Soil health, fruit yield, quality and nutritional value of avocado as influenced by different mulch types

Year 3 of 3

B Nzanza* and P Pieterse

Natuurboerdery Research Centre, ZZ2-Bertie van Zyl
Mooketsi 0825, South Africa
*Correspondence: bombiti@zz2.biz

ABSTRACT
The aim of this study was to investigate the effect of mulch application on soil health, leaf and soil chemical analysis, fruit yield and quality and chemical analysis of avocado fruit. The trial commenced in 2010 on two ZZ2-Bertie van Zyl Farms in Limpopo, South Africa. The study consisted of four mulch types *viz*. grass, eucalyptus chips, composted chips and an untreated control. Treatments were arranged in a completely randomised design, with three replications with fifteen trees per treatment. Two years after the trial initiation, mulching with composted chips and grass increased fruit yield at Politsi, while at Mooketsi no significant effects could be found. At both sites, mulching reduced the percentage of small fruits as compared to the untreated control. Mulching significantly increased the fruit P content, except with woodchips at Politsi. Mulching with composted chips increased soil pH and K contents at Mooketsi and soil Mg and P at Politsi. Increased soil Ca and K contents at Politsi were found with woodchips. Wood chips also increased the soil PMN, soil C and active carbon at Politsi. The woodchips treatment had the highest percentage of plant parasitic nematodes at Mooketsi, but the lowest at Politsi. Leaf B was significantly affected by mulching at both sites. The results of this study have shown that different mulch types differ in their affect on soil health indicators, yield and fruit chemical analysis avocado.

INTRODUCTION
Mulching in avocado is one of the best production practices, advocated over the years by many researchers in South Africa and around the world. It presents numerous advantages in improving the soil's chemical, physical and biological properties (Nzanza & Pieterse, 2012). Mulching is also used to control *Phytophthora cinnamoni* root rot, the most destructive disease of avocado (Broadbent & Baker, 1974; Downer *et al*., 2001). Mulching creates optimum conditions for the reproduction and development of beneficial microbial organisms, antagonistic to *Phytophthora cinnamoni* (Turney & Menge, 1984). Studies have shown that mulching have a positive effect on the nutrient content and CEC of avocado soils (Stephenson & Schuster, 1945; Wolstenholme *et al*., 1996). Mulching also improves soil permeability and water holding capacity and decrease run-off and soil compaction (Tuney & Menge, 1994; Wolstenholme *et al*., 1996). In this trial the Cornell soil health concept was used to assess the effect of mulching on specific soil characteristics (Gugino *et al*., 2009; Nzanza & Pieterse, 2011). Nematode community profiling was also assessed (Neher, 2001; Zheng *et al*., 2011; Nzanza & Pieterse, 2011).

Reports in the literature on the effects of mulching on avocado plant health, yield and fruit quality are often contradictory. Downer *et al*. (1999) reported that mulching increased yield of avocado by 13% at one site, but decreased it by 39% at another. They cited poor irrigation practices and soil water management as the reason for discrepancies. In Israel the yield decreased when the avocado orchard was mulched (Lahav, 1984). In New Zealand, Dixon *et al*. (2006) did not find any effect on yield with mulching, probably due to the high soil organic matter of New Zealand soils (7 to 13%), compared to low levels in California (2 to 3%) and South Africa (1%).

The aim of this study was to investigate the influence of different mulch types on yield and fruit size of avocado in South Africa, soil health and nematode community structure. In the first report, we established a baseline assessment of soil health of the two trial locations prior to the onset of the trial (Nzanza &

Pieterse, 2011). This was followed by summary findings in year 2. In this paper, we present the major findings after two years of treatment application.

MATERIALS AND METHODS

The trial was conducted on ZZ2-Bertie van Zyl (Pty) Ltd Farms at Politsi and Mooketsi in three-year-old 'Maluma Hass' and 'Hass' orchards. Mean monthly maximum and minimum temperatures during the trial period were 25.8°C and 14°C at Politsi and 26.2°C and 14.4°C at Mooketsi, respectively. Politsi is situated in a high annual rainfall (>1100 mm) area, whereas Mooketsi receive an annual rainfall of less than 600 mm. The soil in Politsi can be classified as a clay (45% clay, 36% sand and 19% silt) and in Mooketsi a sandy loam (24% clay, 4% silt and 71% sand).

Treatments consisted of three mulch types *viz.* mowed veld grass (grass), *Eucalyptus* wood chips (wood chips), pre-composted *Eucalyptus* wood chips (mixed with the same volume of cattle manure and composted for approximately two months) (composted chips) and an untreated control. The trial was laid out as a complete randomised design with three replications with fifteen trees per replication. The mulch was applied in a strip of approximately 2 m wide with a thickness of 15 cm (Nzanza & Pieterse, 2012). Soil sampling, soil health analysis and nematode community profiling have been previously described (Nzanza & Pieterse, 2012). Chemical analysis was done on the leaves to determine the nutrient levels in the leaves (N, P, Ca, Mg, K, S, B, Cu, Cl, Fe, Mn and Zn). Fruit were harvested at maturity to measure yield, as well as the size distribution. Fruit samples were analysed for P, K, Ca, Mg and Zn contents (Nzanza & Pieterse, 2012). Data were subjected to analysis of variance using SAS (SAS Institute Inc., Cary, NC, USA. 2002-2003). Mean separation was achieved using Fisher's least significant difference test. Unless stated otherwise, significant differences were obtained at the 5% level of probability.

RESULTS AND DISCUSSION

Soil chemical indicators

At Politsi the chemical composition of the soil were significantly affected by mulching, with exception of sodium content, whereas at Mooketsi only the soil pH, Ca and K were affected (Table 1). Wood chips significantly increased the soil Ca and K at Politsi, whereas at Mooketsi the same two nutrients were increased by composted chips. The composted chips also increased the soil Mg and P at Politsi, but not at Mooketsi. Faber *et al*. (2001) also found higher soil K content in mulched soils. They also observed higher pH levels. In our study, soil pH was significantly increased by composted chips mulch in Mooketsi. The highest soil pH in Politsi was obtained with wood chips.

Soil biological indicators

Mulching did not have a significant effect on soil biological indicators at Mooketsi (Table 2). At Politsi, the wood chips mulch significantly increased the soil potential mineralisable nitrogen (PMN), C and active carbon. The percentage of C at Mooketsi was only affected by the precomposted mulch, although this affect was not significant (Nzanza & Pieterse, 2012).

Nematode community structure

The nematode community structure varied according to mulch types and locations (Table 3). At Mooketsi the total number of nematodes was significantly increased by composted chips, whereas at Politsi the increase was obtained with wood chips. Bacterivores are in general the most abundant group in agricultural soils (Zheng *et al*., 2011). At Politsi, however, the plant parasitic nematodes were the most abundant in all the treatments, except with wood chips, where the bacterivores were the most abundant. Woodchips and composted chips increased the percentage of bacterivores at Politsi, but woodchips reduced the percentage of this group at Mooketsi. Mulching significantly increased the percentage of fungivores at Mooketsi, but at Politsi it was only improved by woodchips.

Leaf micronutrients

Leaf B was significantly affected by mulching in both sites (Table 4). Mulching with composted chips significantly increased the leaf B content at Politsi, but reduced it at Mooketsi. Leaf Mn content was also affected by mulching at Politsi, where grass mulch resulted in the highest levels.

Table 1. The influence of different mulch types on the soil chemical analysis in avocado orchards at two sites.

Mulch treatments	pH	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	P (mg/kg)	Na (mg/kg)
Site: Mooketsi						
Control	5.60b	860a	222b	320a	37a	59a
Grass	5.90b	887a	332ab	285a	38a	44a
Wood chips	5.80b	934a	278b	285a	46a	40a
Composted chips	6.30a	1236a	424a	307a	47a	45a
Site: Politsi						
Control	5.10ab	717b	88.3b	132b	12.0b	40.0a
Grass	4.90b	672b	191b	138b	8.67b	37.7a
Wood chips	5.60a	1474a	321a	122b	5.67b	39.3a
Composted chips	5.20ab	855b	135b	183a	25.7a	36.3a

Means followed by the same letter in a column were not significantly different ($P \leq 0.05$) according to Fisher's LSD test

Leaf macronutrient
Mulching had no significant effect on leaf macronutrient (Table 5). This is in agreement with Faber *et al*. (2001) who did not find any significant effect.

Fruit chemical analysis
Mulching increased the P in the fruit at both sites, with the exception of the wood chips at Politsi (Table 6). Mulching with composted chips increased fruit K at both sites.

Yield and fruit size distribution
At Politsi mulching with composted chips and grass significantly increased the yield (Table 7). The same trend was observed at Mooketsi, although not significantly. Increased yield and fruit size of avocado following mulch application has previously been reported on by Wolstenholme *et al*., 1998, Downer *et al*., 1999 and Mavuso, 2008. The composted chips treatment had the highest count of large fruits (count 10-14) and it significantly decreased the percentage of small fruit at both sites. The highest count of small fruits (30%) was recorded with the untreated control at Politsi.

CONCLUSION
Field experiments were conducted at two sites that differ in terms of climate and soil, to investigate the effect of mulching in avocado production. Findings of the study showed that the effect of mulching soil on health indicators, varies with the mulch types and location. On the one site, mulching with woodchips increase the percentage of plant parasitic nematodes, while it had the opposite effect on the other site. The differences was, however, not significant. The B content in the leaves was reduced, although not always significantly, by mulching on the one site, while it was increased by woodchips on the other site. With the exception of the woodchips on the one site, mulching significantly increase the P content of the fruit. On both sites, the K in the fruit was significantly increased by composted chips, which also resulted in the highest soil K. Significant increased fruit yield was obtained with composted chips and grass mulch at Politsi with no significant effects at Mooketsi. Further investigations are needed to observe the changes of soil health, plant nutrients and fruit chemical contents over time, and how these changes affected the cumulative avocado yield.

REFERENCES
BROADBENT, P. & BAKER, K.F. 1974. Behaviour of *Phytophthora cinnamomi* in soils suppressive and conducive to root rot. *Australian Journal of Agricultural Research* 25: 121-137.
DIXON, J., SMITH, D.B., GREENWOOD, A.C. & ELMSLY, T.A. 2006. Putative timing of irreversible commit-

Table 2. The influence of different mulch types on soil biological indicators in avocado orchards at two sites.

Mulch treatments	Root health	PMN (µN/g/wk)	Carbon (%)	Active carbon (mg/kg)
Site: Mooketsi				
Control	4.30a	-0.20a	0.50a	731a
Grass	3.70a	-0.10a	0.53a	747a
Wood chips	4.70a	0.20a	0.53a	835a
Composted chips	5.70a	0.50a	0.69a	904a
Site: Politsi				
Control	7.30a	0.17ab	0.65b	1064ab
Grass	8.70a	0.30ab	0.69b	1111ab
Wood chips	7.00a	1.63a	2.14a	1272a
Composted chips	6.00a	-0.17b	1.97b	1019b

Means followed by the same letter in a column were not significantly different (P ≤ 0.05) according to Fisher's LSD test
PMN: Potential mineralisable nitrogen

Table 3. The influence of different mulch types on the trophic group composition of nematodes in avocado orchards at two sites.

Mulch treatments	Total numbers	Bacterivores (%)	Fungivores (%)	Omnivores (%)	Plant-parasitic (%)
Site: Mooketsi					
Control	210ab	61a	5.00b	1.70a	31a
Grass	207ab	51ab	12.7a	2.00a	30a
Wood chips	123b	21b	14.0a	0.00a	63a
Composted chips	533a	62a	11.3a	0.00a	25a
Site: Politsi					
Control	156b	14ab	17.3a	1.30b	68a
Grass	387b	8b	10.3ab	3.00b	78a
Wood chips	790a	37a	31.7a	1.30b	30b
Composted chips	327b	35a	4.30b	6.00a	48ab

Means followed by the same letter in a column were not significantly different (P ≤ 0.05) according to Fisher's LSD test

ment to flowering of Hass avocado trees in the Western bay of Plenty. *New Zealand Avocado Growers' Association Annual Research Report* 6: 13-20.
DOWNER, J., MENGE, J.A., OHR, H.D., FABER, B.A., McKee, B.S., POND, E.C., CROWLEY, M.G. & CAMPBELL, S.D. 2001. The effect of yard trimmings as mulch on growth of avocado and avocado root rot caused by *Phytophthora cinnamomi*. *Yearbook California Avocado Society* 83: 87-104.
DOWNER, A.J. 1998. Control of avocado root rot and *Phytophthora cinnamomi* Rands in mulched soils. Ph.D. Dissertation. University of California.
FABER, B.A., DOWNER, A.J. & MENGE, J.A. 2001. Differential effects of mulch on citrus and avocado. Proc. 7th *Int. Symp. on Orch. & Plant. Syst*., Eds. J.W. Palmer & J.N. Wünsche. *Acta Hort*. 557.
GUGINO, B.K., IDOWU, O.J., SCHINDELBECK, R.R., VAN ES, H.M., WOLFE, D.W., MOEBIUS-CLUNE, B.N., THIES, J.E. & ABAWI, G.S. 2009. Cornell Soil Health Assessment Training Manual. Cornell University, New York, USA.
LAHAV, E. 1984. The effect of organic manure on

Table 4. The influence of different mulch types on the leaf micronutrient chemical analysis in avocado orchards at two sites.

Mulch treatments	B (%)	Cu (%)	Cl (%)	Fe (%)	Mn (%)	Zn (%)
Site: Mooketsi						
Control	50.6a	24.1a	0.03a	102a	242a	36.7a
Grass	39.2b	26.2a	0.06a	109a	221a	33.4a
Wood chips	44.2ab	28.5a	0.03a	99a	292a	38.4a
Composted chips	37.9b	26.7a	0.07a	100a	232a	28.6a
Site: Politsi						
Control	40.6b	26.4a	0.03a	102a	219ab	25.7a
Grass	35.3c	34.3a	0.03a	125a	275a	24.9a
Wood chips	40.6b	24.5a	0.03a	102a	209b	23.5a
Composted chips	45.4a	28.0a	0.03a	117a	193b	26.3a

Means followed by the same letter in a column were not significantly different (P ≤ 0.05) according to Fisher's LSD test

Table 5. The macronutrient contents of avocado leave as influenced by different mulch types in avocado orchards at two sites.

Mulch treatments	N (%)	Ca (%)	K (%)	Mg (%)	P (%)	S (%)
Site: Mooketsi						
Control	2.27a	0.90a	1.36a	0.40a	0.18a	0.23a
Grass	2.56a	1.05a	1.34a	0.48a	0.19a	0.25a
Wood chips	2.55a	0.98a	1.29a	0.46a	0.19a	0.27a
Composted chips	2.59a	1.09a	1.30a	0.44a	0.19a	0.25a
Site: Politsi						
Control	2.49a	1.25a	1.03a	0.57a	0.15a	0.27a
Grass	2.72a	1.26a	1.34a	0.59a	0.17a	0.28a
Wood chips	2.57a	1.08a	1.06a	0.51a	0.16a	0.26a
Composted chips	2.59a	1.30a	1.30a	0.46a	0.17a	0.29a

Means followed by the same letter in a column were not significantly different (P ≤ 0.05) according to Fisher's LSD test

Table 6. The influence of different mulch types on the chemical analysis of avocado fruit in avocado orchards at two sites.

Mulch treatments	P (%)	K (%)	Ca (%)	Mg (%)	Zn (%)
Site: Mooketsi					
Control	0.15b	1.87b	0.07a	0.11a	19.3a
Grass	0.19a	1.96b	0.08a	0.11a	23.0a
Wood chips	0.21a	1.93b	0.07a	0.10a	22.7a
Composted chips	0.19a	2.22a	0.06a	0.12a	24.0a
Site: Politsi					
Control	0.15c	1.86b	0.07a	0.13a	21.3a
Grass	0.17b	2.13a	0.07a	0.14a	19.3a
Wood chips	0.14c	1.73b	0.06a	0.15a	17.0a
Composted chips	0.19a	2.25a	0.05a	0.12a	22.3a

Means followed by the same letter in a column were not significantly different (P ≤ 0.05) according to Fisher's LSD test
* No significant difference (P ≤ 0.05) according to Fisher's LSD test

avocado trees in Israel. In: *VIth International Colloquium for the Optimization of Plant Nutrition.* Montpellier, France, 0: 72, 3: 1051-1062.
MAVUSO, Z. 2008. Effect of different mulch material as composts and organic treatments on tree condition and root health. *South African Avocado Growers' Association Yearbook* 31: 32-35.
NEHER, D.A. 2001. Role of nematodes in soil health and their use as indicators. *Journal of Nematology* 33: 161-168.
NZANZA, B. & PIETERSE, P. 2011. Soil health, fruit yield, quality and nutritional value of avocado as influenced by different mulch types: Preliminary results. *South African Avocado Growers' Association Yearbook* 34: 75-78.
NZANZA, B. & PIETERSE, P. 2012. Soil health and nematode community structure responses to different mulch types in avocado production. Paper presented at the 2nd All Africa Horticultural Conference. Skukuza, South Africa.
STEPHENSON, R.E. & SCHUSTER, C.E. 1945. Effect of mulches on soil properties. *Soil science* 59: 219-230.
WASILEWSKA, L. 1979. The structure and function of soil nematode communities in natural ecosystems and agrocenoses. *Polish Ecological Studies* 5: 97-145.
WOLSTENHOLME, B.N., MOORE-GORDON, C. & ANSERMINO, J.S.D. 1996. Some pros and cons of mulching in avocado orchards. *South African Avocado Growers' Association Yearbook* 19: 87-91.
WOLSTENHOLME, B.N., MOORE-GORDON, C. & LEVIN, J. 1998. Mulching of avocado orchards: Quo vadis. *South African Avocado Growers' Association Yearbook* 21, 26-28.
TURNEY, J. & MENGE, J. 1994. Root health: mulching to control root disease in avocado and citrus. *California Avocado Society*. Circular No. CAS-94/2.
ZHENG, G.D., SHI, L.B., WU, H.Y. & PENG, D.L. 2011. Nematode communities in continuous tomato-cropping field soil infested by root-knot nematodes, *Acta Agriculturae Scandinavica*, Section B-Soil & Plant Science, DOI:10.1080/09064710.2011.598545.

Table 8. The influence of different mulch types on the avocado yield and fruit size distribution in avocado orchards at two sites.

Mulch treatments	Yield (kg/plant)	Count 10-14 (%)	Count 16-20 (%)	Count 22-26 (%)	Count >>26 (%)
Site: Mooketsi					
Control	65.6a	41.3a	36.9a	17.0a	4.70a
Grass	77.2a	36.9a	47.1a	12.7a	3.33a
Wood chips	62.1a	41.6a	42.6a	10.0a	5.77a
Composted chips	70.4a	56.3a	34.3a	8.70a	0.70b
Site: Politsi					
Control	26.2c	17.4a	38.8a	13.4a	30.3a
Grass	51.4ab	23.4a	47.9a	13.2b	15.5ab
Wood chips	32.0bc	13.3a	49.1a	28.5a	9.01b
Composted chips	51.5a	28.1a	51.8a	16.3a	3.77b

Means followed by the same letter in a column were not significantly different ($P \leq 0.05$) according to Fisher's LSD test