advantaged by paclobutrazol at moderate rates, it was important to gauge as accurately as possible if fruit shape was influenced by treatment. A range of micrometer measurements were made on 20 to 50 fruit/vine, randomly selected throughout the vine. The short diameter, long diameter and length measurements were made to give a mean width as a percentage of length, a formula which can identify short fruit. A figure of 100 equals square fruit, and a lower figure equates to more oblong fruit.

In Trials G2 and G3 where high rates (5.0-7.5 g/vine) of paclobutrazol were used on young vines growing in light soils, fruit shape was affected (Table 6). On older vines and on heavier soils this effect was less marked, but was seen, also, on the observational trial with the methanol formulation injected directly into the stem. The high injected rate (2.1 g/vine) on 3 year old vines affected fruit shape as well as increasing buds whilst lower injected rates of 0.7 and 1.4 g/vine on 4 year old vines appeared to influence only bud numbers. This method of injecting paclobutrazol directly into the plant is worthy

of further investigation, particularly on older non-irrigated vines where root uptake has been less successful.

Samples taken at harvest for residue analysis from vines treated the previous spring with 1.25 and 2.5 g/vine showed paclobutrazol residues of less than 0.01 ppm. Where high rates of 5.0 and 7.5 g/vine were used, residues were below 0.1 ppm.

TABLE 5: Effect of paclobutrazol on kiwifruit weights and size from the 1988 harvest

Trial	Treatment g ai/vine	Fruit weight (g)	% in export fruit sizes	
			>33's	<42's
P Autumn 1987 (mean of 100 fruit)	0.	99	37.2	17.9
	3.0	105	57.1	4.6
	5.0	108	68.8	11.6
	7.5	107	40.5	28.5
G1 Spring 1986 (Whole vine)	0.	97	39.5	23.5
	1.25	118	86.4	3.9
	2.50	104	61.4	13.6
	5.00	120	86.9	4.0
T Autumn 1987 (Mean of 100 fruit)	0.	103	47.2	15.7
	3.0	112	64.0	12.2
	5.0	106	56.7	13.3
	7.5	103	50.3	21.9

TABLE 6: Effect of paclobutrazol on kiwifruit shape (mean of 100 fruit)

Treatment g ai/vine	Mean width as % of length	
	G1 Spring 1986	G3 Spring 1987
Untreated	79.5	79.7
1.25	81.1 NS	80.4 NS
2.50	79.4 NS	81.7 NS
5.00	80.1 *	82.1 *
		P Autumn 1987
Untreated	81.1	81.9
2.0	81.8 NS	—
3.0	82.3 NS	81.6 NS
5.0	83.6 NS	80.6 NS
7.5	86.3 *	81.4 NS

NS not significantly different from untreated

* significantly different from untreated at the 5% level

DISCUSSION

As pointed out by Wilton (1985) the New Zealand fruit industry is largely export orientated and, in terms of chemical residues, export fruit must meet the requirements of the industry's overseas customers. Because paclobutrazol is xylem-transported, practically no residues would be expected from soil application and this has been confirmed by residue analyses of whole kiwifruit.

Trials described in this paper demonstrate that soil application of paclobutrazol to young avocado and kiwifruit can be successful if concentrated at irrigation dripper zones or confined in a narrow band 0.5 m around the trunk of plants. This technique of concentrating the active ingredient in a band to increase uptake is well known in the fertiliser industry (Duley 1930, Peterson 1964). The dispersal of the paclobutrazol dose

over 4 m² around vines could, in part, help explain earlier failures on kiwifruit when paclobutrazol was used as a soil treatment (Davison and Martin 1985, Henzell and Briscoe 1985).

In kiwifruit, increases in potential fruit buds/metre of replacement cane occurred at 1.25 and 2.5 g/vine, without deleterious effects on fruit size or shape. Rates higher than this gave no greater advantage and may affect fruit shape. The increase in potential fruit buds particularly in the first metre of replacement cane is an exciting possibility. It is an area of the vine normally fairly bare of buds, so an increase would be highly desirable, particularly if the observed cane strength can assist preservation of replacement canes in wind prone areas where blow outs of renewal canes are common. These preliminary trials serve as a guide to the choice of a rate range for more research in the future.

In avocado the 1.2 g/m² of profile appears unnecessarily high as lower rates achieved similar reductions in growth. After 18 months both the 0.4 and 0.8 g/m² rates are still affecting avocado growth significantly, indicating that a 2 year effect can be achieved from these rates. The lower dose of 0.2 g/m² may also reduce growth for longer than one season.

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