Effect of spray and/or soil application of paclobutrazol, and spray application of potassium nitrate during flowering on new shoot growth and cropping of Mendez avocado

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ABSTRACT

Bearing Mendez avocado trees were sprayed with paclobutrazol or paclobutrazol (Austar at 1 or 2%) + KNO_3 (2%) during inflorescence development and flowering. In addition, soil applications of paclobutrazol were made (3 ml or 6 ml Austar applied around the trunk). The general effect of paclobutrazol treatment was to reduce the vigour of the new shoots arising after flowering and to increase fruit size. The increase as assessed in terms of individual fruit weight was of the magnitude of 46%. Fruit numbers were not reduced, and hence yield was increased. No cropping benefit or additional reduction in shoot vigour occurred as a result of the added application of paclobutrazol to the soil around the tree trunks. The specific effect of the addition of KNO_3 to paclobutrazol was an increase in number of fruits retained until harvest. Retention was increased by an average of 32%. This contributed to an increase in yield. No effect relating specifically to the difference in the rate of paclobutrazol application to the soil around the trunk was observed. Further research to assess the benefit of adding KNO_3 to paclobutrazol in spraying other important varieties of avocado trees during inflorescence development and flowering is justified by the results of the present study.

INTRODUCTION

Fruit drop after flowering can be excessive in Mendez avocado grown in Jalisco and other avocado-growing states of Mexico. Excessive fruit drop once the fruits are about 3 to 5 cm long is considered to be a problem of most avocado cultivars grown commercially, including 'Mendez', 'Fuerte' and 'Hass'. The extent of drop is considered to be related positively to the vigour of the new shoots emanating from and close to the inflorescences at and after inflorescence development and flowering (Kalmar & Lahav, 1976). Paclobutrazol, applied by spraying or to the soil during inflorescence development and flowering, is highly effective in reducing new shoot vigour. Reduced vigour is considered to lessen competition between the newly developing fruits and new shoots for assimilates, and is thus associated with reduced fruit drop and increased fruit numbers and yield at harvest (Wolstenholme *et al*., 1988). Increased fruit size in the absence of an increase in fruit number has also been reported (Whiley *et al*., 1992).

Generally in avocado, monetary income per kg for small fruit is less than that for larger fruit. Fruit size generally declines with increases in number of fruit set (Oosthuyse & Donkin, 2001). Tree sprays containing KNO_3 are known to increase fruit size in a number of fruit crops, e.g. peach,, e.g., peach, olive or orange (Dikmelik *et al*., 1999; Boman, 2001;

Sarfaraz, 2011). They may reduce fruit drop after flowering in facilitating assimilate movement to competing, newly developing fruit. Inflorescence sprays of KNO_3 have been found to increase fruit retention in mango in numerous studies (Oosthuyse, 1997).

In the current study, the effect of spray application of paclobutrazol + KNO_3 and that of the addition of paclobutrazol to the soil during inflorescence development and flowering, were assessed on new shoot vigour, fruit set and retention, and fruit size at harvest in Mendez avocado.

MATERIALS AND METHODS

Ninety 3-year old Mendez avocado trees (on 'Criyoyo' seedling rootstock) of uniform size and approximately 2 m in height were selected in an irrigated, commercial orchard in the Guadalajara region, Mexico, in early September 2012. In mid-September, when inflorescence development was occurring, 10 inflorescence bearing terminal branches were labeled per tree. These were well distributed on each tree. All data were collected from these branches.

The following treatments were applied when the trees were in bloom on 1 October 2012:

- A_0 – Untreated control
- A_1 – Spray application of Austar at 1% at flowering, specifically to the inflorescences, full cover
- A_2 – Spray application of Austar at 2% at flowering, specifically to the inflorescences, full cover
- A_3 – A_1 + inflorescence application of KNO_3 at 2% (w/v)
- A_4 – A_2 + inflorescence application of KNO_3 at 2% (w/v)
- A_5 – A_3 + Soil application of 3 ml Austar per tree
- A_6 – A_4 + Soil application of 3 ml Austar per tree
- A_7 – A_3 + Soil application of 6 ml Austar per tree
- A_8 – A_4 + Soil application of 6 ml Austar per tree.

Austar is an Australian paclobutrazol formulation containing 250 g of active ingredient per litre. The spray and soil applications were made on 1 October 2012, when the trees were flowering and the inflorescences were developing (Fig. 1). Knapsack sprayers were used in spraying, and full-cover sprays were applied. The general stage of flowering on 1 October 2012 is shown in Figure 2. In making a soil paclobutrazol application to a tree, Austar in the correct amount was poured into a bucket filled with 10 litres of water and mixed in thoroughly. The resulting solution was applied evenly to the soil around the trunk.

At harvest on 5 September 2013, the total length of the new shoots and the weight and number of fruits on each marked branch were recorded. Also, earlier on 5 January 2013, the total length of the new shoots on each marked branch and number of fruits set on each was recorded. The tree averages were subjected to Analysis of Variance. There were 10 single tree replications of 9 treatments (incl. control) in a Complete Randomized Blocks design. In the analysis of variance, the treatment's sum of squares was sub-divided for seven orthogonal comparisons. Those of direct relevance and consideration are indicated in the result-table to follow.

RESULTS

The least squares means and the significance levels of four comparisons of direct relevance are shown in Table 1.

In general, paclobutrazol treatment (Control vs. Treatments A_1 to A_8) was effective in reducing new shoot vigour, as determined by total shoot length shortly after flowering or at harvest. The treatments did not reduce the number of fruits present on 5 January 2013, or the number of fruits present at harvest on 5 September 2013. Individual fruit weight was increased, however.

In spraying KNO_3 (2%) + paclobutrazol (1 or 2%) as opposed to spraying paclobutrazol (1 or 2%) alone (Treatments A_1, A_2 vs. Treatments A_3, A_4), the number of fruits present on 5 January 2013 was not affected. The number of fruits present at harvest was increased, however. An effect of KNO_3 spraying on shoot vigour or individual fruit weight was not apparent.

Application of paclobutrazol to the soil in addition to spray application of paclobutrazol and KNO_3 (Treat-

Figure 1. Spraying of the trees using knapsack sprayers when the inflorescences were developing and blooming on 1 October 2012.

Figure 2. General stage of flowering at the time of spraying on 1 October 2012.

ments A_1 to A_4 vs. Treatments A_5 to A_8) may have reduced fruit retention. An effect was not clear though. A benefit of soil paclobutrazol application was not evident in the current study.

The difference in rate of soil paclobutrazol application (Treatments A_5 and A_6 vs. Treatments A_7 and A_8), whether 3 ml of 6 ml per tree did not result in a difference of any of the parameters assessed.

DISCUSSION AND CONCLUSION

Our results indicate that paclobutrazol application at flowering is effective in increasing fruit size and not fruit retention. Spray application was apparently sufficient for this response, as no added benefit was noted in additionally applying paclobutrazol to the soil. Combining paclobutrazol with 2% KNO_3 resulted in an increase in the number of fruits retained until harvest on 5 September 2013. The number of fruits present earlier on 5 January 2013 was not apparently affected. Paclobutrazol spray application only affecting size without increasing or reducing fruit number has previously been documented (Wolstenholme *et al*., 1988; Whiley *et al*., 1992). The additional effect of increasing fruit retention in combining paclobutrazol with KNO_3 in spraying has not been previously reported.

KNO_3 spraying has been observed to increase leaf K and N concentration in 'Hass' avocado (Sing & McNeil, 1992). It is noteworthy that KNO_3 spraying did not result in an increase in new shoot vigour in the current study. It may be argued that the influence of additional K facilitated assimilate movement to competing fruit. K is known to be implicitly involved in assimilate movement in the phloem (Vreugdenhil, 1985). Further work will be required to elucidate the mechanism of action for the KNO_3 effect observed of increased fruit retention.

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Table 1. Least squares means of number of fruit present and total new shoot length on 5 January 2013 or 5 September 2013 and average "individual" fruit weight at harvest on 5 September for each of the comparisons of relevance.

Comparison	Number of fruit on Jan. 5, 2013	Number of fruit retained	Total length of shoots on Jan. 5 (cm)	Total length of shoots later on Sep. 5 (cm)	Average fruit weight at harvest (g)
Control	2.09	0.70	18.63	34.57	119.71
PBZ spray, soil + KNO_3 (2%)	2.04	0.61	10.47	23.33	175.07
Significance level	0.8926	0.4137	**0.0005**	**0.0001**	**0.0002**
Spray PBZ at 1 or 2%	2.14	0.57	10.08	23.63	171.38
Spray PBZ at 1 or 2% + KNO_3 (2%)	1.98	0.75	11.65	24.21	173.16
Significance level	0.6071	**0.0621**	0.4418	0.8152	0.8908
Spray PBZ and KNO_3	2.06	0.66	10.87	23.92	172.27
Addition of soil PBZ	2.02	0.55	10.07	22.74	177.87
Significance level	0.8186	**0.1310**	0.6062	0.5744	0.5282
Sprays + Soil 3 ml PBZ	1.93	0.59	8.84	21.93	171.92
Sprays + Soil 6 ml PBZ	2.11	0.51	11.30	23.55	183.81
Significance level	0.5259	0.3001	0.2613	0.6359	0.3846