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

Year 2 of 3

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ABSTRACT

A 3-year trial was laid out in 2010 at ZZ2-Bertie van Zyl Farms to determine the effect of mulch application on soil health, fruit yield, quality and nutritional value of avocado. The four mulch treatments *viz*. grass, eucalyptus chips, composted chips and an untreated control, were arranged in a completely randomised design, with three replications consisting of 15 trees per treatment. Standard commercial avocado cultural practices were carried out. Twelve months after treatment application, mulch had no effect on yield or fruit size of avocado. Mulching with composted chips increased soil pH, P and Mg contents when compared to untreated controls in Politsi, but increased soil K content and active carbon in both sites. Conversely, grass and wood chips reduced the active carbon of the soil in both locations. The number and trophic groups of nematodes were not affected by mulching but there was a trend of decreasing plant parasitic nematodes with mulch application. Similarly there was a trend of increasing Zn, K and P fruit contents with mulching. Findings of this study suggested that mulch types have different effects on soil health indicators with possible resultant effects on fruit chemical contents.

INTRODUCTION

Avocado (*Persea americana*) is one of the top commodities in South Africa with more than 12500 ha of planted trees in 2011. Production is mainly export driven and to remain competitive on the world stage, the South African Avocado Growers' Association promotes among others the optimisation of best production practices, such as mulching. The benefits of mulch application in avocado production are well-documented. Mulching reduces the incidence of *Phytophthora cinnamoni* root rot, the most destructive disease of avocado worldwide (Broadbent & Baker, 1974; Downer *et al*., 2001). Other benefits of mulching include: increased microbial diversity and soil organic matter (Tuney & Menge, 1994), increased nutrient availability and CEC (Stephenson & Schuster, 1945; Wolstenholme *et al*., 1996), improved soil permeability and soil water holding capacity, decreased water run-off and soil compaction (Tuney & Menge, 1994; Wolstenholme *et al.*, 1996), and improved root growth and tree health (Moore-Gordon *et al*., 1996). In short, mulch application improves the physical, chemical and biological characteristics of avocado soils.

To assess the effect of mulching on soil characteristics, the Cornell soil health concept, which involves integrating and optimising the biological, chemical and physical properties of the soil for farm profitability, was used (Gugino *et al*., 2009). Thirty-two potential indicators were considered of which 12 were selected for soil health analysis (Nzanza & Pieterse, 2011). The nematode community profiling was included as an additional soil health test due to the fact that nematode populations are very sensitive to environmental disturbances, and thus are suitable bio-indicators for soil management changes (Neher, 2001; Zheng *et al*., 2011).

The aim of this study was to investigate the influence of different mulch types on soil health and nematode community structure, with the resultant effects on yield and fruit size of avocado.

In the first report, we established a baseline assessment of soil health of the two trial locations prior to the trial onset (Nzanza & Pieterse, 2011). The present paper summarises major findings one year after the onset of the trial.

MATERIALS AND METHODS

The trial was laid out on ZZ2-Bertie van Zyl (Pty) Ltd Farms in Politsi and Mooketsi, using three-year-

old 'Maluma Hass' and 'Hass', respectively. Mean monthly maximum and minimum temperatures at Politsi were 25.8°C and 14°C, respectively, whereas at Mooketsi the variables were 26.2°C and 14.4°C, respectively. Politsi was characterised by high annual rainfall (1103 mm), whereas the total precipitation received at Mooketsi was 608 mm. The soil was classified as clay in Politsi (clay 45%, sand 36% and slit 19%) and sandy loam in Mooketsi (71% sand, 24% clay and 4% slit).

Treatments consisted of three mulch types *viz.* mowed veld grass (grass), *Eucalyptus* wood chips (wood chips), pre-composted *Eucalyptus* wood chips (composted chips) (mixed with the same volume of cattle manure and composted for approximately two months) and an untreated control. The trial was laid out in a complete randomised design with three replications consisting of 15 trees per replication. Mulch was applied in a strip of approximately two meters wide with a thickness of 15 cm. The same standard avocado orchard management practices were observed for all treatments.

Soil samples were collected at 30 cm depth and sent to ZZ2-Laboratories, Polokwane, South Africa. Soil health indicators were assessed 12 months after treatment application using the Cornell Soil Health test model (Gugino *et al*., 2009; Nzanza & Pieterse, 2011). The amount of ready available water (RAW) was measured with DFM continuous logging probes as previously described by Nzanza and Pieterse (2011).

Nematodes were extracted from 250 g soil by elutriation and centrifugation (Bulluck *et al*., 2002). Nematodes were classified in four trophic groups (bacterivores, fungivores, omnivores and plant-parasitic nematodes), whereas the nematode community structure was characterised by calculating ecological indices such as free-living maturity index (MI), plant-parasitic index (PPI), channel index (CI) and enrichment index (EI) (Pan *et al*., 2010).

Harvesting was done at industry standard fruit maturity. Fruit were pooled per treatment and sent through the commercial pack line to determine fruit size distribution. Fruit samples were sent to Agrilab Tzaneen for fruit P, K, Ca, Mg and Zn contents.

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, treatments discussed were different at 5% level of probability.

RESULTS AND DISCUSSION

Soil chemical indicators

Soil chemical indicators varied according to locations or mulch types (Table 1). Mulching had no significant effect on soil pH, soil P and soil Ca in Mooketsi, whereas in Politsi composted chips increased soil pH and soil P contents. In Politsi, grass reduced soil Ca content while in Mooketsi no significant differences were detected among treatments. Wood chips reduced soil Mg content in both sites. Incidentally, composted chips reduced soil Mg content in Mooketsi but increased it in Politsi. Similarly, composted chips increased soil K content in both locations. The increases in soil K and P were probably due to the higher nutrient content of composted chips.

Soil biological indicators

In both locations biological indicators such as root health and potential mineralisable nitrogen (PMN) were not significantly influenced by mulching (Table 2). There was a slight increase in the carbon (C) and active carbon (AC) (an indicator of readily available soil organic matter as energy source for microbes) (Gugino *et al*., 2009) in the plots that received composted chips on both locations; these differences were, however, not significant.

Nematode community structure

Mulching tends to increase, although not significant, the number of nematodes in both sites (Table 3). The variation in the number of nematodes was more

Table 1. Soil chemical indicators as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	pH	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	P (mg/kg)	Na (mg/kg)
Site: Mooketsi						
Control	6.50a	1031a	176b	358a	50.7a	57.3a
Grass	6.20a	738a	188b	325ab	52.7a	52.3a
Wood chips	6.20a	757a	197b	266b	60.0a	50.3a
Composted chips	6.30a	934a	345a	277ab	68.7a	54.7a
Site: Politsi						
Control	5.40b	844ab	168b	132b	12.0b	40.0a
Grass	5.20b	596b	213b	138b	8.67b	37.7a
Wood chips	5.30b	881ab	176b	122b	5.67b	39.3a
Composted chips	5.70a	1017a	354a	183a	25.7a	36.3a

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

pronounced in Politsi than in Mooketsi. There was a slight but not significant increase in the fungivores in Mooketsi and a slight decrease in the plant parasitic nematodes in both sites with mulching (Table 3). Generally, bacterivores are the most abundant trophic groups in agricultural soils (Wasilewska, 1979; Zheng *et al*., 2011). Incidentally, bacterivores represented the most abundant nematode trophic groups in all treatments with a variation of 62% (control) and 76% (grass) in Mooketsi and 49% (wood chips) and 66% (composted wood chips) in Politsi.

Ecological indices are widely used to quantify the response of nematode community to environmental or management changes in soil (Pan *et al*., 2010; Nzanza & Pieterse, 2012). Biederman *et al*. (2008) did not observe any significant changes in ecological indices of nematodes after soil organic amendment. In this trial, mulching also did not have a significant effect on maturity, enrichment, channel or plant parasitic indices of nematodes (Table 4). In Mooketsi, however, mulching had a positive effect on the channel index.

Soil physical indicators and moisture content

Soil aggregate stability was not affected by mulching in both sites. Similarly, mulching had no effect on available water content in Politsi, whereas in Mooketsi mulch-treated plots had higher available water content than untreated control (Table 5). Results of this trial also confirmed our preliminary observations on the effect of mulching on soil moisture content. There were clear differences in soil moisture fluctuations between mulch-treated and control (data not shown). Generally, mulch treatment showed little soil moisture fluctuations, in comparison with the control treatment, suggesting that mulching created a more mesic environment underneath the tree (Nzanza & Pieterse, 2011).

Yield, fruit size and chemical analysis

Although fruit chemical contents were not analysed statistically due to insufficient data, there was a trend of increasing Z, K and P fruit contents in both locations, except with wood chips treated plots in Mooketsi (Table 6). Mulching had no effect on fruit

Table 2. Soil biological indicators as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	Root health	PMN (µN/g/wk)	Carbon (%)	Active carbon (mg/kg)
Site: Mooketsi				
Control	7.67a	0.83a	0.48a	320ab
Grass	4.00a	1.00a	0.60a	295ab
Wood chips	6.33a	1.00a	0.51a	213b
Composted chips	6.67a	1.23a	0.51a	465a
Site: Politsi				
Control	8.00a	2.83a	1.24ab	675ab
Grass	8.00a	3.03a	1.06b	572ab
Wood chips	7.30a	2.07a	1.16ab	468b
Composted chips	7.30a	3.00a	1.55a	742a

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

PMN: Potential mineralisable nitrogen

Table 3. Number and trophic groups of nematodes as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	Total numbers	Bacterivores (%)	Fungivores (%)	Omnivores (%)	Plant-parasitic (%)
Site: Mooketsi					
Control	460a	62.0a	5.66a	1.00a	28.0a
Grass	473a	76.0a	8.66a	1.00a	13.3a
Wood chips	560a	62.3a	11.7a	1.66a	23.7a
Composted chips	560a	64.3a	11.7a	1.00a	22.0a
Site: Politsi					
Control	277a	50.7a	9.66a	0.00a	39.7a
Grass	453a	62.0a	3.66a	1.00a	32.0a
Wood chips	240a	48.7a	15.3a	0.00a	34.3a
Composted chips	547a	66.0a	5.30a	0.33a	26.0a

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

size or fruit yield of avocado (data not shown). The non-responses of avocado fruit quality and yield to mulch application during the first year of this study are understandable. Many researchers only observed increased yield or fruit size after subsequent years of mulching (Wolstenholme *et al*., 1998; Downer *et al*., 1999; Dixon *et al*., 2006; Mavuso, 2008).

CONCLUSION

Preliminary results, 12 months after treatment application, showed that mulching had differential effects on most of the soil health indicators and varied according to mulch types or locations. The nematode community structure of avocado soils was not significantly influenced by mulching, although there were

Table 4. Ecological indices of nematodes as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	Maturity index	Enrichment index	Channel index	Plant-parasitic index
Site: Mooketsi				
Control	1.34a	93.0a	2.66a	2.33a
Grass	1.51a	85.7a	6.00a	1.95a
Wood chips	1.38a	90.0a	6.33a	2.22a
Composted chips	1.41a	89.0a	6.33a	2.16a
Site: Politsi				
Control	1.37a	90.3a	5.66a	2.20a
Grass	1.23a	95.0a	1.33a	2.46a
Wood chips	1.34a	90.0a	8.33a	2.23a
Composted chips	1.31a	92.7a	3.66a	2.30a

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

Table 5. Soil physical indicators as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	Aggregate stability (%)	Avail water content (mm/m)
Site: Mooketsi		
Control	11.2a	92.0b
Grass	9.10a	100a
Wood chips	10.5a	100a
Composted chips	10.0a	100a
Site: Politsi		
Control	80.9a	69.3a
Grass	78.2a	68.0a
Wood chips	76.1a	69.7a
Composted chips	82.7a	69.8a

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

Table 6. Fruit chemical content of avocado as influenced by different mulch types in commercial avocado orchards.

Mulch treatments	P (%)	K (%)	Ca (%)	Mg (%)	Zn (%)
Site: Mooketsi					
Control	0.17	3.03	0.12	0.17	22.0
Grass	0.23	3.47	0.04	0.20	29.0
Wood chips	0.16	3.25	0.07	0.13	25.0
Composted chips	0.21	3.37	0.08	0.17	28.0
Site: Politsi					
Control	0.17	2.74	0.09	0.10	27.0
Grass	0.25	2.99	0.07	0.10	37.0
Wood chips	0.26	2.72	0.09	0.11	35.0
Composted chips	0.26	3.08	0.09	0.12	30.0

indications that mulching reduces the populations of plant parasitic nematodes. Findings of this study did not show any significant effect of mulching on yield or fruit size. Further investigations will look at changes in soil health characteristics, yield and fruit quality over times following mulching.

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