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The use of ethephon to promote uniform harvest drop of mature macadamia nuts in south-east Queensland

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Summary

The effectiveness of ethephon in promoting abscission of mature macadamia nuts was assessed in 1982 and 1983 on cultivars Keauhou (246, Hawaii Agricultural Experiment Station No 246), Kakea (508) and Own Choice. Ethephon at 200 mg/L plus the standard rate (0.25 mL/L) of Plus 50® wetting agent resulted in more than 90% of the crop dropping consistently within 14 days from 246 and 508 trees. The response to ethephon by Own Choice trees was more variable. Increasing the concentration of wetting agent to 0.5 mL/L enhanced the effectiveness of ethephon. The practice of applying 200 mg/L ethephon to achieve a single harvest with cultivars 246 and 508 is economically feasible although with Own Choice, because of the high concentration needed for effective drop, the economics are doubtful at this stage. Inexpensive additives which significantly increase the effectiveness of ethephon in dropping nuts from Own Choice trees are required before its use with this cultivar can be recommended. Leaf drop was not considered to be excessive with any of the treatments used.

INTRODUCTION

Some *Macadamia integrifolia* cultivars such as Own Choice, an Australian selection, are unpopular because mature nuts do not drop readily from the trees. This condition is referred to locally as stick-tight nuts. In Australia, this is not associated with anthracnose, unlike the stick-tight problem which occurs in Hawaii. However, the incidence of stick-tight nuts results in extension of an already long harvest season and allows insect populations to build up and be maintained for longer periods (Ironside 1982). Furthermore, mature nuts which do not drop are predisposed to pre-germination while still on the tree. Such kernels are rejected during processing. The advantage of promoting uniform early drop of mature stick-tight nuts are obvious.

Even for the major commercial cultivars in Australia such as Keauhou (246, Hawaii Agricultural Experiment Station No. 246) and Kakea (508), which do not have a stick-tight problem, it could be advantageous to promote uniform, early drop of mature nuts. This would avoid the problems of a long harvest season and reduce the number of harvests required.

Ethylene, as ethephon, has been shown to induce nut drop in macadamia and Ethrel® is registered for this purpose in New South Wales (Trochoulias *et al.* 1983). However, as reported by Nakata (1976) and frequently observed in Queensland, the nut drop achieved with ethephon is variable. Nakata obtained satisfactory results under favourable moisture but not under hot, dry conditions. The addition of a wetting agent and low concentrations of urea to ethephon sprays appeared to enhance abscission, although results were variable (Bell 1976). The present work was initiated to investigate further the efficacy of ethephon on cultivars Own Choice, 246 and 508 and to establish the most effective concentrations of ethephon and wetting agent, with or without the addition of urea, in inducing uniform drop of mature nuts from Own Choice trees in south-east Queensland.

MATERIALS AND METHODS

Experiment locations, cultivars, dates, treatments, tree age and weather conditions during Ethrel® application are shown in Table 1. In all cases soil moisture was adequate for tree growth.

Table 1. Experiment details

Experiment	Location	Cultivar	Tree age (yrs)	Date of treatment	Experimental design	Ethephon concentration (mg/L)	Weather conditions at spraying
1	Beerwah	Keauhou (246)	14	21 Apr 82	10 tree observation	200	overcast with showers, 24°C
				20 Apr 83	10 tree observation	200	fine, 24°C
2	Beerwah	Kakea (508)	14	20 May 82	10 tree observation	200	fine, 26°C
				9 May 83	10 tree observation	200	fine, 25°C
3	Glasshouse Mountains	Own Choice	10	20 May 82	4 treatments*× 3 blocks×5 tree plots	1600 0	fine, 26°C
4	Didillibah	Own Choice	8	7 June 83	4 treatments×2 sub-treatments**×3 replicates	0 400 800 1600	fine, 23°C

* Different levels of wetting agent applied; 0, 0.25, 0.50 and 0.75 mL/L.

** Sub treatments of±2500 mg/L urea. Control trees (0 ethephon) all received a spray of 2500 mg/L urea.

Ethephon was applied in the form of Ethrel® (480 g/L ethephon) with the addition of Plus 50® wetting agent, both chemicals being supplied by Ciba-Geigy.

For Experiments 1, 2 and 4, Plus 50® was added at the standard rate of 0.25 mL/L.

In Experiment 3, the treatments consisted of 0.25, 0.5 and 0.75 mL/L of Plus 50® wetting agent combined with 1600 mg/L ethephon and a control plot with no ethephon or wetting agent. Treatments were arranged in a randomised block design with three blocks. Each plot consisted of five trees. This design was dictated by practical field considerations.

In Experiment 4, rates of 400, 800 and 1600 mg/L of ethephon were applied with or without 2500 mg/L urea. Control trees received sprays containing wetting agent and urea but no ethephon. Three replicates of single tree plots were used.

Experiments 1 and 2 consisted of observation plots of 10 trees. Although no data were collected from untreated control trees, observations of similar adjacent untreated trees were noted.

In all experiments, trees with mature nuts were sprayed from both inside and outside the canopy. Each tree received approximately 16 L of spray which was more than adequate to wet all the foliage. The sprays were applied when nuts were considered to be physiologically mature.

Fourteen days after spraying, the weight of fallen nuts was recorded after husking. All remaining nuts were stripped from trees by hand, 2 to 4 weeks later. Weights were then recorded after husking. In all cases, sub samples of nuts were oven dried to constant weight in stages with temperatures from ambient up to 50°C and all weights adjusted to the standard 10% moisture content. Percentage nut drop at 14 days was calculated.

Data from 10 trees of each of the cultivars 246 and 508 in the observation Experiments 1 and 2 were used to calculate means and standard errors. In Table 2 these were compared with data from Experiments 3 and 4 on the Own Choice cultivar. In Experiment 3, data from individual trees were subjected to analysis of variance using a randomised block design of four treatments and three blocks of five tree plots. An incomplete factorial analysis of variance was used for the data in Experiment 4.

RESULTS

The effect of ethephon at 200 mg/L on cultivars 246 (Experiment 1) and 508 (Experiment 2) and at 1600 mg/L on Own Choice trees is shown in Table 2. Ethephon promoted nut drop from Own Choice trees in Experiment 3 (1982) and Experiment 4 (1983) was more variable than that from either cv. 246 or cv. 508 with respect to weight of nuts and per cent drop. In both 1982 and 1983, percentage drop by Own Choice at 14 days was considerably less than for cv. 246 and cv. 508, in spite of the higher concentration of ethephon applied. Percentage drop from cv. 508 14 days after treatment in 1982 was nearly 100%. In all experiments, nut drop from adjoining trees of the same cultivars which did not receive ethephon sprays was negligible.

Table 2. The effect of ethephon sprays plus wetting agent (0.25 mL/L Plus 50®) on nut drop in Keauhou (246), Kakea (508) and Own Choice macadamia cultivars at 200 mg/L, 200 mg/L and 1600 mg/L ethephon respectively

Experiment	Cultivar	1982		1983	
		Nut*** weight (kg/tree)	Nut drop (%)	Nut*** weight (kg/tree)	Nut drop (%)
1	cv. 246	25.1±3.5	94.9±5.1*	15.1±3.3	97.2±2.2
2	cv. 508	13.2±3.1	**	21.3±2.3	91.3±4.4
3 and 4	Own Choice	12.4±3.8	72.6±10.9	15.3±4.4	86.3±9.6

* Means±s.e.

** Nut drop was approximately 100%.

*** Nut in shell at 10% moisture.

The use of 1600 mg/L ethephon plus wetting agent sprays on Own Choice trees in 1982 (Experiment 3) significantly increased the weight and percentage of the nut crop which dropped in 14 days compared with the control (Table 3). Increasing the rate of wetting agent up to 0.5 mL/L further enhanced drop.

Table 3. The effect of different concentrations of Plus 50® wetting agent with 1600 mg/L ethephon on harvest nut drop from Own Choice macadamia trees (Experiment 3)

Treatment	Nut weight** (kg/tree)	Nut drop (%)
Control	1.7*b*	10.9*c*
1600 mg/L ethephon+0.25 mL/L wetting agent	10.5*a*	55.8*b*
1600 mg/L ethephon+0.50 mL/L wetting agent	11.7*a*	66.2*a*
1600 mg/L ethephon+0.75 mL/L wetting agent	12.3*a*	72.9*a*

* Numbers followed by the same letter are not significantly different.

** Nut in shell at 10% moisture.

The effect of urea at different rates of ethephon (plus the standard rate of wetting agent, 0.25 mL/L) on Own Choice trees in 1983 is shown in Table 4. As the concentration of ethephon was increased to 1600 mg/L, percentage drop increased significantly. The addition of 2500 mg/L urea did not increase nut drop significantly although it tended to enchance drop at the higher concentrations of ethephon.

Table 4. The effect of ethephon concentration, with or without 2500 mg/L urea, on harvest nut drop from Own Choice macadamia trees (Experiment 4)

Treatment	Nut drop (%)
Control—no ethephon+urea	5.6*c*
Ethephon—400 mg/L	38.8*c*
400 mg/L+urea	36.5*c*
800 mg/L	60.3*b*
800 mg/L+urea	75.2*b*
1600 mg/L	80.2*ab*
1600 mg/L+urea	92.3*a*

* numbers followed by the same letter are not significantly different.

DISCUSSION

Ethephon applied at 200 mg/L was very effective in promoting drop of mature nuts from the main commercial cultivars, 246 and 508. The percentage drop achieved was sufficient for a single harvest in both years (Table 2). In contrast, there were insufficient nuts under adjacent untreated trees of the same cultivars to warrant harvest. The natural pattern of mature nut drop with these cultivars is for nut drop to commence in February and, unless there is a high incidence of insect or disease damage, continue steadily up to a peak in April–May and cease in July (Winks, pers. comm. 1985). Mason (1983) showed that nuts of cv. 246 and cv. 508 mature on the tree by mid April in this district.

With Own Choice, the mean level of drop achieved after a 1600 mg/L spray of ethephon was 86.3% (Table 2), and, with the addition of 2500 mg/L urea, 92.3% of nuts dropped (Table 4). This level of effectiveness is likely to be commercially acceptable. A consistently high percentage of nut drop has also been obtained from Own Choice trees in New South Wales (Trochoulias *et al.* 1983). Standard errors in Table 2 indicate that Own Choice was more variable with respect to ethephon induced nut drop than were the other cultivars.

Effectiveness of ethephon in inducing nut drop in Own Choice was increased by increasing the concentration, and by the addition of more wetting agent (Tables 3 and 4). The best percentage drop was achieved with 1600 mg/L ethephon plus 2500 mg/L urea and standard wetting agent. Although this was 15% greater than that achieved with 1600 mg/L ethephon and standard wetting agent alone, it was not significantly better.

Except at the low (400 mg/L) concentration, the addition of 2500 mg/L urea to ethephon sprays tended to increase percentage nut drop. Although the increase was not statistically significant at a given concentration, this was possibly due to limitations of experimental design. Nevertheless, for the relatively small additional cost of adding urea, the possible benefit of a 10 to 15% increase in nut drop could make the practice attractive. Further work is needed to confirm this. There was no obvious increase in leaf fall with the addition of 2500 mg/L of urea under these conditions although higher concentrations of urea applied with ethephon has caused excessive leaf drop (Ironside, pers. comm. 1985). This is similar to the experience with olives (Hartmann *et al.* 1968) where the addition of 13.5 g/L urea to ethephon sprays accentuated the lossening effect of fruit but also caused severe defoliation. Urea additives should therefore be used sparingly and cautiously.

The ethephon concentration of 1600 mg/L was greater than that recommended by the manufacturer for Own Choice. Trochoulias *et al.* (1983) have shown that 1600 mg/L ethephon is required for optimum nut drop from Own Choice trees within 14 days although

after 26 days, rates from 1200 to 2000 mg/L had removed most of the crop. In Queensland, higher concentrations may loosen an even larger percentage of the crop although the cost of chemicals and greater defoliation of trees may discourage their use. In New South Wales (Trochoulias *et al.* 1983) there was no significant benefit from concentrations above 1000 mg/L. Even at this level, the cost of applying the chemical is high and the benefits of decreasing the number of harvests and reducing pregermination, quality deterioration and insect damage would need to be evaluated.

Observations on an adjoining plot of five Own Choice trees at Glasshouse Mountains showed that 1600 mg/L ethephon plus 0.5 mL/L of wetting agent sprayed from under the trees in an attempt to wet nuts primarily suggest that this is not as effective as an overall spray. Trees sprayed from inside the canopy only had an average drop of 57.6% compared with 68.8% drop from similar trees sprayed from both inside and outside the canopy. In practice, sprays applied from outside the canopy are more feasible.

Leaf drop was observed to be negligible with 1600 mg/L ethephon on Own Choice trees at both Glasshouse Mountains and Didillibah, light to medium with 200 mg/L on cv. 246 (a single layer of leaves covering from half to all the area under the canopy) and medium to high on cv. 508 (a layer of 2 to 4 leaves deep under the whole canopy), at Beerwah. Trees at the Beerwah orchard tend to drop relatively large amounts of leaf at harvest under normal conditions. It is probably these leaves which fall more readily after spraying. Even with cv. 508 trees which dropped most leaves, the canopy was still dense and healthy, dropped leaves being a small percentage of those on the tree. Trochoulias *et al.* (1983) found leaf drop after ethephon treatment of several cultivars to be insignificant. Nevertheless it is recommended that ethephon be applied to healthy trees only.

In this study, treated trees were not considered to be under stress since soil moisture supplies were adequate. Moreover, the temperatures when ethephon sprays were applied were not extreme. Nakata (1976), found that ethephon was ineffective when used on cv. 246, cv. 508 and Ikaika (cv.333) after an unusually dry summer but effective under wet conditions. Ethephon applied to olive trees was most effective in cool, wet conditions and ineffective under hot, dry conditions (Weaver 1972). In this work, there appeared to be no advantage from the overcast showery conditions when cv.246 was sprayed with ethephon in 1982 compared with the fine weather in 1983. The rate of ethylene absorption is critical and conditions suitable for generation of ethylene from ethephon and its absorption by the tree are required.

The cost of applying 200 mg/L ethephon plus wetting agent to a 10-year-old tree is estimated at 25c compared with overall harvesting costs, based on 20 kg of nut in shell, of $2.60. Considering the benefits of a single harvest, the use of ethephon is economically feasible with cv. 508 and cv. 246. In contrast, the cost of applying 1600 mg/L ethephon to Own Choice trees is prohibitive. Continued use of ethephon sprays should be monitored carefully to ensure that there are no adverse effects on long term tree health.

The effectiveness of ethephon at 200 mg/L in promoting drop of mature nuts from Keauhou and Kakea trees under Queensland conditions has been confirmed. With less responsive Own Choice trees, the combination of a high concentration (1600 mg/L) of ethephon with 0.25 mL/L of wetting agent and 2500 mg/L urea, gave satisfactory nut drop but the economics of such high rates are questioned.

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