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PACLOBUTRAZOL TRIALS IN AVOCADO ORCHARDS: INITIAL RESULTS FROM QUEENSLAND AND NATAL

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ABSTRACT

A Paclobutrazol foliar spray at full bloom significantly reduced spring flush shoot length and mass, reduced leaf size but not leaf number, and increased initial fruit-set in Fuerte and Hass. Improved dry mass partitioning to fruits, at the expense of stems and to a lesser extent leaves, had occurred by the time that spring extension growth was complete. Pronounced summer fruit drop, in a season of heavy crop load, negated these early benefits and no significant yield differences were found at harvest. Paclobutrazol sprays resulted in rounder fruits in both cultivars and larger fruit size in Hass. Further research is needed on other possible quality effects, and on timing and concentration of sprays.

INTRODUCTION

Avocado cultivars have low average yields in comparison to most fleshy fruits. This is partly due to the high energy costs of fruiting in this oil-storing fruit with a large nutrient-rich seed (Wolstenholme, 1986). In a broader sense, this large tree with a rainforest origin in central America, is relatively undomesticated and unselected by man (Wolstenholme, 1987). Only in recent years have breeders made progress in changing assimilate partitioning from vigorous vegetative growth to fruiting in semi-dwarf trees, although no new breeding selection has yet shown proven commercial superiority (Bergh, 1987).

It is known that vigorous vegetative growth in spring can prejudice fruit-set in cultivars such as Fuerte, with a delicately poised vegetative: reproductive balance. Embleton *et al* (1959) showed that Fuerte leaf nitrogen levels exceeding two per cent in autumn, can result in poor fruit retention in spring. Tipping of the shoot subtending the influorescence during the fruit-set period was shown to improve fruit-set in Israel (Blumenfeld *et al,* 1983).

It appears therefore, that one of the reasons for poor fruiting is vegetative:reproductive competition in spring. The extent of this competition varies with cultivar and season, but it is an inevitable result of the lateral ('pseudoterminal'} position of the influorescence on the shoot which subsequently grows out (Rauh's architectural model of Halle, Oldeman and Tomlinson, 1978). The importance of the phenological growth model as a basis for management is obvious (Whiley *et al,* 1988). Other causes of low yields, such as complex flowering patterns (Bergh, 1967; Davenport, 1986) and unfavourable temperatures (Whiley and Winston, 1987) are not discussed in this paper.

The plant regulator paclobutrazol (Cultar®) offers a chemical means of reducing vegetative growth, with the consequent potential for diversion of assimilates to fruiting. It is effective on many species (Lever *et al,* 1982), especially deciduous fruit trees (Quinlan, 1980; Shearing *et al,* 1986). Acting as an antigibberellin and moving only distally in the xylem, it can be applied as a soil ('collar') drench, a foliar spray or by trunk injection.

Köhne and Kremer-Köhne (1987) reported growth reduction and increased fruit retention in Fuerte, after paclobutrazol spray and injection treatments of marked branches. One of the authors visited experimental avocado sites in Israel where promising results have been obtained from foliar sprays.

Avocado trees sometimes flower profusely and set a sizeable initial crop, only to lose large numbers of fruit during the summer drop. This second drop normally overlaps with the second (summer) growth flush (Whiley *et al,* 1988) and has been little studied in avocado orchards.

Fruit quality is of prime importance for avocado marketing. Small fruit size is of concern in Hass (Zilkah and Klein, 1987), while market preference is for a pyriform or ovoid fruit shape. A number of internal physiological disorders detract from fruit quality (Swarts, 1984). Low fruit calcium content may result from vigorous vegetative growth in spring (Witney *et al,* 1986). Such fruits soften more rapidly after harvest (Tingwa and Young, 1974), are more susceptible to chilling injury (Chaplin and Scott, 1980) and may be more prone to pulp spot (Veldman, 1983). Other flesh browning problems appear to be mediated by specific enzyme reactions (Van Lelyveld and Bower, 1984).

The main aim of this research was to test strategically targeted foliar applications of paclobutrazol on shoot growth, fruit-set, fruit-drop, yield and certain aspects of fruit quality in Fuerte and Hass avocados. This paper summarises the main findings from the first season's research, mostly conducted in Queensland, Australia but supplemented by observational trials in Natal. Supporting data are being published elsewhere and are not presented here.

PROCEDURE

Australia

Two well-managed orchards of young, vigorous trees were used in S E Queensland, latitude 27 S. The Fuerte trees were four and a half years old at the start of the trial and located at Maieny, a cool subtropical coastal environment, altitude 530 m, and mean annual rainfall 2 000 mm. Natural vegetation is subtropical rainforest and soils are deep, well-drained krasnozems. The orchard was not irrigated and all trees had been injected with 20 per cent phosphorous acid, partially neutralised with KOH (Pegg *et al,* 1985) in October 1985 and October 1986 as precaution against Phytophthora root rot.

The Hass orchard was sited on the coastal plain at Palmwoods, a warmer subtropical area, altitude 30 m, and mean annual rainfall about 1 800 mm. The soil type was physically poorer, viz a sandy loam on clay. Trees were seven years old but small for their age, having been restored to vigour with phosphorous acid two years previously, after neglect and severe Phytophthora decline. They were irrigated by one microsprinkler per tree, based on tensiometer readings.

Treatments were identical at both sites and were designed to test two concentrations of paclobutrazol, applied once (at full bloom) or twice. There were five replications (single tree plots) of five treatments in a randomised layout. The formulation was Cultar®, 250 g ai 1^{-1} ICI Australian Operations.

Treatments were:

1 an unsprayed control;

2 2 500 mg 1^{-1} ai paclobutrazol foliar spray at full bloom (1986/09/10 for Fuerte, 1986/09/16 for Hass);

3 5 000 mg 1^{-1} paclobutrazol at full bloom;

4 2 500 mg 1^{-1} paclobutrazol at full bloom, repeated during the active spring growth flush (1986/10/22 for Fuerte, 1986/10/07 for Hass);

5 2 500 mg 1^{-1} paclobutrazol at full bloom, repeated early in the summer growth flush (1987/01/09 for Fuerte, 1986/12/19 for Hass).

Trees were sprayed to runoff with a motorised knapsack sprayer, using four to 71 tree $^{-1}$ for Fuerte and about 51 tree^{-1} for Hass.

Tree dimensions were recorded at the beginning and end of the trials. At the termination of spring flush extension growth, sample shoots (Hass) or representative small branches (Fuerte), were taken to the laboratory for measurements of shoot length and fresh and dry mass, number of leaves and leaf area and mass, and number and mass of fruits.

Summer fruit-drop was monitored from late December (Fuerte) and early January (Hass), collecting all abscissed fruits at approximately weekly intervals for ten to 12 weeks.

Just before harvest, a random 30fruit-sample was collected from each of the 50 experimental trees. Fruit shape was determined as the ratio of length/diameter and fruit maturity by the standard flesh dry mass method. Seed size was measured as a percentage of total fruit mass. The number and mass of fruits were recorded for each tree.

Natal

Observational trials on foliar sprays, soil application and trunk injection of paclobutrazol, were started in 1986 on vigorous four-year-old Fuerte and Hass trees on clonal Duke 7 rootstocks. The orchard is situated in the Bruyns Hill district in a warm subtropical climate with a mean annual rainfall of 830 mm. The Inanda soil series has outstanding physical properties. Irrigation was by microjets, based on tensiometers, and trees were large for their age.

Soil treatments of 2,5 or 5 g ai paclobutrazol per tree in 1,5 ℓ water were applied at the junction of trunk and soil in late April, early June or early July, 1986. Trunk injections of 1 g ai paclobutrazol were given in early July (Fuerte) and early August (Hass). Foliar spray treatments were 5 g ai paclobutrazol in plus minus 4 ℓ water per tree at fullbloom and four weeks later. Five adjacent trees were treated in all treatments.

Standard measurements were taken for shoot length, leaf characteristics and harvested yield. At harvest, one carton (Fuerte) and five cartons (Hass) of count 14 fruit (net carton mass 4 kg) were stored for 28 days at 5°C, allowed to ripen at room temperature and assessed for fruit quality.

RESULTS

Australia

Length of spring flush shoots

On average, sprayed fruiting shoots in Hass were 42 per cent shorter than unsprayed shoots. Sprayed non-fruiting shoots were 43 per cent shorter than in unsprayed shoots. The equivalent figures for Fuerte were 44 and 40 per cent respectively. There were no differences between the paclobutrazol treatments themselves.

A comparison was also made between unsprayed fruiting and non-fruiting shoots. Fruiting reduced mean shoot length by 24 per cent in Hass and 53 per cent in Fuerte. In sprayed trees, fruiting shoots averaged 23 per cent shorter in Hass and 56 per cent in Fuerte. Fruiting therefore dwarfed spring shoot growth in both cultivars, but paclobutrazol was more effective in Hass, whereas the reverse applied in Fuerte. At the termination of spring extension growth, fruit development had over twice the dwarfing effect on spring shoot length in Fuerte as compared to Hass.

Percentage fruiting vs. vegetative spring shoots

Untreated Hass trees averaged 49 per cent fruiting shoots, and sprayed trees 52 per cent. Unsprayed Fuerte trees averaged only 21 per cent fruiting shoots against 46 per cent in sprayed trees. Paclobutrazol sprays therefore doubled the percentage of spring shoots, retaining fruits at the end of their extension growth. Fuerte trees all flowered profusely.

Leaf characteristics of spring shoots

Paclobutrazol sprays did not affect the number of leaves per shoot in either cultivar, except that two spring sprays significantly reduced leaf numbers in Fuerte. Leaf mass and leaf area were however, significantly reduced, especially with two spring sprays.

Fruit-set

Paclobutrazol sprays were effective in increasing initial fruit-set (at the termination of spring flushing) in both cultivars. In early December all sprayed trees (except two spring sprays) had significantly greater total fruit mass than control trees.

Dry matter partitioning in the spring growth flush

It was particularly noticeable in Hass that fruits had appropriated a greater percentage of total spring shoot dry mass by December, at the expense of stems and to a lesser extent leaves. Fruits comprised nearly 50 per cent of total shoot dry mass at this time, compared to about one third in control trees.

Summer fruit-drop

On average, 417 Hass fruits per tree, weighing between 60 and 120 g $fruit^{-1}$, dropped during a 10-week-period from late December to mid-March. This summer drop coincided with the summer growth flush. It peaked in early January and was aggravated by very hot weather in the third week of January.

An average of 589 Fuerte fruits per tree abscissed from mid-December to mid-March, with a peak in late December. Mean fruit mass of dropped fruit rose steadily from 50 g to over 200 g. Sprayed trees abscissed more fruits in both cultivars.

Final yield per tree

Final yields were high for tree size and averaged 117 kg for Hass and 132 kg for Fuerte. Yields of sprayed trees were not significantly better than control trees.

Fruit characteristics

All paclobutrazol treatments caused significantly rounder fruits. Effect on fruit size varied. Fruit size was significantly increased in Hass, except for a single 2 500 mg 1^{-1} spray. In Fuerte, only the two spring spray treatments improved fruit size. This was the only spray treatment which did not increase seed size in Fuerte. Seed size was unaffected in Hass.

Natal

Most results could not be statistically analysed and considerable tree-to-tree variation occurred. Consequently, only certain trends are given.

In general, foliar sprays reduced length and leaf size of the spring flush, but these effects were later outgrown. Yields appeared to be slightly increased, with more fruit in the larger size categories. The tendency for rounder fruit was again noted. Fruit from sprayed trees ripened over a longer period after cold storage and showed less grey pulp.

No clear benefits were noted a full season after soil applications, which appear to be slow-acting in avocado. Trunk injections gave intermediate responses.

DISCUSSION AND CONCLUSIONS

In both Queensland and Natal, the young trees were well-managed and bore heavily for their size and/or age. The authors were able to show that full bloom paclobutrazol sprays, at the concentrations used, successfully reduced spring flush shoot growth, but not overall tree growth during the entire season. Furthermore, particularly in Queensland, the little-studied summer fruit-drop nullified this early advantage. Still to be determined is whether paclobutrazol sprays will increase yields in 'off' years, and whether a spray targeted at the summer growth flush will reduce loss of a potential crop in 'on' years.

Paclobutrazol spray treatments consistently gave slightly rounder fruits at maturity. This was associated with a slightly larger seed in Fuerte. In situations where 'neckiness' is a problem these effects would be advantageous, eg Fuerte on the Atherton Tablelands in

the highland tropics of Queensland, and with Pinkerton in certain localities. Similarly, the increased fruit size of Hass, if it can be shown to be consistent, would be welcomed.

There was no benefit in increasing paclobutrazol concentrations above 2 500 mg 1^{-1} ai, nor in a second spray after a full bloom application. Research now in progress is testing lower concentrations, particularly as chemical costs are structured on the lower application rates used for deciduous fruit trees. This research is also evaluating timing of foliar applications, as the relative timing of growth of influoresences, fruitlets and of the spring flush is believed to be critical in determining the response.

The results of Witney *et al* (1984) suggest that suppression of spring flush vegetative vigour should result in higher fruit calcium content, with benefits to postharvest fruit quality. It is important that this be tested in future research, as this alone may justify paclobutrazol foliar sprays in avocado orchards.

It is stressed that firm conclusions cannot be made on the basis of a single season's results. Treatments must be evaluated over several years, both to include seasonal fluctuations in climate and yield potential, and to evaluate longer-term effects.

There is also undoubtedly scope for more research into soil applications, probably with the main goal of reducing growth in young, high density plantings. The promise of trunk injections must also be followed up.

The final determinant of grower acceptance is whether perceived or proven advantages are of sufficient magnitude to economically justify the use of the chemical. At this stage there are grounds for guarded optimism about the use of paclobutrazol for avocados, exemplified by provisional registration in Israel and registration of soil applications for growth control in South Africa.

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