Growing avocados under shade netting

Progress report – Year 2

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ABSTRACT

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

Shade netting has shown to be very effective in improving the packout (external fruit quality) of 'Carmen®-Hass' and 'Gem®' avocados at Mooketsi and Karkloof, respectively, by reducing sunburn and wind damage. The shade netting only has a slight effect on air temperature and relative humidity, but reduced canopy temperature by about 5°C in the afternoon. Furthermore, the shade netting resulted in about a 2°C increase in canopy temperature during sub-zero winter nights at Karkloof. Minimum fruit maturity (moisture content or dry matter) was advanced by two weeks for the 'Carmen®-Hass' at Mooketsi for two seasons. There was no difference in fruit moisture content in the 'Gem®' fruit at Karkloof which were late-hung into November.

The design and strength of the structures have yet to be tested by a hail storm. The major concern at this stage is achieving optimal pollination by improving bee management practices. The authors are confident that this will be achieved in the 2015 flowering period. These trials are long term and will continue, with results published in the subsequent Yearbooks.

INTRODUCTION

This report follows after year one's report (Blakey *et al.*, 2014) and details the findings from this project between February 2014 and February 2015.

Solar radiation in South Africa is excessive for optimal avocado tree growth and development, resulting in heat and light stress for the trees (Bower *et al.*, 1977) and sunburn to fruit. Wind, hail and frost are other environmental risks affecting avocado production. A shade net structure over an avocado orchard can provide a degree of protection from these factors and reduce tree and fruit damage.

While netting is widely used on deciduous crops, avocados have crop-specific challenges that need to be addressed. These include: Tall trees with large inter-row spacing, synchronous dichogamy flowering pattern, protracted flowering period of up to 6 weeks and vigorous vegetative growth. This requires a much higher, stronger structure which is considerably more expensive than a structure required for deciduous fruit – if built to the same quality specifications. If built to a lower specification to save capital expenditure, there is a higher risk that the structure will collapse in a storm. The following questions need to be answered before large scale use of shade nets over avocados should be considered:

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

Aims

1. Determine the long-term effect of shade net over avocado orchards on yield, pollination, cultural management, fruit quality, fruit maturity, and tree pheno-physiology.
2. Examine different construction methods and nets. Estimate the economic benefit of installing these shade net structures.

MATERIALS AND METHODS

Readers are referred to the previous report (Blakey *et al.*, 2014) for more details. Please note that the materials and methods section is not exhaustive. Detailed reports will be published in the following SAAGA Yearbook.

Trial Sites

Mooketsi (Goedgelegen Estate) and Karkloof (Everdon Estate) are being monitored intensely with an automated weather station installed in- and outside the shade net structure at each location. Less intensive microclimate monitoring, and phenological monitoring, will be done at the Tzaneen Dam (Jagtersfontein) site.

Measurements

Automated weather stations were installed at Mooketsi and Karkloof to measure and record the following at sub-hourly intervals:

- air temperature,
- relative humidity,
- canopy temperature,
- wind speed,
- solar irradiance, and
- leaf wetness.

Soil matrix water potential is recorded three times per week using tensiometers at depths of 30 cm and 60 cm.

The following phenological and physiological measurements were taken:

- Vegetative shoot growth, timing, and leaf area;
- flowering intensity, timing and pattern, as well as bee activity; and
- fruit growth and maturity.

RESULTS

Microclimate

In this progress report, a summary of the effect of shade net on microclimate is given in Table 2.

Fruit maturity

Mooketsi

From data from 2014 and 2015, it appears that the 'Carmen®-Hass' fruit at Mooketsi reached the legal minimum maturity level of 77% MC two weeks earlier under the shade net compared to the open orchard (Fig.1). However, all the treatments were harvested together in week 14 in 2014 and 2015, when the fruit from all the treatments had reached an acceptable level of fruit quality upon ripening.

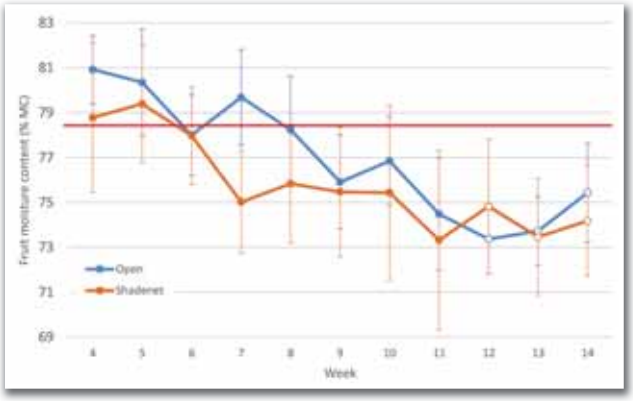

Figure 1. Fruit moisture content of 'Carmen®-Hass' fruit from Mooketsi shade net trial for 2014 and 2015, tree spacing of 6 x 3 m. Minimum fruit moisture content is 77% MC (indicated with red line). Fruit were harvested in week 14 in 2014 and week 13 in 2015. Error bars indicate standard deviation. Unfilled circles in weeks 12 to 14 indicate results are only for 2014.

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

Location	Cultivars	Covered area	Spacing	Shade net	Height
Mooketsi Goedgelegen	Mendez #1 (Carmen®-Hass)	1 ha	3 x 3 m 6 x 3 m	20% white	6.5 m
Karkloof Everdon	3-29-5 (Gem®)	1.5 ha	7 x 4 m	30% crystal	6.5 m
Tzaneen Dam Jagtersfontein	Hass Maluma Carmen®-Hass AO.12	8 ha	8 x 4 m	20% white & 30% crystal	7 m

Table 2. Effect of shade net on microclimate at Mooketsi and Karkloof in 2014/5.

	Mooketsi	Karkloof
Air temperature	Difference <0.5°C	Difference <0.5°C
Relative humidity	No appreciable difference	No appreciable difference
Canopy temperature	Modulates extremes at mid-day	Modulates extremes at mid-day and sub-zero winter nights
Wind speed	Eliminated	Eliminated
Solar irradiance	Reduced by about 18%	Reduced by about 19%
Leaf wetness	Period of leaf wetness prolonged under the net	Period of leaf wetness reduced under net
Soil matrix water potential	Less negative (i.e. higher soil water content) under net	Slightly less negative (i.e. slightly higher soil water content)

Karkloof

'Gem®' fruit are harvested for the late season market. As such, over-maturity is more of a concern. This occurs when the fruit flesh has a very high oil concentration. There was not a significant difference in fruit moisture content at low moisture content levels (less than 65% MC) between fruit growing on trees under shade net vs. those growing in the open (Fig.2).

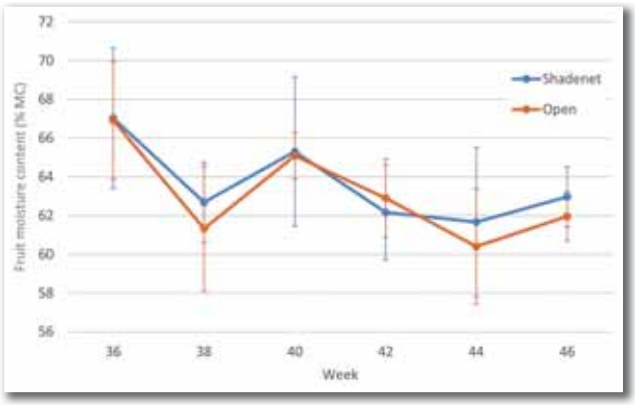

Figure 2. Fruit moisture content of 'Gem®' fruit from Karkloof shade net trial for 2014. Fruit were harvested in week 46. Error bars indicate standard deviation.

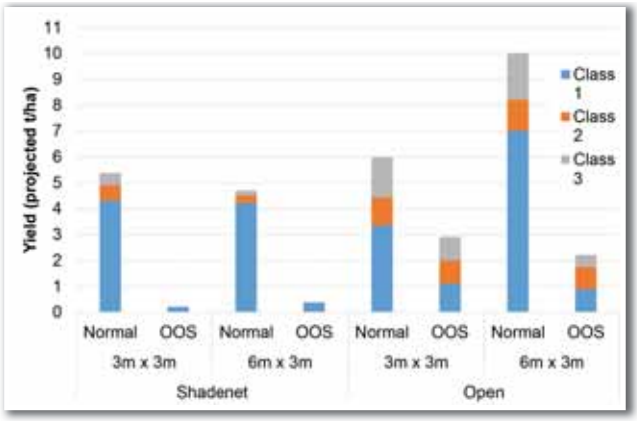

Figure 3. Yield and pack-out for 2014 normal season (March) and out-of-season (OOS - November) for 'Carmen®-Hass' from Mooketsi. Bees were intentionally excluded from the OOS flower. Class 1 is export grade, Class 2 is local market grade and Class 3 is factory grade.

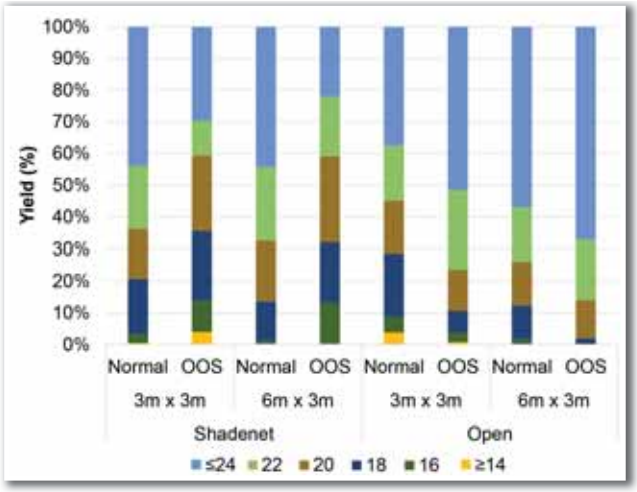

Figure 4. Fruit size distribution for 2014 normal season (March) and out-of-season (OOS - November) for 'Carmen®-Hass' from Mooketsi.

Yield, packout and fruit quality

Mooketsi

The two standout results at Mooketsi are (i) the excellent packout achieved under the shade net in 2014, contrasted with (ii) the poor yields achieved under the shade net (Fig. 3). The improved packout is due to a reduction in sunburn and wind damage. The improved yield in the "Open, 6 x 3 m" treatment is because this orchard was on microsprinkler irrigation while the other three orchards were on inadequate drip irrigation. The reduced yield in the out-of-season (OOS) crop is because bees were not introduced into the orchard to determine whether fruit set from the OOS flower could be prevented. It is apparent that fruit set was greatly reduced when bees were not introduced, providing an option to set a single crop if the grower so desires.

Fruit size distribution is greatly affected by yield,

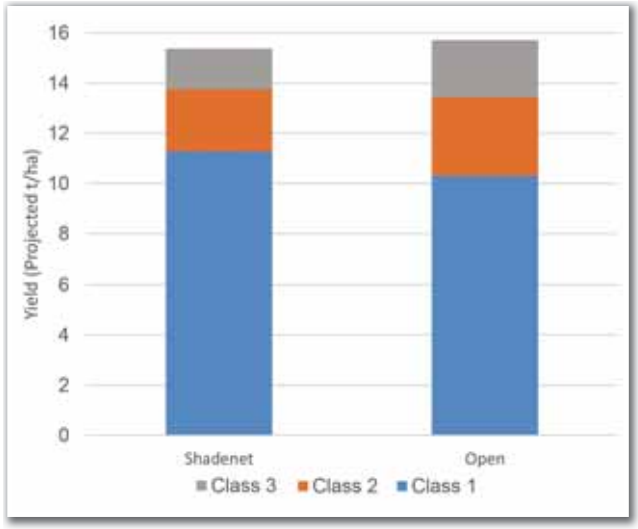

Figure 5. Yield and pack-out for 'Gem®' at Everdon in 2014. Class 1 is export grade, Class 2 is local market grade and Class 3 is factory grade.

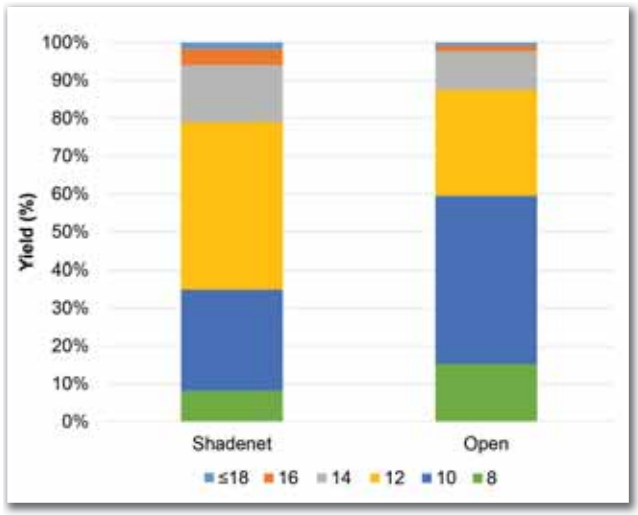

Figure 6. Fruit size distribution for 'Gem®' from Everdon in 2014.

so it is to be expected that the treatments with the higher yield have a higher proportion of smaller fruit (Fig. 4). When, and if, the yields between the treatments are closer, comparisons of fruit size distribution between the treatments will be more appropriate.

Karkloof

The yield was very encouraging for a four year-old orchard, and the 8% increase in the class 1 percentage, considering the orchard was covered three months after fruit set was promising (Fig. 5).

The fruit size distribution from 2014 indicated that the predominant count size under the net was count 12, compared to count 10 outside the net. This decrease in peak fruit size is promising, because a medium-sized fruit is preferred commercially.

DISCUSSION

The reduction in yield under the shade net for the 2015 harvest at both sites is a major concern. It is pertinent to remember the principle of "Sprengel-Liebig Law of the Minimum" or "von Liebig's barrel", which states that "growth is controlled not by the total amount of resources available, but by the scarcest resource or limiting factor" (Van der Ploeg *et al*.). Production was limited by very poor fruit set because of poor bee activity. In other words, bee activity was the most limiting factor. To address this issue, Mike Allsopp, the resident bee expert at the Agricultural Research Council's Plant Protection Research Institute (ARC-PPRI) visited Westfalia in February 2015. His suggestions included:

- Thin the 3 x 3 m orchards at Mooketsi to 6 x 3 m. This will improve flowering intensity and allow the bees access into the block. This will be done immediately after the 2015 harvest.
- Increase the number of hives to at least 4 hives per ha. They must be orientated so the hive entrance faces down the rows, not across. The hives will have to be replaced every two weeks for 4 to 6 weeks, depending on the flowering period. This will be done during the 2015 flowering period.
- The shade net structure should be open in the top corners for the bees so that the bees do not get stuck in the corners. This will be addressed, particularly at Everdon (Karkloof), where it was a notable problem. The structure at Mooketsi does allow the bees to move in and out of the structure as there is a narrow gap between the shade net of the wall and roof.
- Investigate making use of a "bee pasture" inside the net to increase the carrying capacity of the site. The species to be included in the bee pasture have to be chosen carefully, because bees prefer many species over avocados. We have chosen to use white mustard (*Sinapis alba*) at the Mooketsi site, as a source of pollen for the bees during the normal avocado flowering period.
- Optimally the structure should be built so that the sides, and even the top, can be opened during flowering so that the bees have free access into the orchard. However, this does increase the risk of berg winds reaching the trees and drying out pollen, thereby reducing fruit set. This will only be done as a last resort.

A severe infestation of leaf-roller in the 3 x 3 m orchard under the shade net occurred in the summer months of 2014/5. The trees will be thinned to 6 m x 3 m soon after the 2015 harvest, and this should reduce the infestation, but biological control agents are also being investigated.

CONCLUSION

The shade net trials are showing promise in improving fruit quality, however the reduced fruit set in 2015 is a major concern. This has been addressed and it is anticipated that the yields will be improved from 2016. The structures have not been tested by a hailstorm yet so we are not yet able to comment on their hail-shedding techniques and strength. The measurement of sap flow inside and outside the shade net structures will commence in the second quarter of 2015. This is a long term trial with the major change in the growing conditions. As such, it will take a few seasons to optimise avocado production under shade nets.

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