Growing avocados under shade netting

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ABSTRACT

There is a global trend to high intensity horticulture, including high density plantings, in the use of superior cultivars, greater plant manipulation and protected cultivation. Avocado growers have only recently started using protected cultivation and still need to determine the technical details of this type of cultivation.

Following on from previous reports published in the SAAGA Yearbook, special attention was given to honey bee management under shade nets. The shade net resulted in improved fruit quality once again at Everdon, while at Mooketsi severe drought conditions were experienced, which resulted in a total fruit drop end October 2016. The Everdon yield was used to demonstrate some financial implications associated with shade nets. The design and strength of the structures have yet to be tested by a hail storm.

INTRODUCTION

Shade netting over an orchard modulates the micro-climate in the orchard, making the environment more conducive for fruit production and reducing fruit quality defects (Smit, 2007). According to an industry loss factor benchmark study (Winter, 2014), wind and sunburn damage accounted for 28% and 27% respectively loss in export fruit. A shade netting structure has potential to address these limiting factors.

As part of a multi-site long-term study, the following questions were asked before the large-scale use of shade nets over avocados were to be considered:

1. How is the micro-climate of the orchard affected by the nets?
2. How is cultural management affected?
3. How is flower development, pollinators and pollination affected by the nets?
4. How is yield, fruit quality and fruit maturity affected?
5. What is the best structure design, and how long does it last?
6. What is the expected return on investment?

Previous reports answered questions 1, 2 and 4 and the results were published in previous SAAGA yearbooks (2014 – 2016). Question 3 was addressed with regards to flower development and pollination, however, the management of pollinators (honey bees) under the shade nets posed some challenges. No hail has yet been experienced at any of the two shade netting sites, therefore question 5 remains. To answer question 6, several years are needed to answer this question adequately.

However, in this final report some insight into the costs involved with farming avocado under shade nets, as well as bee management under shade nets, will be provided.

MATERIALS AND METHODS

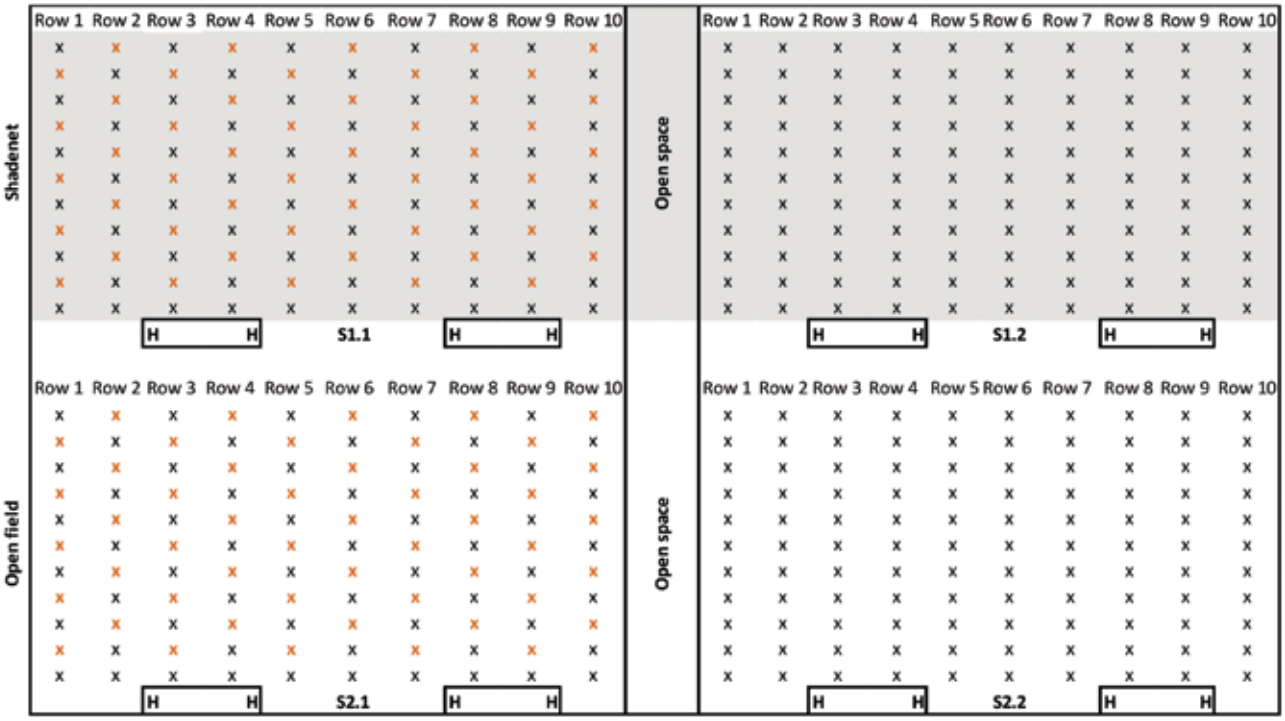
Trial sites

Two Westfalia Fruit farms in Mooketsi, Limpopo Province (23°40'54.59"S,30°01'50.67"E) and Karkloof, KwaZulu-Natal Province (29°26'36.88"S,30°16'21.33"E). Further details about the sites are provided in Table 1.

Table 1. Trial details for shade net trials at Mooketsi and Karkloof.

Location	Cultivars	Covered area	Spacing	Shade net	Height
Mooketsi	Mendez #1 ('Carmen®-Hass')	1 ha	3 m x 3 m[1] 6 m x 3 m[2]	Roof: 20% white Sides: 40% green	6 m
Karkloof	3-29-5 ('Gem®')	1.5 ha	7 m x 4 m	30% crystal	6 m

[1] Trees were thinned to 6 m x 3 m in March 2015.
[2] Trees were thinned to 6 m x 3 m in May 2013.



X = Data tree H = Hive

Figure 1: Layout of data trees under shade net vs. open field to measure bee activity at Mooketsi.

Bee activity

Mooketsi

Fifty trees in the orchard were marked, five trees / row for the block underneath the shade net (S1.1) and the same number of trees in the open field (S2.1) (Fig. 1). Bee-hives were introduced at 20% flowering but bee activity was measured at 80% - 100% flowering, two weeks' post introduction. The bee activity on half a tree on the morning sun side (cool) was monitored. The number of bees was counted on half a tree for two minutes. Research has shown that good pollination demands 5 – 10 bees / tree at least, during the female bloom stage (Ish-Am, 2004; Ish-Am, 1999). This is needed because efficient fertilisation needs 20 pollen grains per stigma (or more) and because of the low average deposited pollen grains on the stigma through a single bee visit (Ish-Am, 2004; Ish-Am, 1999).

Bee management

Water was placed next to each hive, in the open field as well as under the shade net, as bees need water within 250 m of the hive (Allsopp, 2005). The bee-hive stands were placed ±1.9 m above the ground and there was 2 stands / 0.5 ha. On each of these stands two hives were placed. Therefore, there was 4 hives / 0.5 ha; 8 hives under the net (S1.1 & S1.2) and 8 hives outside the net (S2.1 & S2.2) (Fig. 1). It is recommended that only 2 – 3 hives should be placed on a bee-station which is away from pests and possible dampness from standing on the ground (Allsopp, 2005).

Initially the main entrance of the shade net was closed with the aim to investigate bee-activity in an enclosed environment. However, the structure was not originally build as an enclosed environment and there were many places where the bees could get through to the open field. The bees did get out to the open field and it was observed that the bees tried to get back into the shade net structure to their bee-hives, using a lot of energy in trying to achieve this. It was then decided to rather open one side of the shade net behind the hives (Fig. 2) to allow the bees to move freely between the shade net and the open field. It must be noted that all the bee-hive entrances were facing into the shade net, into the rows. Research has shown that bees forage in a row and will move to the next tree in a row 10 – 30 times more, than between rows (Allsopp, 2005, Ish-Am, 2004).

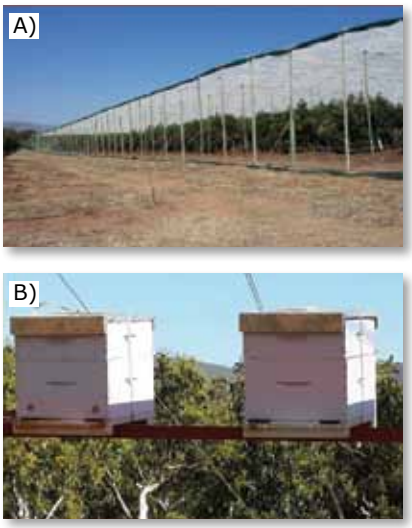


Figure 2. One side of the net lifted (A) to allow bees to move freely between shade net and open field; entrance of bee-hives facing into the net (B).

Both the shade net orchards (S1.1 & S1.2) and the open field orchards (S2.1 & S2.2) were pruned after harvest during March 2016.

Everdon

Twenty bee-hives were put on the eastern border of the shade net, with the entrance of the bee-hives facing into the rows of the orchard. This side of the net was also opened to allow the bees free movement in and out of the shade net. No monitoring of bee activity took place at this site.

Financial implications

The yield achieved at the Everdon site for the 2016 season was used to perform some simple calculations. Unfortunately, the trees at the Mooketsi site experienced severe drought conditions, as the farm ran out of water. This resulted in a total fruit drop (October 2016) in both the shade net and open field orchards, thus the decision to use the Everdon site, where more stable yields were achieved over the past few years.

RESULTS AND DISCUSSION

Bee activity

The average bee activity for three consecutive days under the shade net vs. open field at Mooketsi yielded no statistical difference. Table 2 tabulates the results of the survey. The average bee activity for the open field was 5.5 bees / half a tree / 2 minutes, while under the shade net it was 5.6 bees / half a tree / 2 minutes.

However, when examining specific time periods, a different trend was observed. Figure 3 demonstrates the bee-activity during the morning from 09:00 – 13:00 under the shade net vs. open field orchard. It is clear from Figure 3 that the bee-activity was lower under the net in comparison with the open field orchard. Bee-activity was 20% less under the shade net (4 bees average / half a tree) for this period than the bee-activity in the open field (6 bees average / half a tree). During 09:00 – 12:00 the female flower was the dominant stage in the orchards. Figure 3 demonstrates that the female flower stage started to decrease (close) from 12:00 onwards. It is interesting to note that bee-activity peaked at mid-morning for both the shade net and open field orchard.

Table 2. Average bee activity measured at the morning sun (cool) side of the tree, with 100% female flower stage on the trees.

Average bee activity / 2 minute (10:00 – 12:00)		
Date	**S1.1**	**S2.1**
2016/09/07	5.8 ± 4.3	4.6 ± 2.6
2016/09/08	5.1 ± 4.7	5 ± 2.5
2016/09/09	5.8 ± 2.4	7 ± 2.6
Average:	5.6	5.5

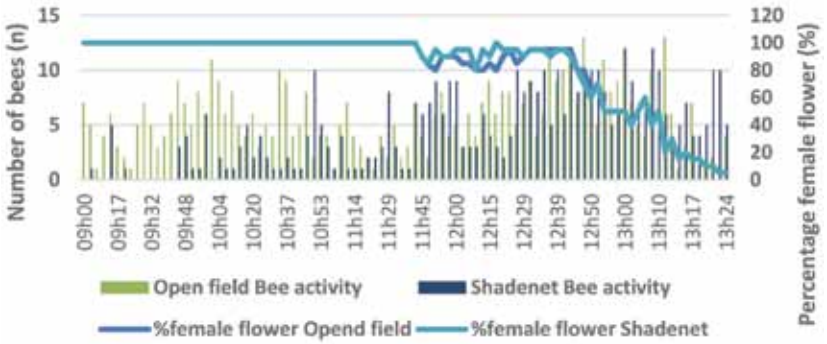


Figure 3. Bee activity shade net vs. open field from 09:00 – 13:30.

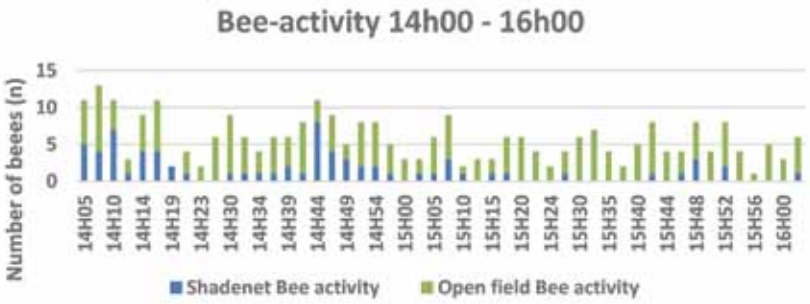


Figure 4. Bee activity shade net vs. open field from 14:00 – 16:00 at 0% female flower.

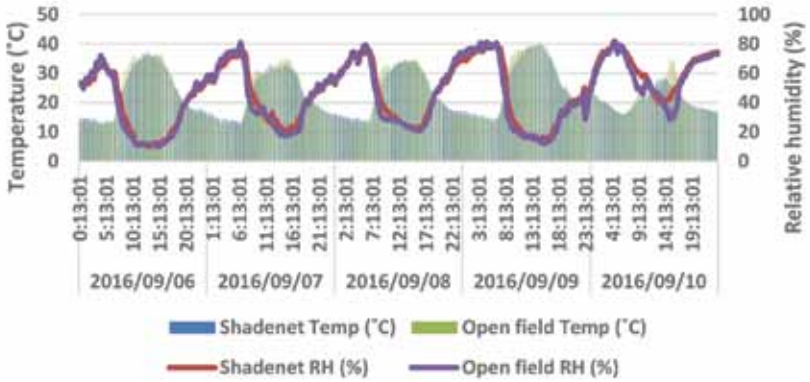


Figure 5. Temperature and Relative humidity during the 6 – 9th of September 2016 shade net vs. open field.

Figure 4 demonstrates bee-activity from 14:00 – 16:00 and once again there was far less bee-activity under the shade net in comparison to the open field. An average of 1 and 4 bees visited half a tree / 2 minutes under the shade net and open field respectively, which resulted in a 67% more activity in the open field. Bee-activity was less active during this afternoon period than in comparison to the morning from 09:00 – 12:00, as previously demonstrated by Figure 3. During the afternoon period, the male flower was the dominant flower stage in the orchard. Bees visiting the male flower will collect pollen, while bees visiting the female flower stage collect nectar (Ish-Am, 2004). The peaked activity during mid-morning and the decline in bee-activity in the afternoon was previously demonstrated by Du Toit and Swart (1993).

Figure 5 demonstrates the temperature and relative humidity during the period of the survey. Temperatures higher than 30°C was experienced from early morning. These continuous high temperatures are not regarded as favourable to avocado pollination, because the pollen dries out, providing less rewards to bees visiting the flowers (Ish-Am, 2004; Salazar-Garcia, 2013).

Bee management

Research indicated that to improve conditions for effective bee activity under shade net, the shade net must be high (at least 1 m above tree canopy) and the orchard pruned, as bees do not favour working in enclosed, overgrown environments (Allsopp, 2005; Ish-Am, 2004). On all accords this was the case under the shade net at Goedgelegen farm. Yet, bee activity was not as was expected.

When the bee-hives were introduced, the number of bees leaving the hive was monitored. At least 60 bees / minute must leave the hive as an indication of a strong hive (Allsopp, 2005). During this time the weather was cold and windy and the lack of bee activity was thought to be because of the weather conditions. Within a week some of the bee activity on 6 of the 16-hives improved. Some of the poor performing hives were examined by a bee-keeper and he found that there was only 4 brood frames / hive and no signs of egg laying by the queen. Allsopp (2005) stated that in a standard hive there should be preferably a minimum of 8 frames of bees and 4 frames of brood of which 2 frames should be open brood, which increases the demand for pollen. This will stimulate pollen foraging and therefore improves pollination and fruit set. There was no open brood amongst the 4 frames / hives. Therefore, it is strongly suggested that when bee-hives are ordered from a bee-keeper, specific conditions of the hives should be agreed upon and inspected after delivery. This will ensure strong bee-hives to perform the task of pollination well.

The open side of the nets enabled the bees to move freely in and out of the net. No more bees were assembling at the corners of the nets trying to get in or out of the net structure. The water inside the nets was frequently visited and rocks were put in the water containers, to provide a resting place for the bees. This prevented drowning of the bees.

Financial implications

The 'Gem' crop were harvested during late November, 2016. Figure 6 demonstrates the yield of the shade net vs. open field from 2014 until 2016 at the Everdon farm, Howick area.

More Class 1 fruit was produced under the shade net in comparison with the open field orchard. During 2014 the Class 1 fruit represented 23% more fruit than the open field orchard, which resulted in 2.8 tons; in 2015 Class 1 fruit represented 42% more fruit than the open field orchard, which resulted in 5 tons and in 2016 the Class 1 fruit represented 13% more fruit than the open field orchard, which resulted in 3.6 tons. Figure 6 also demonstrates that the total yield was more under the shade net in comparison to the open field orchard for the three consecutive years. Of these Class 1 fruit, certain counts were more prevalent than others. Table 3 demonstrates the results. The prevalence of these counts is expressed as a percentage of the total Class 1 fruit, as well as how much fruit (kg/ha) it represented. To demonstrate the benefit of these counts, the price in R/kg for the specific counts was used to calculate the revenue generated. Table 3 demonstrates that the shade net had a benefit of between R36 088 – R130 995 over the 3-year period.

Furthermore, Table 4 compares the total yield and the total production costs of the shade net and open field orchard. Total yield includes Class 1 – 3 fruit and the price (R/kg) was determined by the sum of the average R/kg across all fruit classes for that specific year. This is a very

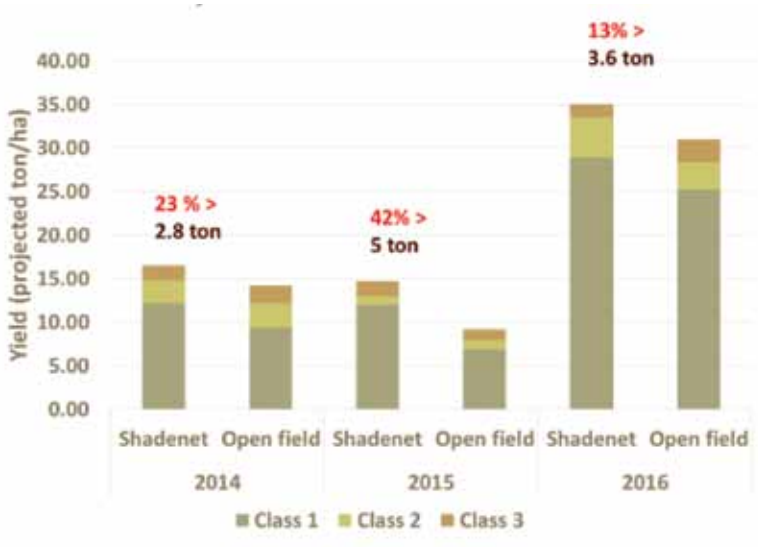


Figure 6. Yield of the shade net vs. open field orchard, 2014 – 2016 at Everdon, Howick.

Table 3. Prevalent fruit counts during the period 2014 – 2016 for the shade net orchard vs. open field orchard.

Year	Treat-ment	Dominant fruit	10	12	14	16	18	Revenue	Net benefit
2014	Shade net	Percentage (%)	18%	36%	14%			R 111 610	R 36 088
		Yield (kg/ha)	2 235	4 365	1 635				
		Price R/kg	R10.45	R14.97	R14.01				
	Open field	Percentage (%)	13%	30%	16%			R 75 522	
		Yield (kg/ha)	1 216	2 820	1 471				
		Price R/kg	R10.45	R14.97	R14.01				
2015	Shade net	Percentage (%)	27%	29%	11%			R 113 214	R 34 684
		Yield (kg/ha)	3 235	3 474	1 281				
		Price R/kg	R11.46	R14.64	R19.74				
	Open field	Percentage (%)	13%	38%	22%			R 78 531	
		Yield (kg/ha)	878	2 592	1 547				
		Price R/kg	R11.46	R14.64	R19.74				
2016	Shade net	Percentage (%)		20%	28%	23%	9%	R 572 036	R 130 995
		Yield (kg/ha)		5 774	7 950	6 545	2 626		
		Price R/kg		R24.84	R23.86	R25.79	R26.73		
	Open field	Percentage (%)		14%	19%	20%	15%	R 441 041	
		Yield (kg/ha)		3 617	4 886	5 057	3 900		
		Price R/kg		R24.84	R23.86	R25.79	R26.73		

Table 4. Comparison of revenue and cost implications of the shade net and open field orchard.

	Shade net			Open field		
Year	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
Total yield (kg/ha)	16 500	14 720	35 000	14 200	9 190	31 000
Sum of ave R/kg	R 15	R 15	R 25	R 15	R 15	R 25
Total revenue	R 247 005	R 215 501	R 875 000	R 212 574	R 134 542	R 770 040
Ave product costs/ha	R 35 344	R 37 600	R 40 000	R 35 344	R 37 600	R 40 000
Bee-hive costs	R 7 500	R 7 500	R 7 500	R 7 500	R 7 500	R 7 500
Extra costs - Shade nets		R 7 500				
Total revenue	R 204 161	R 162 901	R 827 500	R 169 730	R 89 442	R 722 540

conservative price calculation, as Table 3 already demonstrated the benefits of certain fruit counts. The production cost / ha is a general production cost for the broader Westfalia farms in the Tzaneen area, for the specific timeframe. During 2015 one of the sides of the net was damaged and replaced, therefore the R7 500 allocation for that year. Once again, the net had a benefit of between R30 000 – R100 000 for the relevant timeframe.

CONCLUSION

To ensure adequate bee activity under shade net conditions, the following recommendations apply:

- The trees under the shade net should be pruned regularly to ensure an open orchard;
- There should be at least 1 m between the canopy of the trees and the roof of the shade net;
- Water should be placed near the bee-hives (within 500 m);
- One side of the net, away from the prevailing wind, should be opened up to enable the bees free movement between the inside and outside of the net;
- Bee-hives should be inspected to ensure the hives are healthy for successful pollination services. In a standard bee-hive there should be 8 frames of bees, 4 frames of brood of which 2 frames should be open brood.

Simple calculations demonstrated that shade net increased the amount of Class 1 fruit with >10%, which resulted in an average of between R30 000 – R100 000 revenue benefit over the 3-year period.

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