EFFECT OF UNICONAZOLE OR PACLOBUTRAZOL, SPRAY APPLIED WITH OR WITHOUT KNO_3, AT OR AT AND AFTER FLOWERING, ON TREE YIELD, SOLITARY FRUIT WEIGHT AND SPRING FLUSH LENGTH IN 'MALUMA HASS' AVOCADO

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Dr SA Oosthuyse sadly passed away in October 2023 after finalising this research article.

ABSTRACT
In the current study, paclobutrazol (0.6% Avocet v/v) or uniconazole (1% UniQ v/v) sprays, including or excluding KNO_3 (3% powder w/v), were made on bearing 'Maluma Hass' avocado trees when they were in flower, or when they were in flower and subsequently when newly set fruit were on the trees. A three-way factorial experiment was conducted, where growth regulator type, number of applications (at or at and after flowering), and inclusion or exclusion of KNO_3 were factors. Application was made at the rates adopted commercially. Tree yield, solitary fruit weight, and spring flush length were quantified at harvest.

New shoot length (spring flush) was reduced by uniconazole and paclobutrazol. Uniconazole gave rise to greater reductions than paclobutrazol. KNO_3 inclusion did not affect new shoot length. None of the treatments affected solitary fruit weight (size). Uniconazole applied at and after flowering gave rise to a reduction in tree yield and fruit retention, whereas application during flowering only did not. A lesser reduction in yield may have resulted from paclobutrazol applied at flowering and afterwards. Paclobutrazol or uniconazole application at flowering had no apparent effect in reducing fruit retention or yield. Neither paclobutrazol nor uniconazole gave rise to an increase in tree yield, nor was tree yield affected by the inclusion of KNO_3. Uniconazole particularly appeared to enhance fruit drop when applied after flowering. None of the sprays were beneficial regarding effects on fruit size and number at harvest.

Key words: avocado, spray, paclobutrazol, uniconazole, potassium nitrate, flowering

INTRODUCTION

Paclobutrazol and uniconazole are extension growth inhibitors. They act primarily by inhibiting gibberellin biosynthesis in plants (Rademacher, 2016). Paclobutrazol or uniconazole applications to bearing avocado trees during and shortly after flowering are considered to increase tree yield by enhancing fruit retention and size (Wolstenholme *et al*., 1988; Whiley *et al*., 1992). These effects are attributed to reduced spring flush vigour resulting from the application of these growth regulators. New shoots growing during and shortly after flowering are considered to compete with the newly set fruits for resources required for sustained fruit retention and growth. A reduction in new shoot vigour implies lesser competition imposed by the new shoots for available resources. Prior research (Oosthuyse, 2019) showed that the new shoot length reductions resulted from reductions in internode length, and that leaf size and number were not affected, nor shoot girth and new shoot weight. It might thus be argued that shoot vigour is not reduced by paclobutrazol or uniconazole.

KNO_3 sprays made during flowering are considered to improve fruit retention and size by increasing the efficiency of phloem translocation, which is especially reliant on potassium (Cakmak *et al*., 1994;

Vreugdenhil, 1985). Tree sprays containing KNO_3 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, 2010). They may also reduce fruit drop after flowering in facilitating assimilate movement to competing, newly developing fruits. KNO_3 sprays on mango inflorescences have been found to increase fruit retention in numerous studies (Oosthuyse, 1997). Of particular concern is the movement of sucrose to newly developing fruits from leaves and reserve tissues. Positive responses to K application are expected if the tree K status is not optimal.

Comparisons between the effects of uniconazole and paclobutrazol in a single study have not been made previously to the knowledge of the author, nor have the timings of the applications with respect to flowering received specific consideration.

The aim of the current study was to assess the effect of uniconazole or paclobutrazol, spray applied with or without KNO_3, at or at and after flowering, on tree yield, solitary fruit weight and spring flush length in 'Maluma Hass' avocado trees.

MATERIALS AND METHODS

Paclobutrazol or uniconazole sprays, including or excluding KNO_3, were made on bearing 'Maluma Hass' avocado trees when they were in flower, or when they were in flower and subsequently when fruits were set on the trees.

A three-way factorial experiment was conducted, where growth regulator type, number of applications (at or at and after flowering), and inclusion or exclusion of KNO_3 were factors. Applications were made at rates adopted commercially. Tree yield, solitary fruit weight, and spring flush length were quantified at harvest or shortly after harvest.

Factors in factorial treatment arrangement:

Factor I (product)

- P Paclobutrazol (0.6% Avocet v/v spray, light complete cover)
- U Uniconazole (1% UniQ v/v spray, light complete cover)

Factor II (number of applications)

- O Absence of application
- F Application during flowering
- FA Application during flowering and after flowering when the fruits had set and grown to an extent

Factor III (with or without KNO_3)

- K_0 Application without KNO_3
- K_1 Application with 3% (w/v) KNO_3

Treatments (factor combinations):

1) P O K_0
2) P F K_0
3) P FA K_0
4) P O K_1
5) P F K_1
6) P FA K_1
7) U O K_0
8) U F K_0
9) U FA K_0
10) U O K_1
11) U F K_1
12) U FA K_1

There were 10 replications of 12 treatments in a complete randomized blocks experiment. Single trees served as plots. The experiment was carried out in a 'Maluma Hass' hedgerow orchard block on the commercial farm of Nick Human in the vicinity of Tzaneen, South Africa (Fig. 1). The trees were 10 years old and were spaced 8 (between row) x 4 m (within row) apart. They are micro-sprinkler irrigated and managed according to commercial guidelines.

When the trees were in flower, 10 inflorescence bearing terminal shoots well distributed around each tree were labeled.

In applying the treatments, 16 L knapsack sprayers were used. The nozzles were set to fine. The adjuvant Villa 51 was used (8 ml/16 L). A light complete cover spray was made on each tree (Fig. 2). KNO_3 was applied with uniconazole or paclobutrazol. Spraying was carried out in the late afternoon when conditions were relatively cool.

Figure 1: Trees in the trial orchard block.

Figure 2: Degree of leaf wetting. A light complete full cover spray was made on each of the trees sprayed.

Figure 3: Stage of flowering when the first sprays were made (7 September 2018).

Table 1: Analysis of variance for tree fruit yield

Analysis of Variance - Type III Sums of Squares					
Source of variation	**Sum of Squares**	**d.f.**	**Mean square**	**F-ratio**	**Sig. level**
MAIN EFFECTS					
A:MALPU.Block	4191.9374	9	465.7708	1.436	0.1832
B:MALPU.Product	1344.4230	1	1344.4230	4.145	0.0444
C:MALPU.NoApplic	4652.6577	2	2326.3288	7.171	0.0012
D:MALPU.KNO_3	573.3441	1	573.3441	1.767	0.1867
INTERACTIONS					
BC	1663.8482	2	831.92412	2.565	0.0821
BD	16.4280	1	16.42800	0.051	0.8248
CD	726.9104	2	363.45521	1.120	0.3302
BCD	7.8788	2	3.93939	0.012	0.9879
RESIDUAL	32114.170	99	324.3855		
TOTAL (CORRECTED)	45291.598	119			

Table 2: Analysis of variance for solitary fruit weight

Analysis of Variance - Type III Sums of Squares					
Source of variation	**Sum of Squares**	**d.f.**	**Mean square**	**F-ratio**	**Sig. level**
MAIN EFFECTS					
A:MALPU.Block	11835.695	9	1315.0772	2.015	0.0452
B:MALPU.Product	44.008	1	44.0077	0.067	0.7984
C:MALPU.NoApplic	152.647	2	76.3235	0.117	0.8897
D:MALPU.KNO_3	452.913	1	452.9133	0.694	0.4157
INTERACTIONS					
BC	105.63204	2	52.81602	0.081	0.9223
BD	314.31270	1	314.31270	0.482	0.4967
CD	489.17503	2	244.58752	0.375	0.6884
BCD	839.61408	2	419.80704	0.643	0.5277
RESIDUAL	64601.501	99	652.54042		
TOTAL (CORRECTED)	78835.498	119			

Figure 4: Stage of set and fruit development when the second sprays were made (17 September 2018).

The first sprays were made on 7 September 2018, and the second sprays on 17 September 2018. Figure 3 shows the stage of flowering when the first sprays were made, and Figure 4 the post-flowering stage and extent of fruit development when the second sprays were made. The trees were harvested on 5 May 2019. The fruit harvested from each tree were weighed after being placed in crates. 50 randomly selected fruit per tree were then sampled for individual weighing. Shortly after harvest, the length of the longest new shoot that grew from each of the 10 labeled terminal shoots was measured.

RESULTS AND DISCUSSION

Table 1 shows the analysis of variance for tree yield.

Main effect significance for "product" or "number of applications" was evident, as well as for interaction of "product" and "number of applications." Significant interaction resulted from the marked reduction in yield resulting from application of uniconazole during as well as after flowering (Fig. 5). Differences were not evident regarding absence of application and application of uniconazole or paclobutrazol at flowering only or application of paclobutrazol at and after flowering.

Table 2 shows the analysis of variance for solitary fruit weight.

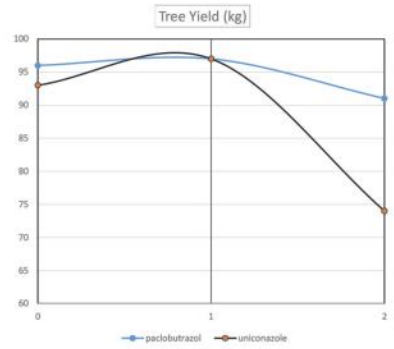

Figure 5: Plot of number of paclobutrazol or uniconazole applications (0 – no applications, 1 – application at flowering only, 2 – application at flowering and after flowering) and tree yield.

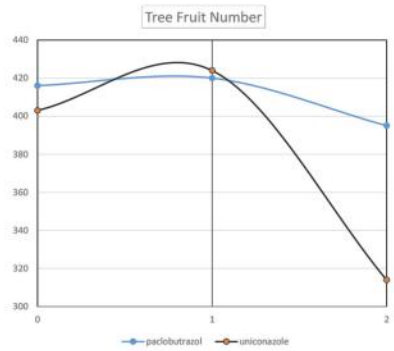

Figure 6: Plot of number of paclobutrazol or uniconazole applications (0 – no applications, 1 – application at flowering only, 2 – application at flowering and after flowering) and tree fruit number.

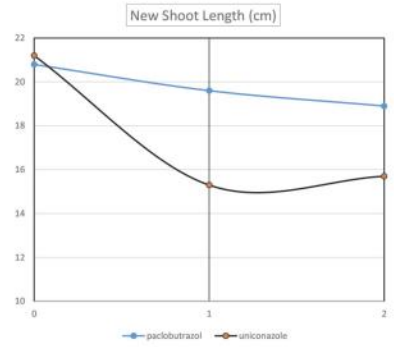

Figure 7: Plot of number of paclobutrazol or uniconazole applications (0 – no applications, 1 – application at flowering only, 2 – application at flowering and after flowering) and shoot length.

Effects of the treatments on solitary fruit weight were indicated to be absent. It might thus be deduced that the effects of the treatments on tree yield related directly to their effect on fruit retention.

Table 3 shows the analysis of variance for tree fruit number at harvest.

Table 3: Analysis of variance for tree fruit number

Analysis of Variance - Type III Sums of Squares					
Source of variation	**Sum of Squares**	**d.f.**	**Mean square**	**F-ratio**	**Sig. level**
MAIN EFFECTS					
A:MALPU.Block	168882.74	9	18764.749	2.318	0.0207
B:MALPU.Product	27573.01	1	27573.008	3.406	0.0680
C:MALPU.NoApplic	102323.52	2	51161.758	6.319	0.0026
D:MALPU.KNO_3	17545.01	1	17545.008	2.167	0.1442
INTERACTIONS					
BC	40654.817	2	20327.408	2.511	0.0864
BD	78.408	1	78.408	0.010	0.9229
CD	9906.317	2	4953.158	0.612	0.5444
BCD	2542.217	2	1271.108	0.157	0.8549
RESIDUAL	801489.96	99	8095.8582		
TOTAL (CORRECTED)	1170996.0	119			

Main effect significance for "product" or "number of applications" was evident, as well as for interaction of "product" and "number of applications." Significant interaction resulted from the marked reduction in fruit retention caused by application of uniconazole during as well as after flowering (Fig. 6). Differences were not evident regarding absence of application and application of uniconazole or paclobutrazol at flowering only or application of paclobutrazol at and after flowering.

Table 4 shows the analysis of variance for shoot length (cm).

Table 4: Analysis of variance for shoot length (cm)

Analysis of Variance - Type III Sums of Squares					
Source of variation	**Sum of Squares**	**d.f.**	**Mean square**	**F-ratio**	**Sig. level**
MAIN EFFECTS					
A:MALPU.Block	280.82667	9	31.20296	1.582	0.1311
B:MALPU.Product	169.93200	1	169.93200	8.614	0.0041
C:MALPU.NoApplic	356.25017	2	178.12508	9.029	0.0003
D:MALPU.KNO_3	8.53333	1	8.53333	0.433	0.5193
INTERACTIONS					
BC	116.89550	2	58.447750	2.963	0.0563
BD	49.92300	1	49.923000	2.531	0.1149
CD	12.02317	2	6.011583	0.305	0.7380
BCD	8.87450	2	4.437250	0.225	0.7990
RESIDUAL	1953.0933	99	19.728215		
TOTAL (CORRECTED)	2956.3517	119			

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Main effect significance for "product" or "number of applications" was evident, as well as for interaction of "product" and "number of applications." Significant interaction resulted from the more pronounced reductions in length resulting from the uniconazole sprays than the paclobutrazol sprays (Fig. 7).

KNO_3 inclusion had no apparent effect on fruit retention or fruit solitary weight. It might be concluded that tree K status was adequate, this being a plausible reason for the absence of a response.

Fruit size was not influenced by any of the spray treatments applied. Increases in fruit retention and yield were not observed. On the contrary, the post-flowering spray of uniconazole would appear to have given rise to increased fruit drop, this resulting in reduced tree yield in trees sprayed with uniconazole at and after flowering. The flowering applications of uniconazole or paclobutrazol had no apparent effect on solitary fruit weight or fruit retention, despite shoot length being reduced by these applications.

In prior research (Oosthuyse, 2021), where 'Maluma Hass' trees were sprayed with paclobutrazol (0.7% v/v) or paclobutrazol and potassium nitrate (2 or 3%) during flowering, paclobutrazol increased fruit drop and gave rise to an increase in fruit solitary weight. Tree yield was reduced by 10%, however, the solitary fruit-weight increase not compensating for the fruit thinning effect of paclobutrazol. Shoot length was reduced by 20% on average. Number of new shoots was not reduced. KNO_3 was effective in increasing leaf N and K concentrations and, to an extent, countering the fruit thinning effect of paclobutrazol.

Whiley *et al*. (1992) reported increased fruit size without an increase in tree yield. This implies a reduction in fruit number following paclobutrazol application made during flowering.

The results of the current and prior study (Oosthuyse, 2019) do not support the practice of paclobutrazol or uniconazole spray application during or during and after flowering. Both products have been found to give rise to increased fruit drop without a benefit arising from increased fruit size or tree yield.

Paclobutrazol and uniconazole are observed to increase the flowering propensity of new shoots. Trees having attained full size require yearly pruning for adequate light exposure during the season. Outgrowth after pruning often has a reduced flowering capacity. Applications of these growth regulators on new shoots arising after pruning to increase flowering may be particularly beneficial. This avenue of research requires attention.

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