Effect of different mulch materials, composts and organic treatments on tree condition and root health

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ABSTRACT

A field trial was established in August 2005 at Westfalia Fruit Estate, on cultivar 'Lamb Hass', to evaluate the effect of different mulch materials, compost and organic products on tree condition and root health. Tree health ratings were done at the start of the trial in August 2005. The second and the third rounds of tree health ratings were done after harvest in August 2006 and August 2007 respectively. Each mulch treatment was applied to a total of 20 trees. The first mulch application was done in October 2005 and the second application in July 2007. In August 2006, only small differences were noted in the tree health ratings of the trees subjected to the different mulches. However, between 2005 and 2007, a general decline in tree health rating was observed in all treatments except in the treatment with avocado wood chips. Root health and density were assessed by means of digital photographs and no differences between treatments have been noted thus far. Soil moisture fluctuations underneath the mulches were monitored with tensiometers. Initial results indicated that under wet conditions the sawdust mulch was saturated and this lead to higher soil moisture readings when compared to other mulches. Under dry conditions water did not easily reach the soil beneath the mulches when compared to the control. *Phytophthora cinnamomi* (Pc) inoculum levels in the soil underneath the mulches were determined in May 2006 and 2007. In 2006 the lowest level of Pc inoculum was found associated with avocado wood chips, while in 2007 the lowest levels were found in association with avocado wood chips, as well as where avocado wood chips were applied as mulch in combination with gypsum. In 2007, no detrimental effect of the different treatments on leaf nitrogen levels was observed, however, between 2006 and 2007, yield per tree was significantly affected by the different mulches applied. The results therefore indicate that the use of avocado wood chips, alone or in combination with gypsum, might reduce the levels of Pc present in the soil. This effect will however be investigated further.

INTRODUCTION

Root rot, caused by *Phytophthora cinnamomi* (Pc), is considered the most important and widely distributed disease of avocados in countries where they are produced. Currently, the world avocado industry relies almost solely on phosphorous acid to control Pc root rot. Therefore, alternative strategies need to be investigated to reduce dependence on phosphorous acid and prevent the danger of resistance development in the long term. Mulching has been widely recommended for avocado orchards worldwide and some of the benefits derived from mulching include increased water and nutrient availability (Gregoriou & Rajkumar, 1984) and improved soil structure and porosity (Gallardo-Laro & Nogales, 1987). Mulching has also been found to promote the development of beneficial micro-organisms that are antagonistic to Pc (Turney & Menge, 1994). Some of these micro-organisms are wood decay fungi, which multiply abundantly in certain mulches and produce enzymes such as cellulase and laminarinase (Downer *et al.*, 2001). These enzymes have been shown to dissolve the fungal hyphae of Pc (Downer, 1998; Downer *et al.*, 2001; Faber & Spiers, 2003). Different types of mulch materials are available to avocado growers in South Africa and these will have differing effects on plant health and Pc levels in the soil. It has, therefore, become important to identify cost effective mulch materials that could be used by South African growers to improve tree condition and root health of avocado trees. The objective of this project is therefore to evaluate the effect of different mulch materials such as composts and other organic materials on tree condition and root health of avocado trees through pot and field trials.

MATERIALS AND METHODS

Field trial

The trial site is located in an organically managed orchard on Westfalia Estate, near Tzaneen, South Africa. Tree health ratings according to the Ciba-Geigy rating scale (Bezuidenhout, Darvas & Toerien, 1987) were done

for all the trees in the orchard in August 2005. Trees were then grouped into replicates and treatments according to tree health ratings. Each of the eleven treatments were allocated randomly to blocks of four trees, each block making up one treatment replicate, with five replicates per treatment. The second and the third rounds of tree health ratings were done after harvest in August 2006 and 2007 respectively and are continuing annually. Raw materials for mulches and compost were collected from Westfalia Estate's compost site and the organic gypsum was obtained from BPB Gypsum (ER Lightweight Building Solutions, 11 Kobalt Street, Superbia, Polokwane 1411). The first mulch application was applied at a rate of 1 m^3 per tree in October 2005 and the second application was also applied at a rate of 1 m^3 per tree in July 2007. Mulches were spread evenly underneath the tree canopy. **Table 1** shows the various treatments and application rates used.

In order to evaluate root health and root density, "root viewing windows" were created by placing squares of newspapers (500 x 500 mm) underneath the mulch layer of one tree per replicate. Digital photographs of the "window" area were taken in November 2005, May 2006, November 2006, May 2007, August 2007 and November 2007 and will be analyzed according to the technique described by Bekker, Kaiser & Labuschagne (2006).

The amount of Pc in the soil beneath the different mulches was estimated by using a semi-quantitative baiting assay system. Soil sampling for this purpose was done in May 2006 and May 2007. Twenty trees were sampled in each treatment, four trees per replicate. Three sub-samples were taken from each tree and the four samples from each replicate were combined and thoroughly mixed to make one sample, giving five samples per treatment. The combined soil from each replicate was then used for the assay. The avocado leaf baiting technique described by Pegg (1977) was used to determine the Pc population levels in the soil. The percentages of leaf discs yielding growth of Pc on parp-H medium were recorded.

Mulch decomposition rate was recorded by measuring the mulch depth (cm) under one tree per replicate, giving five trees per treatment. These measurements are repeated every three months. Soil moisture fluctuations underneath the mulches are recorded by means of tensiometers. One 12-inch tensiometer (Calafrica, 25 Cruiser street, Laser Park, Honeydew 2040) was installed per treatment and readings are recorded twice a week.

Leaf and soil sampling for mineral analysis was done from four trees per replicate of each treatment, during April 2006 and 2007, according to recommended protocols (Köhne *et al.*, 1990). For soil sampling, three sub-samples were taken from each tree and the twelve samples from each replicate were combined and thoroughly mixed to make one sample, again giving five samples per treatment. For leaf sampling, two leaves were collected from each side of each tree, eight leaves for each of the four trees in a replicate. The 32 leaves sampled per replicate were pooled and treated as one composite sample per treatment replicate. Twenty four hours after sampling, the samples were sent to the ARC-Institute for Tropical and Subtropical Crops, Soil Analysis Laboratory (Private Bag X11208, Nelspruit 1200) for standard leaf mineral analysis.

The trial was harvested in August 2006 and 2007 and individual tree yield (kg/tree) was recorded. This was then extrapolated to tons per hectare for 200 trees/ha for each of the eleven treatments. Subsequently, the average yield per hectare for 2006 and 2007 combined was calculated for each mulch treatment. The fruit was furthermore pooled per treatment and sent through the commercial pack line to determine fruit size distribution (according to a 4 kg carton) and pack-out figures according to export, local and factory grades. Fruit samples (ten cartons per treatment), were placed into cold storage at 6°C for 28 days and post-harvest quality was evaluated upon ripening. All results were statistically analyzed using STATISTICA Version 6 (StatSoft, Inc., Tulsa, USA).

RESULTS AND DISCUSSION

Results indicated no significant differences between treatments in average tree health ratings done in August 2005, however, small differences were observed in the tree health ratings done in August 2006 and 2007 (**Table 2**). A general decline in tree condition from 2005 to 2007 was observed for all treatments. However, the decline observed was not significantly different between the 50% mature compost, avocado wood chips and avocado wood chips mixed with gypsum (**Figure 1**). This indicated that the tree condition of trees in these treatments remained fairly constant between 2005 and 2007.

Thus far, no obvious visual differences between treat-

Table 1. Mulch materials and application rates applied in the various mulch treatments in the field trial

	Treatments	Application rate / tree
1	Wood shavings	1 m^3
2	Compost tea / Cattle manure	Foliar 1.5 L, Drench 0.5 L & 200 kg
3	Partially mature Westfalia compost (50% mature)	1 m^3
4	Fully mature Westfalia compost (100% mature)	1 m^3
5	Eucalyptus wood chips	1 m^3
6	Westfalia compost / Eucalyptus wood chips (1:1)	1 m^3
7	Saw dust	1 m^3
8	Cattle manure	200 kg
9	Avocado wood chips	1 m^3
10	Organic Gypsum + Avocado wood chips	15 kg & 1/2 m^3
11	Untreated control (natural mulch removed)	-

ments with respect to root health and density could be observed in the "root viewing windows". The levels of Pc detected in the soil beneath the mulches were affected by the different mulch treatments. In 2006, the lowest level of Pc was found in the soil underneath the avocado wood chip and eucalyptus wood chip mulches respectively (**Figure 2**). In 2007, no significant differences could be observed between the Pc levels in the soil underneath the different mulch treatments (**Figure 3**). The lowest levels of Pc were again associated with the avocado wood chip mulch treatment together with the avocado wood chips mixed with gypsum mulch. These initial findings are in agreement with work done in the USA and New Zealand. Downer *et al.* (2001) found that enzymes, with the potential to attack the components of *Phytophthora* cell walls, are common in eucalyptus mulches and that Pc does not populate this mulch. They also found that root health is improved in mulch layers where the highest enzyme concentrations are detected. The highest incidence of Pc was found associated with the compost tea / cattle manure combination and this could be due to the high nutrient concentration in the compost tea that Pc populations were able to utilize. During the dry season (May to September 2006) tensiometer readings were high for all mulches when compared to the control (results not shown). It seems that water did not easily reach the soil beneath the mulches. This highlights the importance of correct irrigation scheduling when using mulches, since mulch materials may absorb water before it reaches the soil. Additionally, the physical properties of different mulch materials may affect the penetration of water through the mulch layer (Pers. comm., Hans Boyum, Westfalia Marketing SA).

Thus far, no significant differences in mulch depth could be observed between the different mulch treatments, possibly indicating very similar rates of decomposition of the different mulches. During the three years that the trial has been running, no nitrogen fertilizer has been applied and neither will it be applied

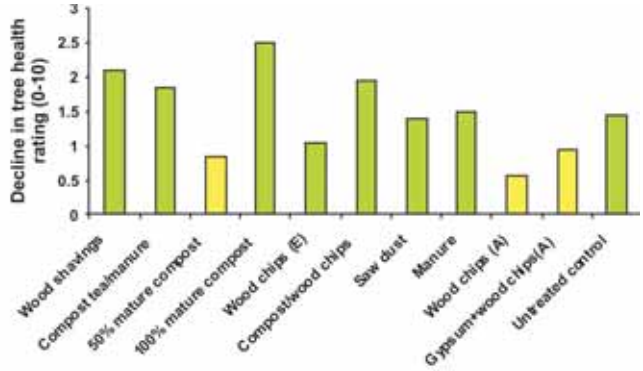

Figure 1. Average decline in tree health, from 2005 to 2007, of trees subjected to the different mulch treatments. Columns with yellow colour did not show a significant decline in tree health

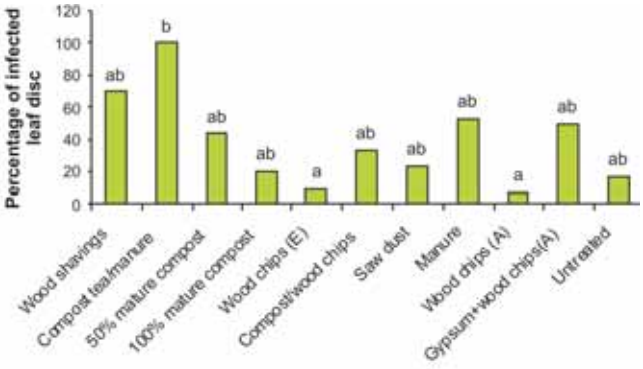

Figure 2. Mean percentages of avocado leaf discs yielding growth of Pc as affected by different mulch treatments in the field trial in 2006. Columns with the same letter are not significantly different (P = 0.05)

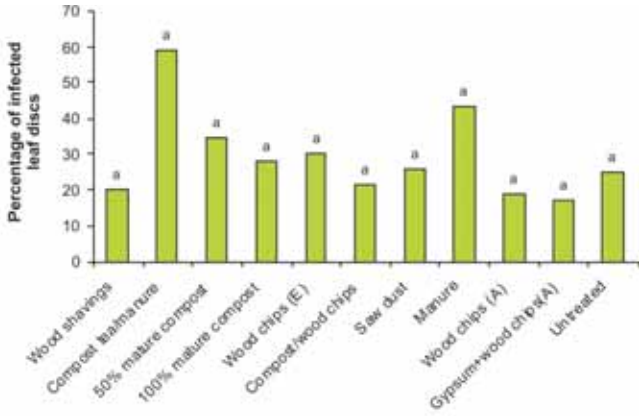

Figure 3. Mean percentages of avocado leaf discs yielding growth of Pc as affected by different mulch treatments in the field trial in 2007. Columns with the same letter are not significantly different (P = 0.05)

Table 2. Mean tree condition rating per mulch treatment as determined in August 2005, 2006 and 2007

Treatments		Tree condition rating (0-10)[1]		
		2005	2006	2007
1	Wood shavings	3.15a[2]	4.05p	5.28y
2	Compost tea / Cattle manure	2.35a	2.5qr	4.20xy
3	50% Mature Westfalia compost (partially composted)	2.5a	23.qr	3.35x
4	100% Mature Westfalia compost (fully composted)	2.75a	3.13pqr	5.11xy
5	Eucalyptus wood chips	3.4a	3.8p	4.37xy
6	Westfalia compost / Eucalyptus wood chips (1:1)	3.25a	3.93p	5.47y
7	Saw dust	3.05a	3.65pq	4.45xy
8	Cattle manure	2.95a	3.36pqr	4.42xy
9	Avocado wood chips	2.8a	2.8pqr	3.30x
10	Organic gypsum + Avocado wood chips	3.2a	3.91p	4.00xy
11	Untreated control	2.9a	2.71pqr	4.35xy

[1] Tree condition rating done according to Ciba-Geigy rating scale where 0 = a healthy tree and 10 = a dead tree.
[2] Means followed by the same letter are not significantly different (P = 0.05).

during the remainder of the trial. It can therefore be concluded that results of leaf and soil mineral analysis done during the trial are an effect of a particular mulch treatment. Results of leaf mineral analysis done in April 2006 showed that the leaf nitrogen content was different in trees subjected to the different mulch treatments (**Figure 4**). Trees with cattle manure and the partially composted compost (50% mature) mulches had slightly lower leaf nitrogen levels than the untreated control (**Figure 4**). It would therefore seem as if these two mulches elicit some nitrogen drawback. This could possibly be attributed to the fact that the materials used for both these mulches were not fully composted when applied. In 2007, no difference were observed between the different mulch treatments with respect to leaf and soil mineral analysis and all the treatments resulted in a normal level of nitrogen in leaves, except the untreated control, which had a nitrogen level slightly lower than the other treatments (**Figure 4**).

Between 2005 and 2007 significant differences in average cumulative yield were noted in trees subjected to the different mulch treatments. Trees with 50% mature compost, eucalyptus wood chips or avocado wood chip mulches had a higher average cumulative yield than the untreated control (**Figure 5**), while all treatments had a similar fruit size distribution, peaking at count 16 (results not shown).

The results therefore indicate that the use of avocado wood chips as a mulch might reduce the Pc levels present in the soil, as well as maintain tree health and increase yield. This could be expected because avocado mulch acts as a natural litter for the tree. Using 50% mature compost has also resulted in the least decline in tree health and it is also one of the treatments with a significant high yield than the untreated control. This is possibly due the 50% mature compost releasing more nutrients as it further decomposes underneath the tree, which can improve tree condition. These results are in agreement with the recommendation of Professor Menge's (University of California, Department of Plant Pathology, Riverside) on his visit to South Africa during 2005. Therefore the use of avocado wood chips and 50% mature compost might reduce the levels of Pc present in the soil, maintain tree condition and increase yield. This effect will however be investigated further.

ACKNOWLEDGEMENTS

The authors wish to thank SAAGA for financial support and Westfalia Agribusiness for the supply of plant material, use of an experimental orchard, equipment and funding.

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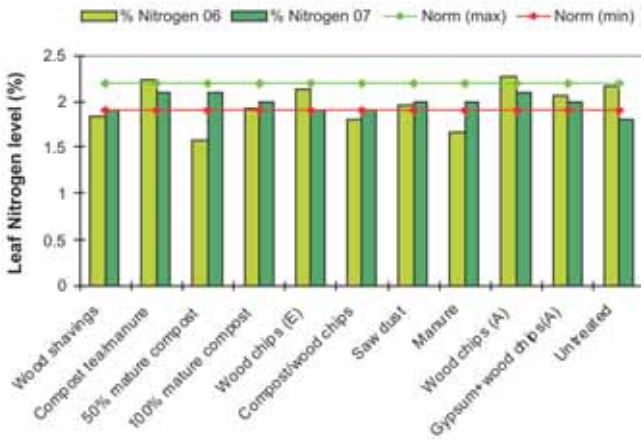

Figure 4. Leaf nitrogen levels of trees subjected to the different mulch treatments as measured in April 2006 and April 2007

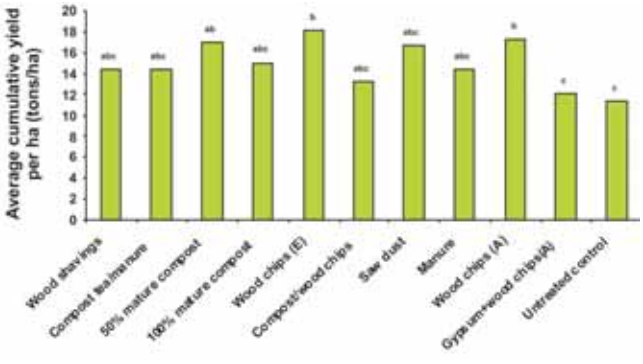

Figure 5. Average cumulative yield per hectare for 2006 and 2007 of trees subjected to the different mulch treatments