Increased fruit retention and size and reduced new shoot vigour in mendez avocado resulting from spray application of Paclobutrazol Plus potassium nitrate during flowering

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Bearing Mendez avocado trees were sprayed with paclobutrazol or paclobutrazol (Austar at 1 or 2%) plus potassium nitrate (KNO_3) (2% w/v) when the inflorescences were developing and flowering. In addition to these applications, soil applications of paclobutrazol were made (3 or 6 ml Austar applied around the trunk). The overall effect of paclobutrazol (spray/soil) plus KNO_3 treatment was to reduce the vigour of the new shoots arising after flowering (final length from 35 to 23 cm, or 33%), and to increase fruit size (120 to 175 g, or 46%). Fruit number was not reduced, and hence yield was increased. No additional cropping benefit or reduction in shoot vigour occurred as a result of the added application of paclobutrazol to the soil around the tree trunks. No effect relating specifically to the rate difference of paclobutrazol applied to the soil was observed. The specific effect of the addition of 2% (w/v) KNO_3 to paclobutrazol in spraying, was an increase in number of fruits retained until harvest (0.57 to 0.75 fruits per inflorescence, or 32%). Our research indicates a marked benefit to spray applying KNO_3 with growth retardant during flowering to increase tree yield.

Los árboles de paltas recibieron aplicaciones en spray de paclobutrazol o paclobutrazol (Austar en 1 o 2%) y KNO_3 (2% w/v) durante el desarrollo y florecimiento de las inflorescencias. Además, se realizaron aplicaciones de paclobutrazol al suelo(3 o 6 ml de Austar aplicado alrededor del tronco). El efecto general del tratamiento conjunto de paclobutrazol y KNO_3 fue la de reducir el vigor de los nuevos brotes que emergieran después de la floración (largo final entre 35 a 23 cm, or 33%), y aumentar el tamaño del fruto (120 a 175 gr, o 46%). No disminuyó el número de frutos, y por ende, aumentó el rendimiento. No hubo beneficios adicionales, como tampoco hubo una reducción del vigor de los brotes, como resultado de la aplicación adicional de paclobutrazol en el suelo alrededor de los troncos. El efecto específico del aumento de 2%(w/v) de KNO_3 paclobutrazol a través de aplicaciones en spray, fue el aumentar la cantidad de frutos mantenidos hasta la cosecha (0.57 a 0.75 frutos por inflorescencia oel 32%). No se observó un efecto específico que correspondiera a la diferencia en la tasa de paclobutrazol aplicado al suelo. Nuestra investigación indica un beneficio marcado tras las aplicaciones en spray de KNO_3 con retardadores del crecimiento durante la floración para aumentar el rendimiento del árbol.

Keywords: Persea americana, PBZ, Austar, Growth retardant, Fruit retention, Soil application.

INTRODUCTION

Fruit drop after flowering can be excessive in Mendez avocado grown in Jalisco State and other avocado-growing states of Mexico. Excessive drop once the fruits are about 3 to 5 cm long is considered to be a problem of most avocado cultivars grown commercially, including Fuerte and Hass. The extent of drop is seen to relate positively to the vigour of the new shoots emanating from and close to the inflorescences during and after the inflorescence development and flowering period (Kalmar and Lahav, 1976). Paclobutrazol, applied by spraying or application to the soil around the trunks during this period, is highly effective in subsequently reducing new shoot vigour. Reduced vigour is said to lessen demand of the new shoots for assimilates, and is thus associated with reduced abscission of fruits near the developing shoots, this giving rise to increased fruit numbers and yield at harvest (Wolstenholme et al., 1988). Increased fruit size in the absence of an increase in fruit number was reported by Whiley et al., (1992) in response to paclobutrazol application. Generally in avocado, monetary income per kg for small fruits is less than that for larger fruits. Fruits size and fruit number retained by trees are inversely related (Oosthuyse and Donkin, 2001).

Foliar sprays of KNO3 are known to increase fruit size in a number of fruit types, e.g., peach, olive or orange (Dikmelik et al., 1999; Boman, 2001; Sarfaraz, 2011). They may also reduce fruit drop after flowering in facilitating assimilate movement to competing, newly developing fruits. Potassium is intricately involved in the movement of assimilates in the phloem (Cakmak et al., 1994; Vreugdenhil, 1985). KNO3 sprays on mango inflorescences were found to increase fruit retention in numerous studies (Oosthuyse, 1997).

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

MATERIALS AND METHODS

Ninety, three-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 labelled 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:

A0 – Untreated control
A1 – Spray application of Austar at 1% at flowering, full cover
A2 – Spray application of Austar at 2% at flowering, full cover
A3 – A1 including KNO3 at 2% (w/v)
A4 – A2 including KNO3 at 2% (w/v)
A5 – A3 plus soil application of 3 ml Austar per tree
A6 – A4 plus soil application of 3 ml Austar per tree
A7 – A3 plus soil application of 6 ml Austar per tree
A8 – A4 plus soil application of 6 ml Austar per tree
Austar is an Australian paclobutrazol formulation containing 250 g pacloburazol per litre.
The spray and soil applications were made on October 1, 2012, when the inflorescences were developing and blooming (Fig. 1).

Fig. 1 Spraying of the trees on October 1, 2012, when the inflorescences were developing and blooming.

Knap sack sprayers were used in spraying, and full-cover sprays were applied. The general stage of flowering on October 1, 2012, is shown in Fig. 2.

Fig. 2 The general stage of flowering at the time of spraying on October 1, 2012.

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

RESULTS

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

Table 1 On a per branch basis, least squares means of number of fruits present and total new shoot length on Jan. 5, 2012 or Sep. 5, 2012, and average "individual" fruit weight on Sep. 5, for each comparison of relevance

Comparison	Number of fruits on Jan. 5, 2013.	Number of fruits 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 + KNO3 (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% + KNO3 (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 KNO3	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

The treatments were generally effective in reducing new shoot vigour, as determined by total shoot length shortly after flowering (Jan. 5) or at harvest (Sep. 5). Overall, they did not affect the number of fruits present shortly after flowering (Jan. 5), or the number of fruits present at harvest (Sep. 5). Individual fruit weight was increased, as thus fruit yield. New shoot length was reduced from 35 to 23 cm (-33%) on average, and fruit size increased from 120 to 175 g (46%) on average.

In spraying KNO_3 (2%) with paclobutrazol (1 or 2%) as opposed to spraying paclobutrazol (1 or 2%) alone (Treatments A1, A2 vs Treatments A3, A4), number of fruits set on Jan. 5, did not apparently differ. Number of fruits present at harvest was increased as a result of the addition of KNO_3 to the paclobutrazol spray. On average, number of fruits retained per inflorescence was increased from 0.57 to 0.75 (32%). An effect of the addition KNO_3 to paclobutrazol in spraying on shoot vigour or individual fruit weight at harvest was not apparent.

Application of paclubutrazol to the soil in addition to spray application of paclobutrazol plus KNO_3 (Treatments A1 to A4 vs Treatments A5 to A8) may have reduced fruit retention and consequently yield. The effect was not clear, however. An effect on number of fruits initially set, new shoot vigour or individual fruit weight was not apparent.

The rate difference of soil paclobutrazol application (Treatments A5 and A6 vs Treatments A7 and A8) (3 or 6 ml per tree), did not apparently result in a difference in any of the parameters assessed.

DISCUSSION AND CONCLUSIONS

Our results indicate that paclobutrazol application at flowering is effective in reducing new shoot vigour and increasing fruit size. Spray application was apparently sufficient for this response, as no added benefit was noted in additionally applying paclobutrazol to the soil. In adding KNO_3 (2% w/v) to the paclobutrazol solution, an increase in number of fruits retained at harvest resulted. Number of fruits set shortly after flowering was not apparently affected by this addition. 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 benefit of additionally increasing fruit retention when combining paclobutrazol with KNO_3 in spraying has not been reported previously.

KNO_3 foliar spray application has been observed to increase leaf K and N concentration in Hass avocado (Sing and McNeil, 1992). It is noteworthy that KNO3 spraying did not result in an increase in new shoot vigour in the current study. It may be argued that the additional K

facilitated assimilate movement to the competing, actively growing fruits. K is known to be implicitly involved in assimilate movement in the phloem (Cakmak et al., 1994; Vreugdenhil, 1985).

Further work is required to elucidate the mechanism of action for the KNO3 reducing fruit drop when sprayed in combination with paclobutrazol during the inflorescence development period in avocado.

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