Phosphonate treatments as part of early preventative control of *Phytophthora* root rot, pre- and post-planting

Preliminary report

M Grobler, J Meyer and J Liebenberg

Du Roi QMS, PO Box 416, Letsitele 0885, SOUTH AFRCA
Website: www.duroiqms.co.za

ABSTRACT

To inhibit *Phytophthora* root, caused by *Phytophthora cinnamomi* in South African avocado orchards, foliar application or stem injections of phosphite (H_3PO_3), a neutralised solution of the phosphonate anion is currently the standard control method that is applied. This study investigated the application methods for the prevention of *Phytophthora* root rot in newly planted orchard blocks as well as the efficacy of a pre-plant drench application of ammonium phosphonate followed by 6-weekly foliar sprays as a preventative procedure against *Phytophthora* root rot. Phosphite was applied as a foliar application or as a drench during the summer and autumn months when soil temperatures and moisture promotes growth and development of the pathogen (October 2013 – April 2014 and October 2014 – March 2015). Initial drench treatments were applied one day prior to planting (1 October 2013).

During the first season (October 2013 – September 2014), it was found that the disease pressure in the newly planted block was extremely high, causing tree death. In the first season no trees were killed where Brilliant (1X), without a pre-plant drench, was used and only one tree out of fifteen were killed where Brilliant (1X), with a pre-plant drench, was used. Preliminary results from tree height and circumference indicates that trees treated with Brilliant (1X), without a pre-plant drench, and Brilliant (1X), with a pre-plant drench, showed improved vigour (mid-season 1 to end-season 1) in terms of circumference and height improvement from measurements taken over the compared to the untreated control trees. Measurements taken for the growth period of trees from the end of season 1 to the beginning of season 2 showed the difference to still be present, although results were not significantly different from the other treatments. Treatments continued in season 2 (October 2014 – March 2015) and evaluations will continue until November 2015.

OBJECTIVES

To develop a practice that focuses on the prevention of *Phytophthora* root rot in newly planted orchard blocks.

Determine the efficacy of a pre-plant drench application of ammonium phosphonate followed by 6-weekly foliar sprays as a preventative procedure against *Phytophthora* root rot in newly planted orchard blocks.

INTRODUCTION

Phytophthora cinnamomi Rands is a plant pathogen of global importance as it affects wild and cultivated plants (Bekker *et al*., 2007; Perez-Jimenez, 2008). This aggressive pathogen causes extensive root rot in avocados (*Persea Americana* Mill.) and on average affects 20% of South African avocado orchards (Perez-Jimenez, 2008).

Several strategies have been implemented for the management of *Phytophthora* root rot. These include: Planting resistant rootstocks (Smith *et al*., 2011), biological control (Duvenhage & Kotze, 1993), yet, chemical control, namely with phosphite (H_3PO_3), a neutralised solution of the phosphonate anion (Fenn & Coffey, 1984), is still the main control method used for effective inhibition of *Phytophthora* root rot. Phosphonate fungicides control *Phytophthora cinnamomi* by a combination of direct fungitoxic activity and stimulation of host defence mechanisms (Guest & Grant, 1991).

Phosphite is highly mobile in plants as they are translocated in both the xylem and phloem (Ouimette & Coffey, 1989; Guest & Grant, 1991; Whiley *et al*., 1995). This property, therefore, permits its use as either stem injections or foliar sprays during periods of high disease pressure. Disease pressure in avocado orchards is highest during the summer and autumn months when soil temperatures and moisture promote growth and development of the pathogen (Whiley *et al*., 1995). Thus, strategic timing of phosphite applications, beginning at spring shoot growth maturity through to the mid to late summer months, will protect the roots of susceptible trees from colonisation by *Phytophthora cinnamomi* during this critical period.

A study done by Tynan *et al*. (2001) indicated that foliar applications of phosphite remained effective for five to 24 months in native Australian plant spp. and Shearer & Fairman (2007) showed that when *Banksia* spp. were treated with phosphite, by stem injections or foliar sprays, phosphite effectiveness persisted two years for foliar applications and four years for stem injections. Similar observations with cherry trees by Wicks & Hall (1988) indicated that the foliar sprays were not as persistent as stem injections, yet they concluded that foliar sprays were less phytotoxic and were the most economical means for phosphite applications. Fosetyl-Al and potassium phosphonate applied to avocado trees as foliar sprays has also indicated prolonged effective levels up to eight weeks (Ouimette & Coffey, 1989).

A pre-plant application of phosphite in pineapples has been described as 'highly effective' in controlling *Phytophthora* root rot (Anderson *et al*., 2012). Anderson *et al*. (2012) investigated two pre-plant applications, high volume sprays and pre-plant dip. Pre-plant dips were found to be the most effective application method, as the efficacy persisted until flowering. Pre-plant applications of potassium phosphonate, followed by monthly post-plant applications, were used by Smith *et al*. (2011) as a standard procedure for avocado rootstock selections for new avocado production blocks already infested with *Phytophthora cinnamomi*.

Previous work done at QMS with phosphite on avocado nursery trees in bags, found the ammonium phosphonate formulation was more effective than potassium phosphonate products and that a nursery drench application gave superior results than foliar applications. The South African avocado industry relies on phosphonate trunk injections for the management of *Phytophthora* root rot and phosphonate applications usually begin once infection has occurred and yield has been lost. In some instances trees with severe root rot may not recover, even after phosphite treatments. Thus, there is a need to develop a practice that focuses on the prevention of *Phytophthora* root rot in newly planted orchard blocks from an early stage with phosphonate other than fosetyl-Al.

MATERIALS AND METHODS

One day before the trees were planted, certain plots were treated with an ammonium phosphite (Brilliant SL) drench. For the first season, the various treatments (Table 1) were applied approximately every six weeks and evaluations regarding stem circumference and height improvement were done every four months.

Table 1 indicates the monthly planned second season applications (until March 2015). The same evaluations that were performed during season 1 will be applied and include: overall tree health, monthly stem girth and height, to determine whether the applications had any effect in preventing the onset of *Phytophthora* root rot. Evaluations will continue until November 2015.

The results were subjected to ANOVA and Fischer (LSD) t-test at a 95% confidence interval using XL-STAT 2014.5.04.

Table 1. Treatments

Treatments	Pre-plant drench (ml/200 ml water/tree)*	Foliar spray (%a.i/tree) (1st year)	Foliar spray (%a.i/tree) (2nd Year)	
1. Untreated control	0	0	0	
2. Ammonium phosphite (X1)	0	1	1	
3. Ammonium phosphite (0.5X)	1.33	0.5	0.5	
4. Ammonium phosphite (1X + drench)	2.67	1	1	
5. Ammonium phosphite (2X)	5.33	2	2	
		Soil drench (g a.i/m²/tree) (1st year)	Soil drench (g a.i/m²/tree) (2nd year)	
6. Ammonium phosphite (1X drench)	2.67	0.8	0.8	
7. Ammonium phosphite (2X d drench)	5.33	1.6	1.6	
		Commercial company protocol (g a.i/m²/tree) APPLY BI-WEEKLY	Stimu-Guard (ml/tree)	Stimu-Root (ml/tree)
8. Commercial programme	0	0.8	8	2

* Previous work done at QMS found soil drenching to be superior to foliar applications on avocado nursery trees

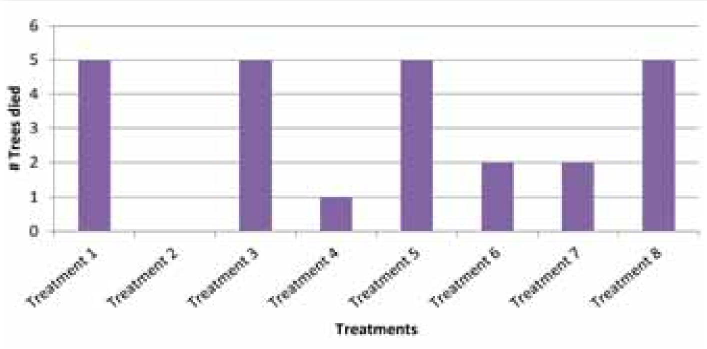

Figure 1. Number of trees per treatment that died due to *Phytophthora* root rot.

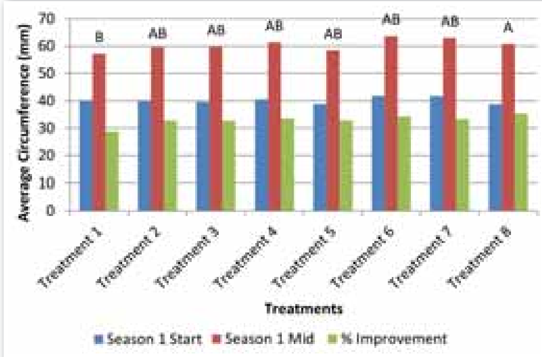

Figure 2. Stem circumference improvement from the beginning to mid-season 1.

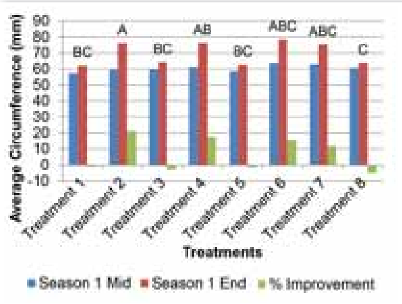

Figure 3. Stem circumference improvement from mid to end season 1.

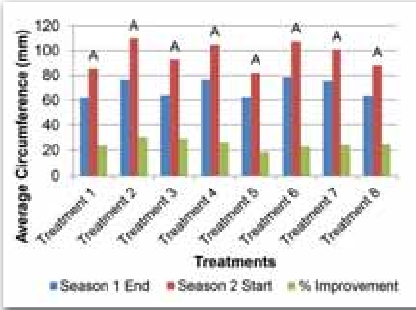

Figure 4. Stem circumference improvement from end season 1 to the beginning of season 2.

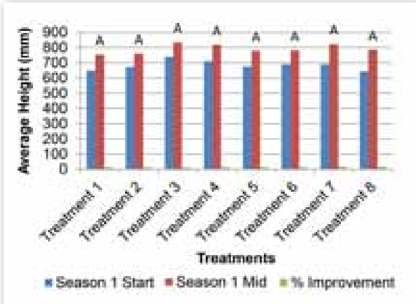

Figure 5. Height improvement from the beginning to mid-season 1.

RESULTS AND DISCUSSION

During the first season, it was found that the disease pressure in the newly planted block was extremely high and some of the trees needed to be replaced. Only with treatment 2 (Brilliant [1X] without pre-plant drench) were no trees killed due to disease, followed by treatment 4 (Brilliant [1X] with pre-plant drench) where one tree out of fifteen (6.7% loss) was killed. In treatments 6 (Brilliant [1X] drench) and 7 (Brilliant [2X] drench), two trees (13.3% loss) were killed. For the untreated control, treatments 3 (Brilliant 0.5X), 5 (Brilliant 2X) and 8 (commercial company protocol), 5 trees were killed during the run of this project (33.3% loss). These results are shown in Figure 1.

Average increase in stem circumference

Evaluations of stem circumference and height increase showed some very interesting results.

The initial evaluations taken at planting was compared to evaluations taken during (mid) the season (Fig. 2). This comparison indicated that treatment 8 had the highest stem circumference increase from the start of the season with an improvement percentage of 35.4%, which was significantly higher than that of the untreated control which had the lowest improvement percentage at 28.8%. No significant differences were found between the remaining treatments. Treatment 6 was the second best performing treatment, with an improvement percentage of 34.3%. It was closely followed by treatments 4 (33.5%), 7 (33.3%), 5 (32.81%), 2 (32.76%) and 3 (32.68%).

The mid-season results were then compared to the results obtained at the end of season 1 (Fig. 3). Negative values for improvement percentage clearly show which treatments performed very poorly as dead trees were replaced with new, younger trees. Here it is clear again that treatment 2 performed very well. With no trees lost to *Phytophthora* root rot, the improvement percentage reached 21.2% from mid-season to the end of the season. Treatment 4 came in second, with an improvement percentage of 17.7%, followed by treatments 6 (15.8%) and 7 (11.7%). The untreated control, where 5 trees were killed during the season, had an improvement percentage of -0.89%, followed by treatments 5 (-1.5%), 3 (-3.1%) and 8 (-5.2%). Treatments 2 and 4 were significantly different from treatment 8. No significant differences were found between the other treatments.

When comparing the stem circumference increases at the end of season 1 (2014) to the start of season 2 (2015) (Fig. 4), treatment 2 improved the most with 30.5%, followed by treatments 3 (29.3%), 4 (26.4%), 8 (24.8%) and 7 (24.02%). The untreated control improved by 23.7%, treatment 6 by 22.7% and treatment 5 by 18.4%. There were no significant differences between any of the treatments.

Average increase in height

Initial evaluations compared to evaluations taken during (mid) the season (Fig. 5) showed that treat-

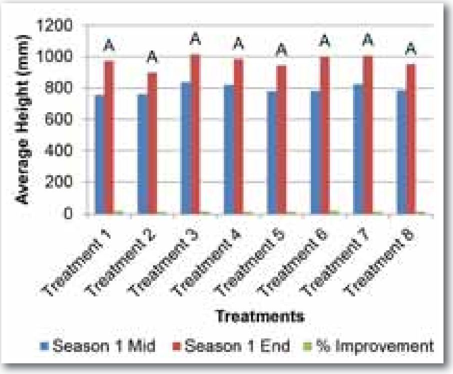

Figure 6. Height improvement from mid- to end-season 1.

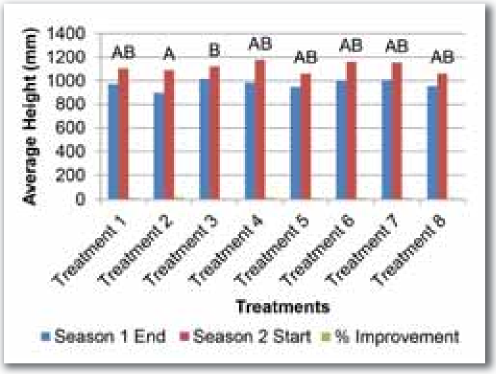

Figure 7. Height improvement from end season 1 to the beginning of season 2.

ment 8 started off strong with a height improvement of 17.1%, followed by treatments 7 (15.9%), untreated control (13.5%), 4 (13.1%), 5 (12.5%), 6 (11.6%), 2 (11.5%) and 3 (10.99%). There were no significant differences between these treatments regarding improved height.

From mid-season to the end of season 1, no significant differences were found (Fig. 6). The treatment that performed the best during this time period was treatment 6 with an improvement percentage of 21.3%. The untreated control improved with 20.2% followed by treatments 7 (17.2%), 3 (16.6%), 5 (15.7%), 8 (15.3%), 2 (14.6%) and 4 (14.5%).

Comparing evaluations taken at the end of season 1 and the start of season 2 (Fig. 7) found that treatment 2 performed the best with an improvement percentage of 17.5%. It was followed by treatments 4 (13.9%), 7 (12.1%), 6 (11.8%), untreated control (10.6%), 5 (10.2%) and 8 (10.1%). Treatment 3 improved only by 8.2%, which was significantly different from treatment 2.

CONCLUSION

So far it would seem that treatments 2 and 4 are the most promising at this stage in preventing and/or inhibiting the development of *Phytophthora* root rot in young, newly planted avocado orchards.

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