

Evaluation of ultra-low volume fungicide applications for the control of diseases on avocado fruit

Results from the 2010/11 season

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ABSTRACT

Cercospora spot, anthracnose and stem-end rot is the main diseases affecting the quality of avocado fruit. These diseases are controlled by high volume (up to 8200 L/ha) pre-harvest copper oxychloride applications using mist blowers. Ultra-low volume (ULV) fungicide application could possibly reduce the amount of fungicide needed per hectare in avocado, compared to the currently used mist blowers. This could be achieved by reducing the amount of run-off as the fungicide fog settles on the target tree with little or no run-off, while giving good fungicide cover and disease control. During the 2009/10 avocado season a prototype ULV spray machine was used in trials to apply copper oxychloride to trees of avocado cultivars 'Fuerte', 'Ryan' and 'Hass' according to the commercial spray program. In these trials the machine was compared to mist blowers with regards to copper residues deposited on the leaves and the level of disease control achieved. Results achieved showed that the ULV machine has great potential for use in avocado production. In the 2010/11 season the disease control trials were repeated, while the machine was also used to apply growth regulator on the spring and summer flush of 'Hass' trees. Results in the disease control trials again showed that the ULV machine compared very favourably to commercially used mist blowers in terms of disease control. It was furthermore shown that this machine can also be used successfully for the application of growth regulators as the growth retardation achieved with the different machines was statistically similar. Results obtained in the second season of testing again indicated that this type of application technology has great potential for use in avocado production.

INTRODUCTION

Several diseases occur on avocado fruit (Lonsdale & Kotzé, 1989), including Cercospora spot, anthracnose and stem-end rot (Darvas & Kotzé, 1981; Lonsdale & Kotzé, 1989). These diseases are controlled in the South African avocado industry by the pre-harvest application of high volume copper fungicides (Boshoff *et al.*, 1996; Willis & Mavuso, 2009). Initially, these applications were done using hand gun sprayers, but these have been replaced by mist blowers. Mist blowers allowed the application of lower volumes of spray mixture per hectare to achieve the same level of disease control. This was due to less run-off that were a big problem with the high volume handgun applications.

Ultra-low volume application of fungicides was tested in avocado by Duvenhage and Köhne (1999). They applied different systemic fungicides as well as copper ammonium acetate and copper oxychloride to 'Fuerte' trees for the control of Cercospora spot (black spot). In their trials they used hand-held

thermal foggers from pulsFOG®. Results obtained in these trials indicated that, in comparison to the standard commercial practice of two high volume copper oxychloride applications, reasonable results were obtained with either four benomyl or four carbendazim applications applied by ULV thermal fogging. These two treatments both had $\geq 80\%$ fruit clean from Cercospora spot, compared to the 90%+ clean fruit obtained with the high volume copper applications (Duvenhage & Köhne, 1999). These results were quite promising given the fact that they were obtained under high disease pressure conditions in the Tzaneen area. Under low disease pressure conditions in the Mooketsi valley, three applications of copper ammonium acetate using the pulsFOG® machines gave exactly the same disease control compared to the two high volume copper ammonium acetate applications used commercially (Duvenhage & Köhne, 1999).

The pulsFOG® TracFog 100F machine was developed specifically for orchard crops and was imported to South Africa in 2009. The first disease con-



trol trials using this machine were conducted in the 2009/10 season on 'Fuerte', 'Hass' and 'Ryan' in the Tzaneen area. Results from these trials indicated that on all cultivars the level of disease control achieved using the ULV TracFog 100F to apply copper oxychloride was the same and in some cases better than that achieved with the commercial copper applications using mist blowers.

Based on these promising results, the trials were repeated in the 2010/11 season. Additional disease control trials were conducted in the Howick area, KwaZulu-Natal (KZN), to determine if other copper formulations can also be applied with this machine. Uniconazole is registered on avocado as a foliar spray for control of vegetative growth after mid-summer pruning when re-growth is 10-15 cm long. On 'Hass' uniconazole was applied for re-growth control to the spring and summer flush using the TracFog 100F, again to test the principle of using ULV applications for the application of this chemical. The results from the various trials are reported below.

MATERIALS AND METHODS

Fungicide application – Tzaneen, Limpopo

In the 2010/11 season the trial was repeated on 'Fuerte', 'Ryan' and 'Hass'. In the trial the TracFog 100F was compared to mist blowers with regards to disease control achieved. The treatments applied were the following:

1. Untreated fruit.
2. Standard production copper oxychloride application (3 g/L, 50% metallic copper) with mist blowers. The application volumes were: 'Hass' = 3000 L/ha; 'Fuerte' = 8200 L/ha; 'Ryan' = 3500 L/ha.
3. TracFog 100F, application at 133 L/ha. In the case of 'Fuerte' the spray mixture consists of copper oxychloride at a concentration of 150 g/L, water and 20% di-ethylene glycol (VKII Spezial). On 'Hass' and 'Ryan' the same mixture was used but the copper oxychloride concentration was 112.5 g/L.

The treatments were applied according to the following spray schedule:

- 'Hass' – November 2010 and January 2011.
- 'Fuerte' – November 2010, December 2010, January 2011.
- 'Ryan' – November 2010, December 2010, January 2011, February 2011.

Fruit samples from the different treatments were picked from the 'Hass' and 'Fuerte' replicates in June

2011 and 'Ryan' in July 2011. 'Fuerte' and 'Ryan' fruit were rated for percentage marketable fruit based on black spot symptoms, while 'Hass' fruit were rated for percentage marketable fruit based on pepper spot symptoms observed on the 'Hass' fruit. The rating was done according to a rating scale of 0 - 3, with fruit with a 0 rating being disease free fruit and fruit with a rating of 3 being severely diseased fruit. After storage at 5.5°C for 28 days, fruit were ripened at 22°C before being evaluated for the post-harvest diseases stem-end rot and anthracnose, using above-mentioned rating scale. After fruit evaluation, the percentage clean fruit in each treatment was calculated for each disease before this data was subjected to statistical analysis.

Fungicide application – Howick, KZN

The trial was done in Howick, KwaZulu-Natal. The aim of the trial was to test the application of different copper formulations on 'Hass' using the TracFog 100F. At the trial farm no copper applications are done on 'Hass' and the TracFog 100F applications were therefore compared with this standard no-spray practice. The treatments applied were the following:

- Copper oxide applied at 130 L/ha using the TracFog 100F in November 2010 and January 2011. The spray mixture consisted of water, 20% EOS mineral oil and 25 g/L copper oxide (25 x concentrate solution).
- Copper hydroxide applied at 130 L/ha using the TracFog 100F in November 2010 and January 2011. The spray mixture consisted of water, 20% EOS mineral oil and 45 ml/L copper hydroxide (25 x concentrate solution).
- Unsprayed control.

Fruit samples from each treatment were picked during June 2011. 'Hass' fruit were externally rated for pepper spot symptoms. The rating was done according to abovementioned rating scale.

Fruit samples from each treatment were directly ripened before being evaluated for post-harvest diseases, anthracnose and stem-end rot using the same rating scale as mentioned above. After fruit evaluation, the percentage clean fruit in each treatment was calculated for each disease before this data was subjected to statistical analysis.

Uniconazole application – Tzaneen, Limpopo

The trial was conducted during February 2011 in a 'Hass' orchard when the summer flush was 10 - 15 cm long. In the trial the TracFog 100F application of uniconazole was compared to the commercial practice of mist blower or motorised back pack sprayer

Table 1. Spray volumes, solution concentrations and active ingredient per hectare applied with different spray machines to 'Hass' trees for the control of the summer vegetative flush.

Spray equipment	Spray volume (L/ha)	Concentration (%)	a.i./ha (g/ha)
TracFog 100F	124	2.4%	150
Mist blower	600	0.5%	150
Motorised back pack	300	0.5%	75



applications. The spray volume per hectare (L/ha), spray solution concentration (%) and active ingredient per hectare (a.i./ha) applied as different treatments during the trial are given in Table 1.

Each of the treatments was applied to at least 70 trees. For each of the treatments 50 flushes, 10 - 15 cm long, were marked. After application of the treatments, the flushes were measured weekly for four weeks from the date of application. The weekly measurement data was used to calculate the average growth (cm) achieved weekly with the different treatments over the four week evaluation period before being subjected to statistical analyses.

RESULTS

Fungicide application – Tzaneen, Limpopo 'Fuerte'

Results indicated that in all tree positions the mist blower and TracFog 100F gave statistically better control of *Cercospora* spot compared to the untreated control (Figure 1). On average, the TracFog 100F resulted in more disease free fruit compared to the mist blower. However, there was a significant difference in disease control obtained in the top and bottom of the trees with the TracFog 100F. Disease free fruit in the top of trees sprayed with the TracFog 100F was 49.1% compared to 88.1% in the bottom of the trees (Figure 1). This was a much more pronounced difference in comparison with the 2009/10 results. Even in the case of the mist blower, there was a difference of 12.8% in disease free fruit in the top and bottom of the tree (Figure 1). This is again in stark contrast with the 2009/10 results when the mist blower applications resulted in the same percentage of disease free fruit in the top and bottom of the tree.

The control of post-harvest diseases was very good with the mist blower and the TracFog 100F. In all positions in the tree, both machines resulted in more than 95% marketable fruit based on stem-end rot and anthracnose symptom ratings. Both machines performed statistically better than the untreated control (Figure 2; control data not included).

'Hass'

Control of pepper spot on 'Hass' in terms of clean fruit was the best with the mist blower copper oxychloride applications. This was followed by the TracFog 100F applications that was only slightly better than the unsprayed control (Figure 3). Results obtained with the mist blower and TracFog 100F was also not significantly better than the untreated control (Figure 3). Due to severe hail damage to the trial orchard there was not enough fruit available to make a distinction between the disease control achieved in the top and bottom of the sprayed trees. The results is in contrast to the 2009/10 results when both machines resulted in more than 95% marketable fruit. This can possibly be attributed to an extremely wet season that would have increased the disease pressure in the trial orchard enormously in comparison to the previous season.

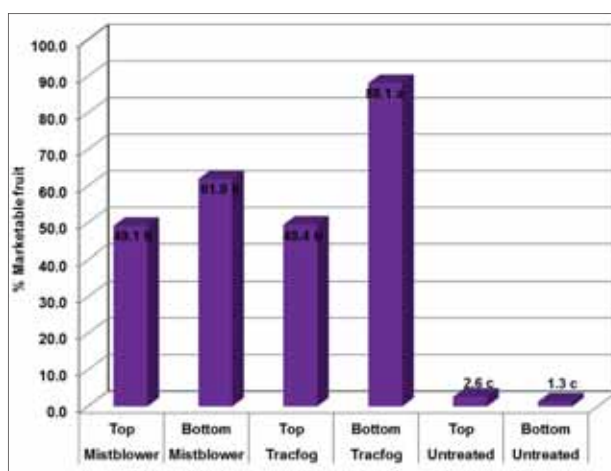


Figure 1. Mean percentage clean fruit based on black spot symptom ratings obtained with the TracFog 100F and mist blower copper oxychloride applications in different positions in 'Fuerte' trees.

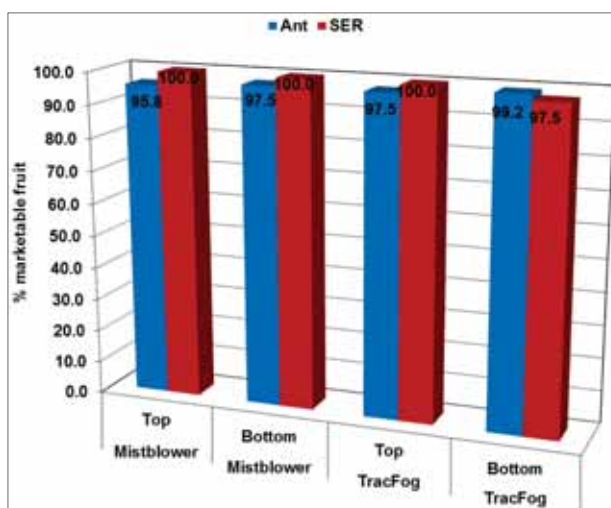


Figure 2. Mean percentage marketable fruit based on stem-end rot and anthracnose symptom ratings obtained with the TracFog 100F and mist blower copper oxychloride applications in different positions in 'Fuerte' trees.

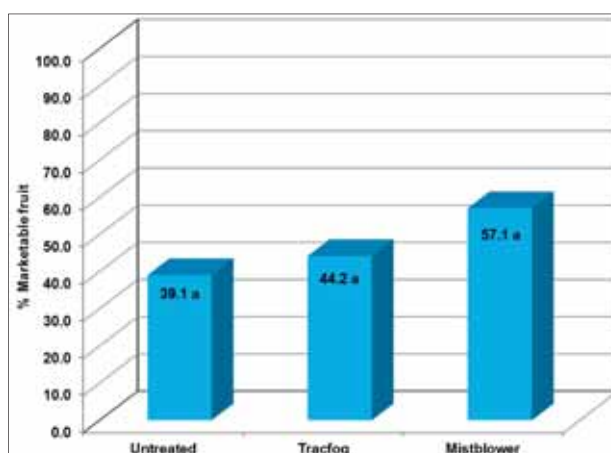


Figure 3. Mean percentage clean fruit based on pepper spot symptom ratings obtained with the TracFog 100F and mist blower copper oxychloride applications in 'Hass' trees.



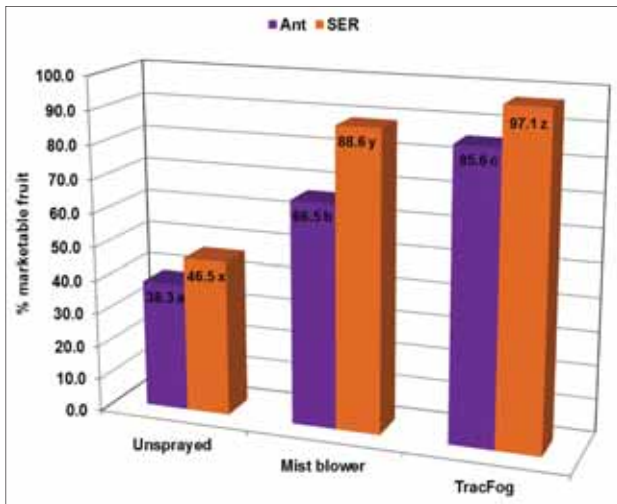


Figure 4. Mean percentage marketable fruit based on stem-end rot and anthracnose symptom ratings obtained with the TracFog 100 and mist blower copper oxychloride applications on 'Hass' trees.

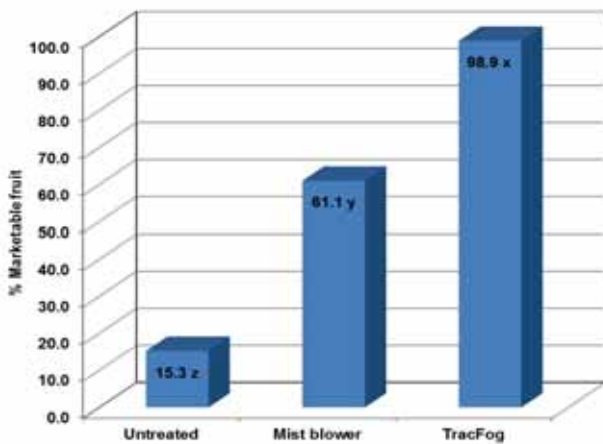


Figure 5. Mean percentage clean fruit based on black spot symptom ratings obtained with the TracFog 100F and mist blower copper oxychloride applications in 'Ryan' trees.

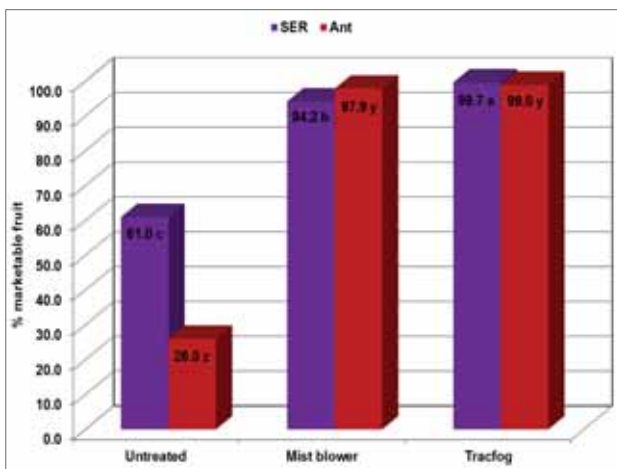


Figure 6. Mean percentage marketable fruit based on stem-end rot and anthracnose symptom ratings obtained with the TracFog 100 and mist blower copper oxychloride applications in 'Ryan' trees.

On 'Hass' the best control of stem-end rot was obtained with the TracFog 100F. Copper oxychloride applications with this machine resulted in 97.1% marketable fruit that was significantly better than the mist blower (85.6%) and untreated control (46.5%) (Figure 4). With regards to anthracnose control, the best control was again achieved with the TracFog 100F machine. This machine achieved 88.6% marketable fruit relative to the mist blower that achieved 66.5% marketable fruit and the untreated control with 38.3% marketable fruit (Figure 4).

'Ryan'

On 'Ryan' fruit the mist blower and TracFog 100F gave statistically better control of *Cercospora* spot compared to the untreated control (Figure 5). The TracFog 100F also gave almost 1.5 times better control of *Cercospora* spot compared to the mist blower. With regards to differences in control between the top and bottom of the trees, no significant differences were observed in any of the treatments (Figure 5).

The TracFog 100F applications resulted in statistically more marketable fruit, based on stem-end rot symptoms, compared to the mist blower applications. With regards to anthracnose control, applications with both machines resulted in more than 97% marketable fruit (Figure 6).

Fungicide application – Howick, KZN

'Hass'

The copper oxide and copper hydroxide applications were done with the TracFog 100F in November 2010 and January 2011 (Figure 7). Despite the high percentage of marketable fruit in the unsprayed treatment, the best results in terms of pepper spot free fruit were achieved with the copper oxide applications. This application resulted in between 9% and 10% more fruit free from pepper spot, compared to the copper hydroxide applications and the unsprayed treatment (Figure 7).

In the trial orchard the disease pressure for stem-end rot and anthracnose was very low. Due to this, no difference could be observed in disease control achieved with the TracFog 100F applications of the two copper formulations. All treatments led to more than 95% marketable fruit based on stem-end rot and anthracnose symptoms (Figure 8).

Uniconazole application – Tzaneen, Limpopo

'Hass'

The best result was achieved with the commercial control treatment of 0.5% applied with a mist blower at a volume of 600 L/ha. Results achieved with the TracFog 100F and motorised back pack was similar, although not as good as the mist blower application. However, the differences were not statistical (Figure 9).

CONCLUSION

The results obtained in the second season of testing of the TracFog 100F again showed the potential of this technology in avocado production. In the dis-



ease control trials of the 2010/11 season the TracFog 100F again performed just as well and in some cases better than the commercial mist blower applications of copper. In the case of 'Fuerte', the average control of Cercospora spot achieved by the TracFog 100F was better than the mist blower. The control achieved by the TracFog 100F in the top of the trees was very poor and about two times worse than in the bottom of the trees. This was already observed in the 2009/10 season, but was much more pronounced in the 2010/11 season. This probably again indicates that the two nozzles of the TracFog 100F is not sufficient to give good coverage of especially large trees. In the case of the much smaller 'Ryan' trees where Cercospora spot symptoms were also rated, the difference in control between the top and bottom of the trees was not observed. However, as for 'Fuerte', the control of Cercospora spot achieved with the TracFog 100F on the 'Ryan' was much better than that achieved by the mist blower. In the case of 'Fuerte' these results were achieved by applying 50% less copper.

In the case of pepper spot on 'Hass' in the Tzaneen area, the control achieved by the TracFog 100F applying copper oxychloride was statistically worse than that of the mist blower. In the 'Hass' trials in the Howick area the copper oxide applications with the TracFog 100F was almost 10% better than the untreated control. It also showed that other copper formulations, apart from copper oxychloride, can also be successfully applied using the TracFog 100F. In all the trials the control of post-harvest diseases achieved by the TracFog 100F applications was just as good as the commercial mist blower applications at much higher volumes.

The uniconazole registration allows for a dosage of 0.5% at a spray volume/ha of 1200 L for most fully grown orchards. It further states that the spray volume/ha needs to be reduced proportionally for smaller sized trees. Therefore, the registration allows for a maximum of 300 g a.i./ha to be applied for vegetative re-growth control during summer (0.05 g a.i./ml of uniconazole at 5 ml uniconazole/L of spray volume at 1200 L spray volume/ha). As the dosage of uniconazole applied with the TracFog 100F application was adjusted to allow the same amount of a.i./ha to be applied as with the mist blower treatment, sufficient growth control was thus achieved, but at an ultra-low spray volume of 124 L/ha.

The results of all the trials reported on in this paper indicate that the principle of ULV applications of agrochemical in avocado production has great potential. Developed further, this technology can lead to lower applications cost due to a reduction in the amount of chemical used, smaller tractors being used and less time used to do applications. However, the results also indicate that the current TracFog 100F machine is probably not the best machine to use in ULV applications and would also need to be further developed, especially by adding more fogging nozzles to get more even chemical coverage in the tree.

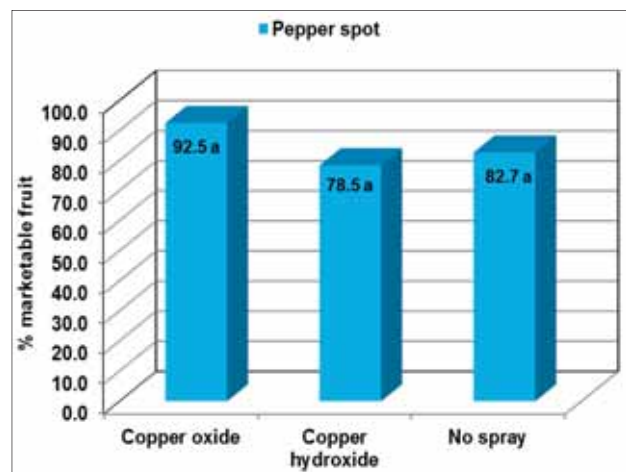


Figure 7. Mean percentage clean fruit based on pepper spot symptom ratings obtained with TracFog 100F applications of copper oxide and copper hydroxide on 'Hass' trees.

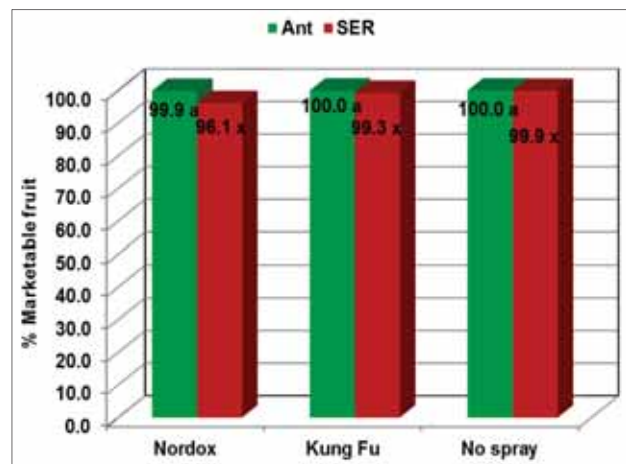


Figure 8. Mean percentage marketable fruit based on stem-end rot and anthracnose symptom ratings obtained with TracFog 100F applications of copper oxide and copper hydroxide on 'Hass' trees.

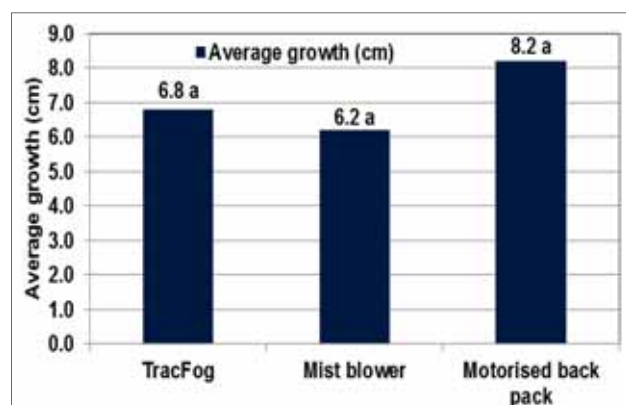


Figure 9. Mean growth of the vegetative flush on 'Hass' trees after application of uniconazole, using different spray machines.

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