Effect of paclobutrazol on growth and flowering of lychee (*Litchi chinesis*)

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Summary. The effects of either foliar (1.00–4.00 g/L) or soil applications (0.25–1.00 g/m^2 tree ground cover) of paclobutrazol, during autumn, on vegetative flushing and flowering of 3 lychee (*Litchi chinensis*) cultivars (Bengal, Kwai May Pink and Tai So) were investigated over 3 years at 8 sites in subtropical southern Queensland. Cultivars at these sites varied in the level of vegetative flushing prior to panicle emergence in May–August and flowering in spring. Paclobutrazol reduced flushing and increased flowering in 5 out of 8 orchards, maintained dormancy and reduced flowering in 1 orchard, and had variable effects in 2 orchards, depending on the method of application.

The maximum level of flowering in paclobutrazol treated trees occurred when the control trees bloomed moderately (40–60% of terminal branches). The responses were sometimes weak when the trees were very vigorous (<30% bloom). Paclobutrazol had no significant effect or reduced flowering of heavily blooming (70–100% bloom) trees. Paclobutrazol had only a small effect on panicle development, fruit set and fruit quality at most sites. Yield reflected the flowering response to paclobutrazol, except when yields were lowered by excessive male flowering or bird damage to the fruit.

Introduction

One of the major concerns of lychee growers in subtropical areas of Australia is that yields are often irregular and frequently below the tree's bearing capacity (Menzel and Simpson 1987). The main reason for low, irregular cropping is excessive vegetative growth in the 1–2 months before panicle formation in May–July and, subsequently, poor flowering in spring (Menzel *et al.* 1988*a*). There can also be problems with poor fruit set and excessive fruit drop or splitting, but normally these do not reduce yields as severely as poor flowering (Menzel and Simpson 1990).

Rainfall and temperature conditions in subtropical Australia are adequate for growth of lychee trees during most of the year and nitrogen (N) nutrition is a major factor determining the vegetative flushing and flowering patterns in this environment (Menzel *et al.* 1988*a*). These authors suggested that leaf N concentrations should be below 1.8% N prior to panicle formation to inhibit vegetative growth and promote flowering, especially during warm, wet weather. Consequently, consistent flowering in lychee is best obtained in localities with cool, dry winters (especially when soil and leaf N reserves are high), or in other localities with careful control of tree growth.

Although vegetative growth in lychee can be manipulated by N supply, this is not always practical as it may take several years to obtain the desired leaf concentrations. Even then, reduced cropping and lower than average rainfall can result in higher leaf N concentrations before flowering than was predicted by tissue analysis the previous season.

An alternative approach to the control of vegetative growth is the use of growth retardants such as paclobutrazol. Paclobutrazol was developed in the late 1970s and has been successfully used to control vegetative growth in a range of temperate fruit crops including apple, pear, peach and cherry (Quinlan 1981; Raese and Burts 1983; Edgerton 1986; Looney and McKeller 1987; Early and Martin 1988) and, more recently, in woody ornamentals (Sterrett 1985) and a few subtropical and tropical tree crops such as citrus (Bausher and Yelenosky 1986) and mango (Andres and Rondon 1986; Hashim 1986; Kulkarni 1988).

Since the initial experiments with paclobutrazol on apple by Quinlan (1980, 1981), researchers have concentrated on the control of shoot elongation in temperate, deciduous fruit trees. There have been few investigations with tropical and subtropical evergreen trees, especially attempts to stop vegetative growth for several weeks. Complete cessation of shoot growth is essential for successful flowering in lychee, as floral induction occurs in the terminal buds of dormant shoots (Menzel 1983). There has been only 1 published report on the use of paclobutrazol in lychee (Chatree and Nuntisak 1986). These authors showed that paclobutrazol [0.25 g/L foliar or 8.0 g/tree as a collar drench applied in September to 7-year-old trees in

Table 1. Experimental details and dates of paclobutrazol applications to three lychee (*Litchi chinesis*) cultivars

Each experiment also included untreated trees

Location	Soil type	Cultivar	Tree age (years)	Canopy cover (m^2)	Paclobutrazol treatment Foliar sprays (g/L)	Soil drench (g/m^2 canopy cover)	Dates of application
Nambour	Sandy loam on heavy clay	Bengal	4	5	—	0.25, 0.50, 1.00	5.iii.86
Childers	Deep sandy clay loam	Tai So	10	15	1.0, 2.0 + 2.0[A], 4.0	1.0	26.iii.87
Gympie	Heavy clay	Tai So	4	6	2.0, 4.0	0.5, 1.0	31.iii.87
Gympie	Heavy clay	Bengal	5	10	1.0 + 1.0[B], 4.0	1.0	5.v.87
Nambour	Sandy clay loam	Tai So	8	10	4.0	1.0	17.iii.88
Nambour	Sandy clay loam	Bengal	8	10	4.0	1.0	17.iii.88
Yandina	Heavy clay	Bengal	5	10	4.0	1.0	18.iv.88
Yandina	Heavy clay	Kwai May Pink	5	10	4.0	1.0	18.iv.88

[A] A second spray was applied on 23.iv.87.
[B] A second spray was applied on 19.v.87.

northern Thailand (cultivar not specified)] reduced shoot extension to 25–41% of that of control trees. No data on flowering or yield were presented.

We investigated the effects of paclobutrazol on vegetative flushing, flowering and yield of lychee cultivars in subtropical Queensland (lat. 27°S.). Paclobutrazol was applied after maturation of the postharvest flush of vegetative growth in autumn, in an attempt to prevent further flushing which would eliminate flowering.

Materials and methods

Experimental design

The sites, cultivars, tree ages and vigour, and dates of paclobutrazol applications are listed in Table 1. Paclobutrazol was applied after the maturation of the postharvest vegetative flush. Collar drenches were dissolved in 10 L of water and applied in a 0.5 m diameter zone around the base of the trunk. Application rates are expressed on a tree canopy cover basis (m^2). The canopy cover of a tree is the surface area of the soil covered by the tree's foliage. Foliar sprays were applied to the point of run-off with addition of 1 mL/L of Agral 60 as a wetting agent. Trees of age 4–5 years received 2–3 L and trees aged 8–10 years, 5–6 L of spray. The treatment trees were arranged in randomised complete blocks with 6 trees per treatment. Trees were managed as commercial crops with respect to irrigation, nutrition, and weed and pest management (Menzel and Simpson 1987; Menzel *et al.* 1988*b*).

Measurements

A monthly record (March–October) was kept of vegetative flushing and flowering (panicle formation) until the end of fruit set, and yield was determined at harvest. Flushing and flowering data are expressed as a percentage of the terminal branches on a tree, recorded as an average of visual estimates by 2 observers working independently. Measurements were also made, 1–2 weeks after fruit set, of panicle length and dry weight on 4 panicles per tree and, at harvest, of total fruit number and fresh weight per panicle, average fresh fruit weight and per cent aril (relative to fruit fresh weight).

Weather

Weather data were collected at 3 of the experimental sites (Nambour, Gympie and Childers), but only data for Nambour are presented. Minimum temperatures are 2–3°C cooler in winter at Nambour and Gympie than Childers, while maximum temperatures are 1–3°C cooler at Nambour than Childers and Gympie. Total yearly rainfall is 35% higher at Nambour, mainly because of heavier rainfall from October to May (Table 2). This rainfall pattern tends to provide ideal conditions for continuous vegetative growth and inconsistent flowering at Nambour compared with Gympie and Childers, especially where tree N levels are high (Menzel and Simpson 1990). No weather data were available for Yandina, which is less than 10 km from Nambour and has a similar climate.

Statistical analyses

Data were analysed by 1-way ANOVA with each site and cultivar analysed separately. Percentage flowering data were transformed by inverse sine before analysis. Data are the means of 6 trees.

Results

Weather

The weather during the experiment was similar to the long-term averages for Nambour (Table 2), with the following exceptions. In 1988, the average monthly

Table 2. Mean monthly minimum and maximum daily temperatures (°C) and total monthly precipitation (mm) at Nambour during the experimental period

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average or total
						1986							
Max. temp.	29.1	29.8	27.7	26.7	23.7	21.3	20.8	21.4	25.0	26.6	26.5	28.7	25.6
Min. temp.	18.8	18.8	16.8	15.8	13.5	8.1	9.2	7.5	10.5	13.9	15.2	18.1	13.9
Precipitation	47	54	38	99	189	20	120	75	52	232	99	258	1283
						1987							
Max. temp.	31.3	28.2	28.3	24.8	23.2	20.7	20.8	21.9	24.1	25.6	27.0	28.8	25.4
Min. temp.	20.8	19.4	17.2	15.7	13.4	11.4	6.5	9.5	9.3	13.6	14.6	17.7	14.1
Precipitation	188	178	95	132	136	127	118	97	2	208	87	196	1564
						1988							
Max. temp.	28.5	27.9	26.0	25.6	23.9	22.0	21.9	21.9	25.2	31.1	29.6	28.0	26.0
Min. temp.	19.0	18.2	17.2	17.4	12.6	9.6	10.0	9.9	11.8	15.9	16.4	19.4	14.8
Precipitation	102	100	256	461	73	181	209	86	25	11	36	444	1984
						Long-term average (25 years)							
Max. temp.	28.6	28.2	27.2	25.9	23.1	21.4	20.7	22.1	24.2	26.0	27.4	28.7	25.3
Min. temp.	19.1	19.5	17.9	15.0	11.6	9.1	6.9	7.5	10.1	13.4	16.1	17.9	13.7
Precipitation	284	277	247	137	122	82	91	48	45	111	155	180	1779

maximum temperature was 2–3°C warmer in July–August and 2–5°C warmer in October–November. In 1986, January–March and November were drier, and May and October were wetter. In 1987, January–March and November were drier, and June, August and October were wetter. In 1988, January–February, May and October–November were drier, and April, June–July and December were wetter.

Vegetative flushing and flowering

Paclobutrazol reduced the percentage of terminal branches flushing vegetatively before panicle emergence and increased the level of flowering in cv. Tai So at Childers in 1987 and Gympie in 1987 (soil and foliar applications) and in cv. Bengal at Nambour in 1986 and 1988, at Gympie in 1987 and at Yandina in 1988 (soil applications) (Table 3). Paclobutrazol sprays slowed the development of the autumn flush and decreased flowering in cvv. Bengal and Kwai May Pink at Yandina in 1988 (soil applications either increased or had little effect on flowering). Paclobutrazol applications (soil drench and especially foliar sprays) at Nambour in 1988 reduced the level of flowering in Tai So, independently of any affects on vegetative flushing.

Soil applications of paclobutrazol were more effective than foliar sprays at controlling vegetative growth and promoting flowering (Table 3). The only exception was in cv. Tai So at Gympie in 1987 when the level of vegetative control was greater with foliar sprays. There were no clear differences in variety response to paclobutrazol across sites (Table 3).

Panicle growth

Foliar applications of paclobutrazol generally reduced panicle length, as did soil applications for cv. Tai So at Childers in 1987 and Nambour in 1988 (Table 3). Although the panicles on treated trees were shorter, they had more axillary branches and so paclobutrazol had no significant effect on panicle dry weight. Consequently, paclobutrazol had no significant effect on the number of fruit set per panicle (data not presented).

Average fruit weight, and number and weight of fruit per panicle at harvest

Paclobutrazol generally had only a small effect on average fruit weight and on yield per panicle (Table 3). Paclobutrazol sometimes decreased or increased average fruit weight, but these effects were usually offset by changes in the number of fruit per panicle, so that the net effect on fruit weight per panicle was small.

Aril recovery

The effect of paclobutrazol on the proportion of aril was small and variable (Table 3).

Yield

The effect of paclobutrazol on fruit yield generally reflected the flowering responses of the trees (Table 3). The only exceptions were cvv. Tai So and Bengal at Gympie in 1987, and cv. Tai So at Nambour in 1988, when yields were uniformly low because of poor fruit set or bird damage to the fruit.

Table 3. Effect of paclobutrazol (applied as collar drenches and foliar sprays) on vegetative flushing, flowering and fruiting of lychee cvv. Tai So, Bengal and Kwai May Pink

Data are the means of six trees. Means within a column followed by different letters are significantly different (P<0.05)

Paclobutrazol treatment	Flushing (%) April	May	June	July	Flowering (%)	Panicle weight (g)	Panicle length (cm)	Yield (kg/tree)	No. fruit/ panicle	Average fruit weight (g)	Aril recovery (%)
					Childers 1987, cv. Tai So[A]						
0	16.7	0	0	0	83.3a	11.3	32.4b	40.0	18.7	17.2	67.9
1.0 g/L	7.5	0	0	0	95.3ab	13.0	24.8a	49.5	18.2	16.5	67.9
2.0 g/L	0.0	0	0	0	98.9b	12.6	22.1a	49.5	16.9	15.6	67.6
4.0 g/L	6.7	0	0	0	96.2b	11.7	27.0a	48.0	16.5	15.3	64.1
1.0 g/m^2	1.7	0	0	0	96.5b	12.4	23.1a	47.0	16.3	15.8	66.2
					Nambour 1986, cv. Bengal[B]						
0	30.8b	28.3b	48.3b	8.3	35.9a	n.r.	n.r.	8.3a	20.0	17.8	n.r.
0.3 g/m^2	10.8a	5.0a	18.3a	5.0	84.1b	n.r.	n.r.	19.5b	19.2	17.2	n.r.
0.5 g/m^2	3.3a	2.5a	8.3a	3.3	92.8b	n.r.	n.r.	19.8b	21.7	16.8	n.r.
1.0 g/m^2	10.0a	3.3a	0.8a	3.3	91.6b	n.r.	n.r.	16.3b	21.7	16.7	n.r.
					Gympie 1987, cv. Tai So[C]						
0	48.3b	55.0c	45.8b	25.0	16.2a	12.1	n.r.	0.8	9.4	17.9	74.7
2.0 g/L	0a	5.0ab	3.3a	0	95.9cd	12.9	n.r.	1.0	7.4	18.9	75.2
4.0 g/L	2.5a	0.8a	0a	0	98.9d	13.0	n.r.	0.5	6.8	19.8	73.3
0.5 g/m^2	2.5a	35.0bc	8.3a	8.3	75.1bc	12.6	n.r.	1.3	9.8	18.8	77.7
1.0 g/m^2	0a	44.2c	15.0a	18.3	52.8ab	12.3	n.r.	1.1	8.6	20.5	76.0
					Gympie 1987, cv Bengal[D]						
0	100.0	81.7b	78.3c	61.7b	6.0	16.9	23.8	1.8	8.5	18.4	56.6
1.0 g/L	100.0	25.8a	37.5b	8.3a	31.8	22.0	20.0	3.8	7.4	19.6	55.0
4.0 g/L	100.0	35.0a	33.0ab	8.3a	23.0	16.4	19.3	2.9	6.0	19.7	56.9
1.0 g/m^2	100.0	16.7a	9.1a	0.8a	55.6	14.5	23.1	5.0	7.3	19.7	58.3
					Nambour 1988, cv. Tai So[E]						
0	5.0	0	0	0	98.9c	2.5	26.0b	0	n.f.	n.f.	n.f.
4.0 g/L	3.3	0	0	0	23.0a	3.2	19.5a	0	n.f.	n.f.	n.f.
1.0 g/m^2	3.3	0	0	22.5	67.3b	3.8	24.5ab	0.0	n.f.	n.f.	n.f.
					Nambour 1988, cv. Bengal[B]						
0	3.3	70.0b	33.3b	31.7b	81.7	3.6	21.9	10.8	5.9	18.9	53.0
4.0 g/L	10.8	1.7a	0.8a	0a	76.7	4.2	17.4	10.0	5.9	16.3	57.2
1.0 g/m^2	0	5.0a	1.7a	0a	98.9	4.9	23.4	10.0	6.0	17.4	55.6
					Yandina 1988, cv. Kwai May Pink[F]						
0		8.3	11.7	11.7	91.9b	3.8	18.5	11.3ab	6.6	8.2	60.5
4.0 g/L		28.3	35.8	18.3	36.3a	3.1	13.2	3.3a	7.0	8.9	59.6
1.0 g/m^2		7.5	7.5	4.1	83.2b	3.1	15.1	18.0b	7.2	10.8	61.8
					Yandina 1988, cv. Bengal[G]						
0		86.6b	80.0	38.3b	68.7b	6.4	23.4	4.2	5.6	23.6	70.8
4.0 g/L		100.0c	95.0	100.0c	0a	n.p.	n.p.	n.f.	n.f.	n.f.	n.f.
1.0 g/m^2		45.8a	51.7	8.3a	96.7c	10.5	25.1	19.0	7.2	21.2	70.0

n.r., not recorded; n.p., no panicles; n.f., no fruit.

[A] First panicle emergence early May, 50% fruit set mid September and first harvest mid December.

[B] First panicle emergence early July, 50% fruit set late September and first harvest mid January.

[C] First panicle emergence late May, 50% fruit set early September and first harvest late December.

[D] First panicle emergence early August, 50% fruit set early October and first harvest mid January.

[E] First panicle emergence early May, 50% fruit set mid August and first harvest late December.

[F] First panicle emergence late May, 50% fruit set mid September and first harvest early January.

[G] First panicle emergence early August, 50% fruit set early October and first harvest early January.

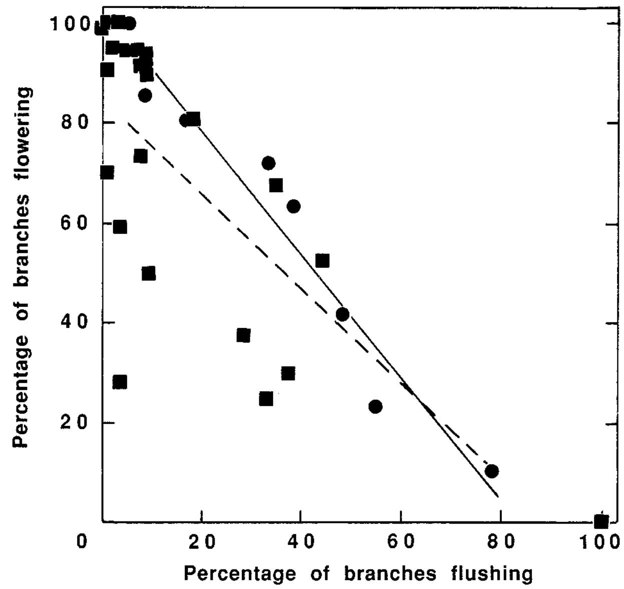

Fig. 1. Correlation between the level of flowering on terminal branches of lychee in spring and vegetative flushing 1–2 months before panicle emergence (May–August). Individual points are the means of six trees. Untreated (●, solid line), paclobutrazol treated (■, broken line). Equations for the linear models are:

Untreated control trees: $y = 102.7 - 1.2x$ ($r = -0.97$; $P<0.001$)
Paclobutrazol treated trees: $y = 84.7 - 0.9x$ ($r = -0.74$; $P<0.001$)

Relationship between flowering in spring and vegetative dormancy in winter

There was an inverse correlation between the percentage of terminal branches flowering and the percentage of terminal branches that were flushing in the 1–2 months preceding panicle emergence, with treated and untreated trees analysed separately (Fig. 1). Trees that were dormant in winter flowered more heavily than trees that had flushed. The only exceptions were some of the paclobutrazol treated Tai So and Bengal trees sprayed with 4 g/L at Nambour (in 1988).

Relationship between flowering of paclobutrazol treated trees and flowering of control trees

There was a quadratic relationship between the percentage of terminal branches flowering in the paclobutrazol treated trees and the percentage flowering in untreated trees (Fig. 2). The maximum level of flowering in paclobutrazol treated trees occurred when the control trees bloomed moderately (40–60% of terminal branches flowering). Paclobutrazol did not always induce heavy blossoming on trees that flowered lightly but did tend to reduce the level of flowering on heavily flowering trees. An exception was cv. Bengal at Yandina in 1988, when some of the untreated trees flowered moderately and paclobutrazol at 4.0 g/L reduced flowering, perhaps because the treatment slowed the development of the winter flush.

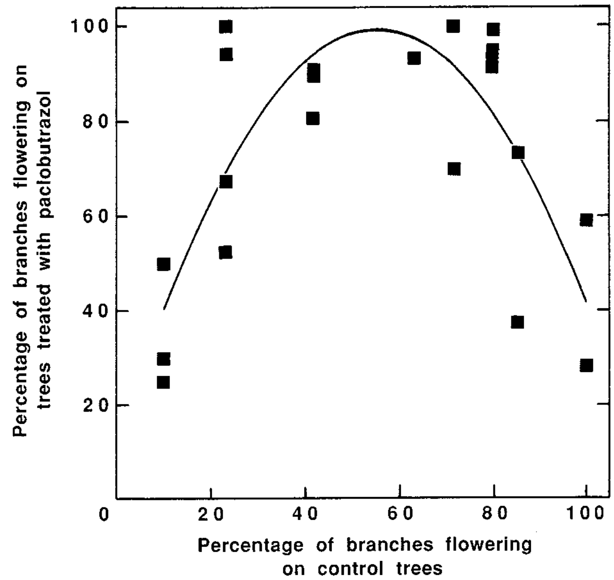

Fig. 2. Correlation between terminal branch flowering of paclobutrazol-treated trees and untreated control trees. Individual points are the mean of six trees. Cultivar Bengal with 4 g/L paclobutrazol foliar spray at Yandina in 1988 was not included in analysis. Equation of the curve is:

$$y = 11.62 + 3.17x - 0.03x^2 \quad (r = 0.77;\ P<0.001)$$

Discussion

Growth of shoots of mature lychee trees in subtropical Australia differs considerably from the growth of deciduous temperate fruit trees which have been used for most experiments with the growth retardant paclobutrazol. The main period of vegetative flushing in high-yielding lychee trees occurred after harvest and ceased 4–6 weeks before panicle emergence in May–August. Trees did not flower if they were vegetative prior to panicle emergence.

An inverse correlation between the level of flowering and the percentage of terminal branches flushing in the 1–3 months before panicle emergence has been demonstrated in several studies in Hawaii and Australia (Shigeura 1948; Nakata 1955; Menzel and Simpson 1987). A period of vegetative dormancy does not, however, ensure successful flowering. Some of the paclobutrazol treated trees did not flower even after a growth check. Menzel and Simpson (1987) noted that lychee trees which were starved of N remained vegetatively dormant in winter but did not flower, even after cincturing. Vegetative dormancy and panicle emergence normally occur in the field after a period of cool dry weather, but the effects of these environmental factors on vegetative dormancy and floral induction have been separated only recently in controlled environment facilities (Menzel *et al.* 1989). It was concluded from these studies that both water stress and low temperatures can stop vegetative growth, but only the latter can induce flowering. Trees that were flushing did not flower even when exposed to low inductive temperatures.

Paclobutrazol reduced the rate of shoot elongation but did not always prevent the initiation of a vegetative flush when the trees were very vigorous. Paclobutrazol has reduced shoot length and promoted flower bud production in a range of temperate and tropical tree crops (Raese and Burts 1983; Edgerton 1986; Lever 1986) but has induced dormancy in vegetative shoots for 1–2 months or longer in only a few species [e.g. citrus (Bausher and Yelenosky, 1986), mango (Andres and Rondon 1986) and California privet seedlings, *Ligustrium ovaliforlium* (Sterrett 1985)]. Some temperate crops flower heavily naturally, and increased flowering with paclobutrazol has sometimes led to the need for intensive thinning of fruit (Lever 1986). Our lychee trees showed increased flowering with paclobutrazol only when the growth retardant inhibited vegetative growth for 1–2 months before panicle emergence. There was no improvement in flowering when paclobutrazol merely delayed the development of a vegetative flush.

Soil applications of paclobutrazol were generally more effective than foliar sprays in reducing vegetative flushing and promoting flowering. With the exception of apples, responses to foliar applications of paclobutrazol in temperate fruit crops have been variable, whereas applications to the roots or directly to the vascular system of the stem have been more effective (Sterrett 1985; Bausher and Yelenosky 1986; Shearing and Jones 1986; Kulkarni 1988). Paclobutrazol is transported in the xylem (Lever 1986). The inability of foliar sprays to check vegetative growth under all circumstances in the present study supports the conclusions that only small amounts of paclobutrazol in foliar sprays reach the growing points and that the growth retardant is quickly metabolised by most plant tissues (Quinlan and Richardson 1986; Early and Martin 1988).

The benefits of paclobutrazol on flowering were greater when trees were expected to bloom moderately (40–60%). In trees which were about to flower heavily, flowering was not affected. Reduced flowering sometimes occurred when paclobutrazol delayed the maturation of a vegetative flush before the time of panicle emergence. There were also instances when natural vegetative growth was so strong that paclobutrazol prevented flushing in only a few of the trees (eg. cv. Bengal at Gympie in 1987). The results indicate the limitations for paclobutrazol to increasing flowering and fruit production under commercial conditions. The potential for improved productivity is limited to orchards with moderate bloom (40–60%). Reduced flowering can be expected in orchards with heavy bloom (70–100%). The main problem with the commercial use of paclobutrazol in lychee is that growers cannot predict the level of flowering of their trees in advance to determine if the growth retardant should be applied.

Exogenous auxins such as sodium naphthalene-acetic acid have been used to restrict vegetative flushing and induce floral initiation of lychee in Hawaii and Florida (Shigeura 1948; Nakata 1955). Auxin applications did not restrict vegetative growth during a dry year or in seasons where very warm and wet conditions preceded flowering. These results indicate that there is a limit to the ability of exogenous growth regulators to inhibit vegetative growth if trees are particularly vigorous. By contrast, cincturing is very effective in inducing vegetative dormancy in lychee trees even when vegetative growth is strong, provided the cincture cuts remain open for 2–3 months (Menzel and Simpson 1987).

The effects of paclobutrazol on panicle development, fruit set and fruit development of the lychee trees were small, with the exception of a reduction in panicle length. Paclobutrazol did, however, increase the number of axillary panicles and, hence, panicle weight, but number of fruit set per panicle was unaffected. Several reports indicate large effects of paclobutrazol on inflorescence size, flower number, fruit set, fruit size, fruit shape and fruit quality in a range of crops (Delgado *et al.* 1986; Lever 1986; Kulkarni 1988). Differences between lychee and other crops in the response of reproductive growth to paclobutrazol may be due to differences in the rates of paclobutrazol used or, more importantly, to differences in the time of application during the growth cycle.

Soil applications of paclobutrazol in excess of 1.0 g/m^2 canopy cover had residual effects on tree growth for 2–3 years after application (C. M. Menzel and D. R. Simpson, unpublished data). Soil applications of less than 1.0 g/m^2 canopy cover delayed vegetative growth after the following harvest by 1–2 months compared with untreated trees, but foliar sprays had no residual effect. Similar responses have been recorded for temperate fruit trees (Lever 1986). The rates of paclobutrazol used in our experiment were generally higher than those recommended for temperate tree crops (Edgerton 1986), but they are similar to those used in citrus and mango (Aron *et al.* 1985; Delgado *et al.* 1986; Kulkarni 1988). Several low dose sprays have given the best control of shoot growth in apple (Elfving and Proctor 1986; Quinlin and Richardson 1986), however, in other species there was no difference between a single large dose or multiple low dose sprays (Lever 1986). Soil treatments have been routinely used in stonefruit, cherry and pear (Quinlan and Richardson 1986), but higher rates than the maximum used in the present experiment (1 g/m^2) are likely to lead to detrimental long term effects (e.g. see Elfving and Proctor 1986). The major problem is that the effects of overdosing may not appear until more than 3 years after a single application, and overdosing cannot be reversed by applications of gibberellins (Lloyd 1988).

There is not always a close relationship between yield and the flowering response of lychee to paclobutrazol. Excessive numbers of male flowers, flower or fruit shedding, or bird damage to fruit before harvest may result in a light crop after profuse flowering (Menzel and Simpson 1987). In our experiments, increases in yield followed heavy flowering after paclobutrazol in about 50% of orchards.

Conclusion

We conclude that paclobutrazol cannot reliably promote flowering of lychee. Paclobutrazol restricted vegetative flushing and promoted flowering when the trees would have bloomed moderately (40–60%), although the responses were sometimes weak when the trees were very vigorous (<30% bloom). Paclobutrazol had little effect or reduced flowering when the trees would have flowered heavily (>70%). Commercial benefits of paclobutrazol applications in lychee are unproven.

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