Influence of photo-selective shade nettings to improve fruit quality at harvest and during postharvest storage

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ABSTRACT

During the 2015 growing season, a three-year study was undertaken to investigate the effect of photo-selective coloured shade nets (red, blue and pearl) (20% shading) on fruit size (diameter), marketable yield, sunburn and wind damage, incidence of diseases and pest on 'Hass'. Open field and widely used common white Knittex nets (20% shading) were included for comparison. It was clearly evident from the three-year data collection that production under the shade nets improved the pack-out rate by minimising *sun damage*. To satisfy market demand and to attain profitable fruit production, growers must produce fruit of maximum quality, while retaining the highest possible yields. In this regard, the total yield obtained for the different colour shade nets appears to be a problem. Considering the yield data obtained with regards to alternate bearing, the 2015 season proved to be an "off year", followed by an "on year" in 2016 and followed by an "off year" in 2017. It is a positive finding that a higher yield was obtained under all the nets in the "off year" in 2015 when compared to that of the open field. However, it must be remembered that the nets were erected after fruit-set in 2015. Therefore, pollination was not negatively affected and during the period following fruit-set, the shading net covering provided protection. In this regard, permanent shade netting may cause excessive shading *in low sunlight intensity periods* during spring, which could potentially promote excessive shoot length, delay the onset of flowering and reduce optimum fruit set. During the 2017 "off season", only the red net yielded a slightly higher crop compared to that of the open field, and the total yield from under the white and blue nets was a little lower, but closer to the total yield obtained from the open field. However, during the 2016 "on season", a highly significant reduction in total yield was obtained from the orchards under all the shading nets when compared to those in the open field. During all the seasons, significantly lower yields were obtained from the orchards under the pearl nets. It is recommended that white, red and blue shade netting be used for avocados.

INTRODUCTION

The extent to which climatic extremes reduce marketable produce leads to reduced profitability. Shade netting effectively reduces the adverse effects of climatic extremes, including intense sunlight, wind and hail. Shade netting is usually designed to reduce midday sunlight by about 20 percent. This reduces the heat loading on trees and fruit from visible and infrared radiation and reduces the amount of damage caused by ultraviolet radiation. It has been argued that sunlight and to some extent wind exert a direct influence on the risk of sunburn (Lolicato, 2011). Higher solar radiation, canopy temperature, wind, hail and limited water resources are major environmental factors affecting avocado production in South Africa. The implementation of net protection to safeguard orchards against excessive solar radiation damage, hailstorms and flying pests (Blanke, 2007), is gaining popularity in modern fruit plantations around the world. Exposure to higher temperatures can cause morphological, anatomical, physiological and biochemical changes in plant tissue. As a consequence, the growth and development of different plant organs can be influenced, with concomitant effects on the yield. Nets are commonly used to protect agricultural crops from either excessive solar radiation, environmental hazards or pests. The pack-out rates for exports are affected due to sunburn, wind and hail at the farm gate, as well as the production of smaller fruits, especially for cv. Hass (Blakey *et al*., 2015).

The most commonly desired effects from shade netting are reduced light intensity and wind speed, as well as buffering of temperature extremes and increasing relative humidity (Wachsmann *et al*., 2014). Prominent findings regarding the effects on orchard micro-climate include increased minimum and reduced maximum temperatures, an increase in relative humidity and up to 85 to 90% reduction in wind speed (Raveh *et al*., 2003).

It is also evident that coloured nets can be used to influence the light ratio changes from red to far-red that can be easily detected by phytochromes, and the amount of radiation available to activate the blue/ultraviolet A photoreceptors, blue light involved in phototropic responses mediated by phototropins, and radiation at other wavelengths that can influence plant growth and development (Stamps, 2009). The effects on air movement and PAR under the nets depend on porosity and knitting pattern of the nets. In a study conducted in southern Italy using white, red, blue and grey netting with shading factors from 20.4% to 26.9%, the number of flowers and inflorescences per shoot were lower in the net than in the open field treatments (Basile *et al*., 2008). According to Shahak *et al*. (2004), after two years under netting, the flowering of 'Hermosa' peaches was increased by five (white - 12% shading; blue, pearl, red and yellow - 30% shading) of the six net treatments compared with the open field control. However, the 30% grey netting did not affect flowering, compared with the control.

This project aimed to focus on the use of coloured nets to create a suitable microclimate to produce healthy plants in order to obtain good quality fruits at harvest that would have higher consumer acceptance at the export markets. The objectives included the effect of photo-selective coloured shade nets on tree canopy morphology, leaf chlorophyll (non-destructive measurement), flowering, fruit set, fruit drop, fruit size (diameter), marketable yield, wind damage, sun scald, incidence of diseases and pests on cv. Hass.

MATERIALS AND METHODS

Trial site and experimental design

The Lombard Avocado farm in Tzaneen, Limpopo Province (23.7° South latitude, 30.13° East longitude and 986 m elevation above sea level) was chosen for the study. The farm is situated in New Agatha, Tzaneen. The orchard is affected by sunburn of fruits, winds and regular hailstorms.

Randomised Complete Block Design with four treatments (nets) replicated within each of the five block replications (blocking was carried out according to slope and the soil differences were assumed to be uniform). The tree spacing is 7 m by 4 m, south-north (S-N) orientation. The nets were erected horizontally at about 6-7 m above ground. The whole trial occupied about 1.15 ha (Fig. 1). An experimental unit included 5 x 4 = 20 trees and 6 centre trees acted as data trees per treatment. The irrigation and fertiliser application was carried out according to standard orchard management practices, which were adapted to SAAGA's recommendations. For the Hass cultivar and shaded netting of a particular colour (three replicates), approximately 10 trees were investigated in terms of plant growth, canopy morphology, leaf chlorophyll (non-destructive measurement), flowering, fruit set, fruit drop, fruit size (diameter), marketable yield, wind damage, sun scald, incidence of diseases and pests, and fruit quality parameters. The effect of three photo-selective shade netting (blue, red and pearl) with 20% shading were compared with the 20% white Knittex netting and the open field cultivation (commercial).

Data gathering

Data were obtained regarding light quality and microclimate; fruit assessments for sun, wind, disease and pest damage; total fruit yield; marketable yield; waste; and pack-out rate according to the different grades and fruit sizes (counts).

Postharvest trial

As reported previously by Tinyani *et al*. (2016), in a similar manner, disease-free uniformly shaped or sized fruit without any injuries or defects were selected and a set of 300 fruit per specified colour shade net (red or pearl or white or blue net) and open field were packed for postharvest storage trials; the fruit were laid out in a completely randomised design. A set of 14 fruit was packed in commercial cartons and then stored at

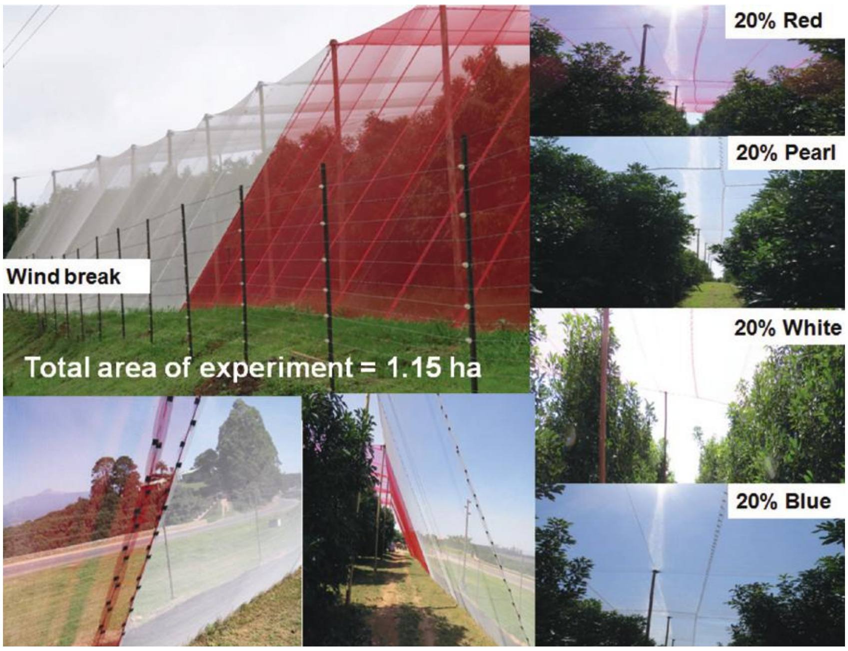

Figure 1: These photographs portray the permanent shading structure with the red nets on the right hand side the blue nets on the left and the pearl and white nets in between.

5.5 °C and 85% RH for 28 days, and thereafter at 25 °C to simulate market shelf conditions (postharvest storage). After completion of low temperature storage, fruit were held at simulated market shelf conditions at 18-20 C. At the market shelf condition, the fruit were evaluated for number of days to ripen, and fruit firmness was recorded after storage and at ripe stage. Ripe fruit quality was assessed daily by gentle hand-squeezing, as mentioned earlier (Tinyani *et al*., 2015). Fruit firmness was measured at two points of the equatorial region of the fruit by using a Chatillon Penetrometer, Model DFM50, with an 8 mm diameter flat-head stainless-steel cylindrical probe (puncture method); the results were reported in kilograms. Fruit firmness of 1 kg represented soft, ripe fruit (Standard ISO 7619, International Organization for Standardization).

Results and discussion

Since the 2017 season was the final season of results of this three-year project, it was decided to reflect the highlights of the three years of results in this report.

Changes in the microclimate: influence on leaf area and chlorophyll content

The average fruit surface temperature was much higher in the open field (30-32 °C) and moderately lower under the red nets (25-29 °C) and even lower under the blue nets (24-26 °C), white nets (23.3-25.6 °C) and lowest under the pearl nets (22-23.6 °C) during March to July in the 2015 growing season (Table 1).

Table 1: Fruit surface temperature under the different shade nets compared to open field.

	Feb-Apr	Apr- May	June-July
Open field	32-35 °C	29-33 °C	29-30 °C
Red nets	29-32 °C	26-30 °C	20-25 °C
Blue nets	27-30 °C	25-27 °C	20-22 °C
White nets	27-30 °C	25-27 °C	18-20 °C
Pearl nets	29-26 °C	22-25 °C	16-20 °C

The % transmittance of UV radiation (290-400 nm) was higher in the open field (Fig. 2) and similar observations were reported in 2016 (Tinyani *et al*., 2016). The UV radiation was remarkably reduced under the pearl nets and moderately under the blue and white nets. It is evident in this study that the fruit from the open field were repeatedly exposed to higher UV radiation during the fruit growth period, which showed an increase in the fruit temperatures from February till the harvest in July.

Figure 3 depicts the changes in the leaf chlorophyll content (spad unit) of 'Hass' trees grown under different shading nets compared to the open field control. The chlorophyll content of the fruit under the white, blue, pearl and red nets was significantly higher compared to that in the open field control. The increased photosynthesis potential due to the higher chlorophyll content of the fruit under the nets led to

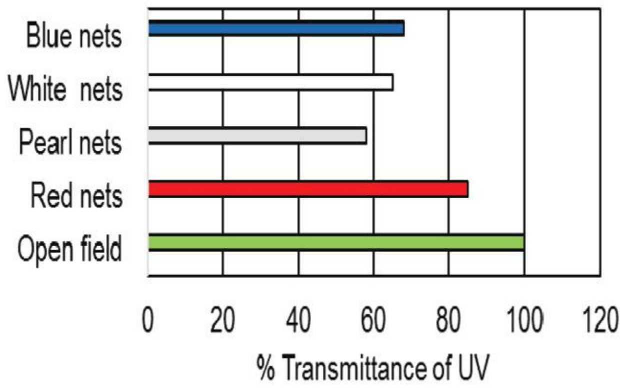

Figure 2: Percentage transmittance of UV light in open field and under the shade nets.

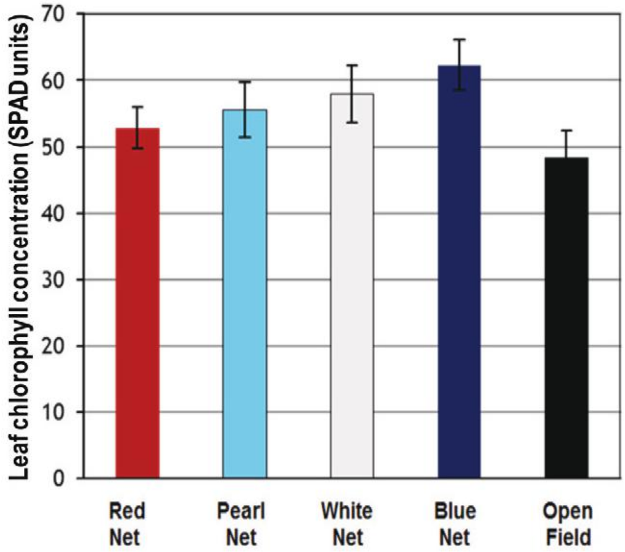

Figure 3: The leaf chlorophyll content (SPAD units) of 'Hass' trees grown under different shading nets compared to the open field.

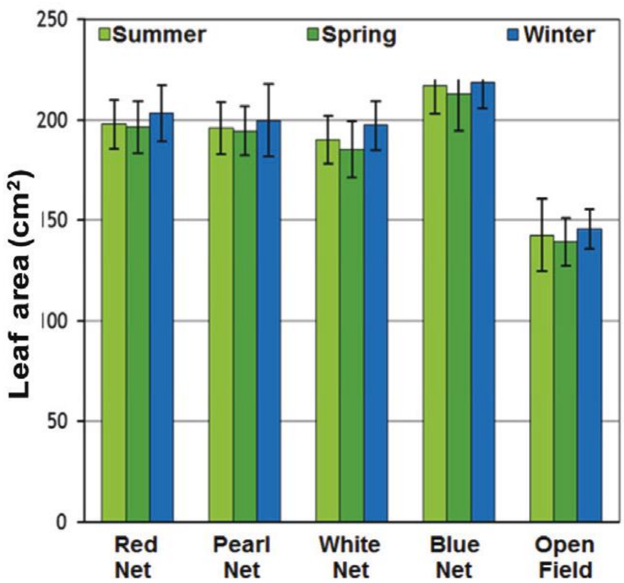

Figure 4: The leaf area (cm^2) of 'Hass' trees grown under different nets compared to the open field. Field control.

Figure 5: The visual appearance of avocado fruit grown under shading nets compared to the fruit grown in the open field.

a significantly higher leaf area (Fig. 4) compared to that in the open field control. In this regard, prominent findings on the effects on the orchard micro-climate include increased minimum and reduced maximum temperatures, an increase in relative humidity, and up to 85 to 90% reduction in wind speed (Raveh *et al*., 2003). Shade nets increase leaf stomatal conductance during hot summer days (a factor of transpiration and sap-flow) by *reducing photo-inhibition* caused by extreme irradiation and mitigating the midday depression. In this regard, in terms of horticultural plant responses, shade nets favour the development of *vegetative tissues* (shoots and leaves) instead of reproductive and root growth (measured in seasonal gain in dry mass) (Raveh *et al*., 2003).

Sunburn and lenticel damage

Figure 5 illustrates the fruit quality under the nets compared to that of the open field control. Figure 6 depicts the percentage sun damage of 'Hass' trees grown under different shading nets compared to the outside control during the 2016 season. It is clear that the outside control obtained a higher incidence of sunburn fruit. The outside control yielded 20% sunburn fruit and it was significantly reduced to values between 4 and 1% under the nets. According to Lolicato (2011), rising fruit surface temperature is the best indicator of sunburn risk. According to the latter author, maximum fruit surface temperatures are normally attained in the hottest part of summer, between 2 pm and 5 pm, and fruit damage usually becomes most apparent after a prolonged hot period. This emphasises the importance of the usage of shading nets which reduce the fruit temperature effectively during the hottest periods of summer. In a similar manner, the results regarding lenticel damage of 2016 (Fig. 7) proved that the open field obtained the highest value (11%) compared to significantly reduced values obtained for the fruit under the nets (red 1.5%, blue 2%, white 2.5% and pearl 4.2% nets).

Fruit size distribution

Figure 8 portrays the percentage fruit size distribution of 'Hass' trees grown under different shading nets compared to the outside control

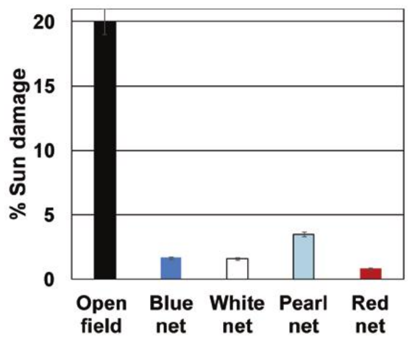

Figure 6: The percentage sun damage of 'Hass' trees grown under different shading nets compared to the outside control.

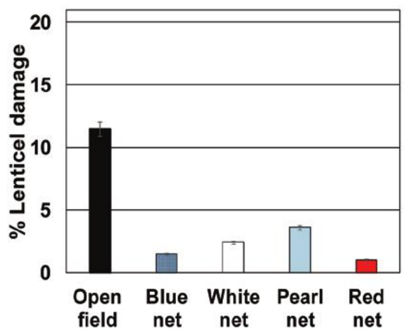

Figure 7: The percentage lenticel damage of 'Hass' trees grown under different shading nets compared to the outside control.

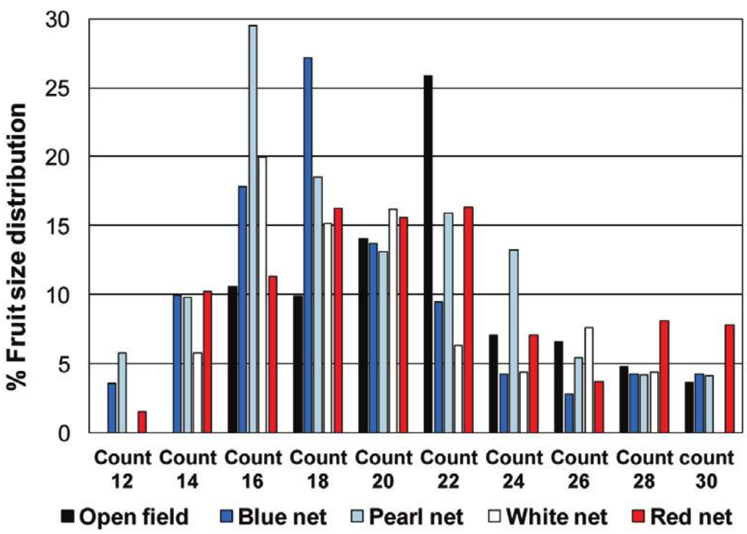

Figure 8: The percentage fruit size distribution of 'Hass' trees grown under different shading nets compared to the outside control.

during the 2017 season. Larger fruit (count 8 or 10) were not observed in the open field or under the different coloured shade nets. However, count 12 and 14 were observed only under the blue, pearl and red nets. The fruit under the white net started at count 14 and in open field at count 14. This already indicated that the coloured nets increase fruit size. However, there is not a move of the total size profile towards the bigger count sizes, as count 24 to 30 was still present under the nets. The fruit size distribution of the open field fruit showed the highest percentage of mostly count 22. The trend of the fruit size distribution was similar to that of 2016. Fruit size distribution under the blue nets showed 27% count 18, 17% count 16 and 13% count 20. The fruit size distribution under the pearl net showed 29% count 16, 18% count 18 and 16% count 22 and that under the red nets showed 16% of fruit belonging to counts 18, 20 and 22. Under the white nets, the fruit size distribution was 20% for count 18, 17% for count 22, 15% for count 16 and 17% for count 22. Therefore, under the white nets, the shift in fruit size distribution is towards average size (medium) fruit, which is preferred for the commercial market.

Yield and pack-out rate

Figure 9 illustrates the total yield (tons/ha) obtained during 2015 (a), 2016 (b) and 2017 (c) for 'Hass' grown under different shading nets compared to that of the open field. During the off year, regarding alternate bearing in 2015 (Fig. 9a), the highest yield (18 tons/ha) was obtained under the blue net, followed by the white nets (16.2 tons/ha), red net (14.9 tons/ha) and the open field (13.5 tons/ha) with the lowest yield (12.5 tons/ha) obtained under the pearl net. The higher total yield under the blue, white and red nets can be attributed to the fact that nets covered the trees just after fruit set. Permanent shading during the entire season was attained only from the 2016 season onwards. In this regard, Sam Lolicato (2011) stated

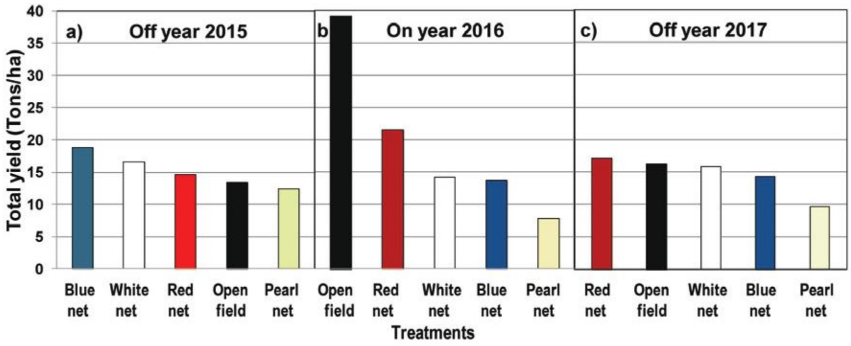

Figure 9: The total yield (tons/ha) obtained during the 2015 (a), 2016 (b) and 2017 (c) season for 'Hass' grown under different shading nets compared to the open field.

that permanent shade netting may cause excessive shading in low sunlight intensity periods during spring, which could potentially promote excessive shoot length, delay the onset of flowering and reduce fruit set.

During the 2016 on season, with regards to alternate bearing (Fig. 9b), the open field produced the highest total yield (39 tons/ha) and the total yields under the nets, which varied between 21 and 7.5 tons/ha (red 21 tons/ha; white 14 tons/ha; blue 13,5 tons/ha and pearl 7.5 tons/ha) were disappointing. It can be argued that the pearl, blue and white nets, which also yielded lower fruit surface temperatures (Table 1) and lower percentages of UV-light transmittance (Fig. 2) compared to those of the open field, led to increased vegetative growth that needed more intense pruning that negatively influenced the yield. On the other hand, the yield under the red net was the highest compared to the yields under the other nets (21 tons/ha). Under the red nets, fruit surface temperature and percentage UV-light transmittance values were also lower but closer to those of the open field, and for that matter, the trees may have needed less intense pruning than those under the other nets. In this regard, it could be wise to refine the manner in which the trees under the nets are pruned. More intense pruning leads to the risk of cutting away potential fruit set. It is well known that larger trees are pruned from only one side in a specific season and that the other side is pruned in the next season so as to reduce the risk of negatively influencing the yield compared with pruning both sides at once. However, the current study neglected to include the pruning that was executed and data regarding tree height before and after pruning could have provided the necessary information to prove the suggestions advanced in this regard.

Permanent shade netting increases the tendency for fruit trees to increase vegetative growth and without suitable management, excessive shoot growth could reduce fruit-set (Lolicato, 2011). However, with well-managed apple trees grown on dwarf and semi-dwarf rootstocks, excessive vigour should not be a significant problem (Middleton, 2010). In this regard, it would not be a wise option to grow the Martin Grande avocado rootstock under shading net because it is known for its increased vegetative growth.

Another factor that influences yield negatively is that bees do not work as well under shade netting, which influences pollination negatively. It is advisable to introduce a larger number of bee hives under the netted orchard during the blossom period and to allow some space between the top of the trees and the netting so that the bees can fly freely along the rows of trees (Lolicato, 2011). During 2017, we tried to increase the number of bee hives under the nets, but this could not be achieved.

During the 2017 off year, with regards to alternate bearing (Fig. 9c) years, the highest yield (16.9 tons/ha) was obtained under the red net followed by the open field (16.2 tons/ha), then the white net (15.8 tons/ha), the blue net (14.3 tons/ha) and the lowest total yield (8.9 tons/ha) under the pearl net. The lowest yield was consistently obtained under the pearl net during the three seasons, which excludes it from being a good choice to be utilised for avocado shading nets. It is a positive finding that a higher total yield was obtained under the red net than in the open field and that a lower but closer total yield to that of the open field was obtained under the white and blue nets.

The yield distribution (tons/ha) and pack-out rate during the 2017 season, including the class 1, class 2, class 3 and waste fruit for 'Hass' grown under different shade nets compared to that of the open field, are portrayed in Figure 9. The open field obtained the highest value of waste fruit, namely 4.6 tons/ha, and there was significantly less waste fruit from under all the nets, varying between 1.1 and 0.2 tons/ha. With regards to the pack-out rate, 28.4% of the open field total yield was waste fruit, compared to that of the nets, which varied between a low 7.5 and 2.2%. This means that the nets led to a reduction between 26.2 to 20.8% in waste fruit compared to that of the open field. When the values of classes 1, 2 and 3 for all the nets are compared, it is clearly evident that this reduction in waste fruit moved mostly into the class 1 fruit category.

The nets obtained very high pack-out rates: the pearl, red, white and blue nets respectively obtained 93.3%, 88.2%, 86.5% and 86.5%, compared to 64.8% of pack out-rates of the open field. To understand the potential economic benefit of utilising shading nets to better the potential tons/ha, class 1 plus class 2 fruit of higher value that can be exported can be compared. In this regard, with the nets the class 1 plus 2 fruits from under the the red, white and blue nets that can be exported amounted to 14.91 tons/ha, 13.69 tons/ha and 12.37 tons/ha respectively, compared to the lower value of 10.95 tons/ha obtained by the open field. Although the 93.3% pack-out rate of the pearl nets was the highest, the lower total yield led to only 8.83 tons/ha that could be exported.

During the 2016 on year, a high waste of 77% was observed in the open field compared to that under the nets; this was mainly due to sunburn damage (data not shown, Tijani *et al*., 2017). In this regard, the economic benefit of shading nets can be greater during the years of high sunburn incidence. Further, the economic benefit will depend on the value of the crop under the netting and the estimated loss of income without the netting. Without netting, in susceptible crops, the amount of sun damaged fruit has varied from 5 to 50% of the total. The degree of damage on individual fruit could vary greatly, with some of the damaged portions of the crop being worthless, while some may be suitable for a downgraded, lower-priced category (Lolicato, 2011). In this regard, for example, slightly sunburnt avocado fruit may be suitable for immediate sale locally but may be unsuitable for export purposes and fruit with a high degree of sunburn can be sold to oil factories, while not taking into account other waste fruit categories. The "insurance value" of netting to protect trees and fruit from weather extremes, including hail and unusual heat waves, did not occur during the past three seasons at our trial site. For example, a damaging hail event, although it occurs once in 10 years, can cause total or 50% or 25% crop loss. With permanent shading nets, the loss is reduced drastically.

Ripening profile and number of days to ripen

Figure 11 depicts the average number of days to ripen (DTR, a) and ripening profiles for 'Hass' grown under different shade nets compared to the open field. Similar DTR values of 12.02 and 11.9 were obtained for the fruit in the open field and under the red net. Significantly lower values were obtained for the blue, white and pearl nets, namely 10.78, 10.44 and 10.22. The similar DTR values for the open field and the red nets can be attributed to the fact that the red nets obtained fruit surface temperature and percentage UV-light transmittance values that were lower but closer to those of the open field compared to the other nets. Although there was a difference in DTR for the net treatments, under which the fruit ripened more slowly as evident in the ripening profile, the nets did not shorten the ripening profile, which indicates that shading nets do not lead to more even ripening.

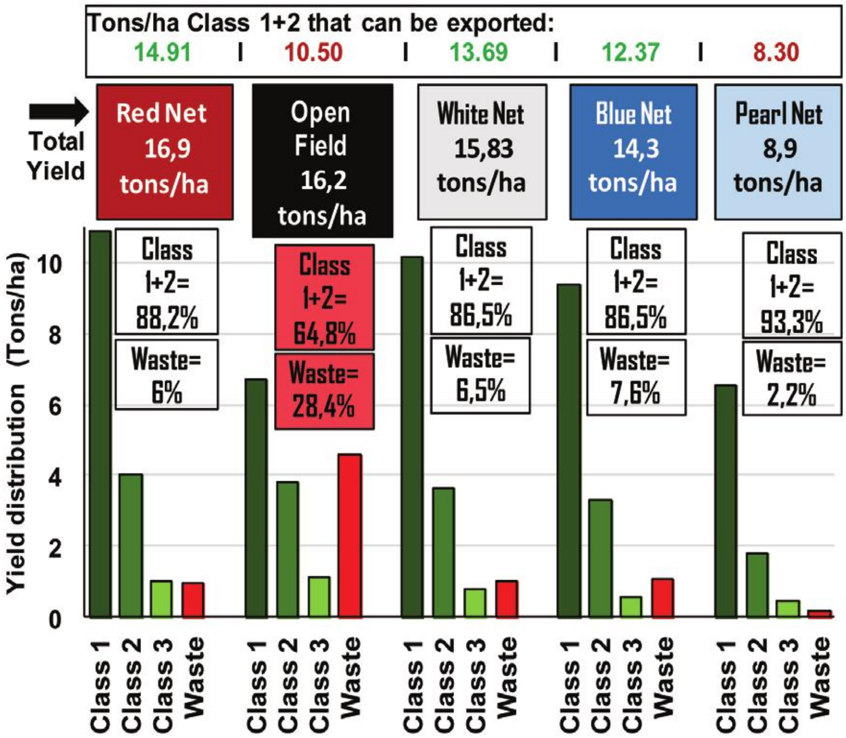

Figure 10: The yield distribution (tons/ha) and pack-out rate during the 2017 season, including the class 1, class 2, class 3 and waste fruit for 'Hass' grown under different shade nets compared to the open field.

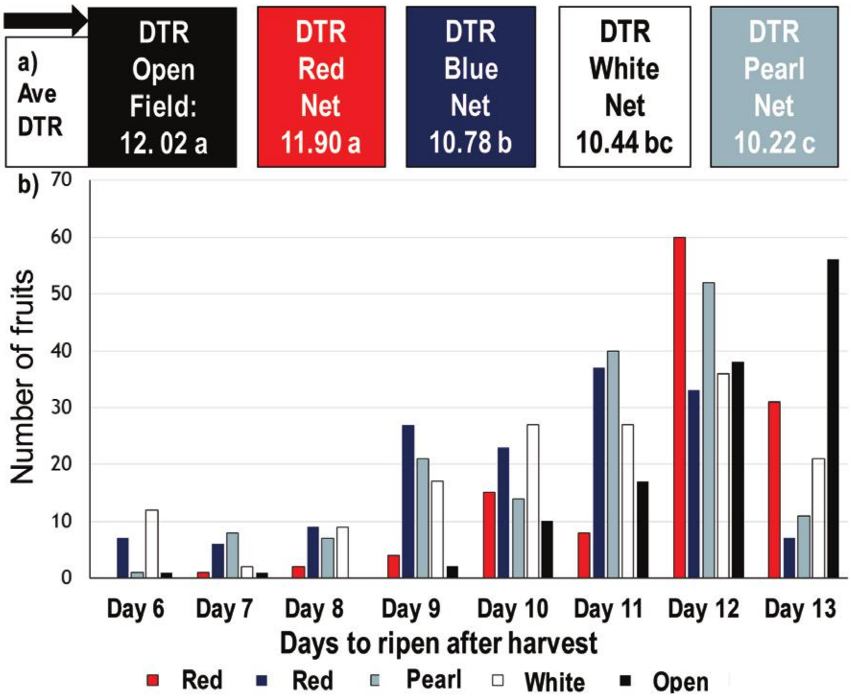

Figure 11: The average no. of days to ripen (a) and ripening profile (b) for 'Hass' grown under different shade nets compared to the open field. (Stats for average no of days to ripen: Student 's T-test (P<0.05))

SUMMARY

During the off year in 2015, the highest yield was obtained under the blue net, followed by the white and red nets and the open field, with the lowest yield obtained under the pearl nets. The higher total yield of the blue, white and red nets can be attributed to the fact that the nets covered the trees just after fruit set.

During 2016, an on year, the total yield and the wastage was higher in the open field. Under the different types of nets tested, the total yield was higher under the red nets. On the one hand, it can be argued that the pearl, blue and white nets, for which lower fruit surface temperatures and lower percentage of UV-light transmittance were obtained compared to those of the open field, led to increased vegetative growth that needed more intense pruning that negatively influenced the yield. On the other hand, the highest yield was obtained under the red net compared to that of the other nets and the fruit surface temperature and percentage UV-light transmittance values were lower but closer to those of the open field. Thus, the trees under the red nets could have needed less intense pruning than the trees under the other nets. In this regard, it could be wise to refine the way the trees under the nets are pruned because more intense pruning leads to the risk of cutting away potential fruit set. The pack-out rates were higher when fruits were grown under the nets, especially the blue net. During harvest, the more preferred fruit count (16, 18, 20, 22) for the commercial market occurred under the blue nets. The soil water content was higher under the nets and soil moisture content was higher during production under the blue nets. Insect and lenticel damage was also reduced remarkably during production under the shade nets.

During the 2017 off year, the highest yield was obtained under the red net, followed by the open field, the white net and then the blue net, with the lowest total yield obtained under the pearl net. Since the lowest yield was consistently obtained under the pearl net during the three seasons, this excludes it as a good choice to be utilised for avocado shading nets. However, as mentioned by Blakey *et al*. (2015), measures should be in place to improve the pollination in order to meet the projected total yields at harvest. Blakey *et al*. (2015) mentioned that measures should be taken to improve the pollination in order to meet the projected total yields at harvest. Therefore, it would be wise to refine pruning techniques to minimise yield loss due to intense pruning. Owing to the excessive pruning after harvest during the 2017 season, a very low yield is expected in 2018. It is known that the coloured nets lead to increased vegetative growth. In this regard, it is to be noted that the blue nets are preferred in nurseries where the faster vegetative growth of nursery plants is an advantage.

It was clearly evident from our three years of data that production under the shade nets improved the pack-out rate by minimising the *sun damage and, to a lesser extent, lenticel damage.* It must be noted that the photo-selective coloured nets have been tested to be stable for 5-8 years under field conditions and dust accumulation can reduce the capacity of the coloured nets which would modify the spectrum. Washing the dust by spraying water onto the nets could help to overcome the problem.

The way forward

The major disadvantage of permanent shading nets is that it may reduce fruit-set during the naturally low sunlight conditions of the early spring, that is, the fruit size would be increased owing to the shading effect of the nets. This would promote excessive shoot length which could delay the onset of flowering. This problem could be addressed by using retractable nets that can cover the orchards when needed.

During the last three years, research was conducted at the Lombard farm using different coloured photo-selective nets as well as the widely used common white Knittex nets (20% shading) that were erected as permanent structures. However, the producer is in the process of erecting retractable net structures, which implies that the nets can be used to cover the orchard during *specific times* during production when needed. This makes it possible to cover the trees after the second fruit-set and that pollination is not negatively influenced, as found with permanent net structures. Furthermore, it is expected that the nets will not only lead to improved yield because of the pollination problem being rectified, but that fruit drop, usually found in fruit from the second set, will be reduced because of the protective environment induced by the timely covering of the trees with the nets during the period of fruit set and harvest.

Additionally, drape nets have become commercially available with similar advantages as retractable net structures that have not been researched for avocados yet. Drape nets offer a cost effective (one third of the cost when compared to permanent structures) tree crop protection from hail, sunburn, wind and insect damage, for the period from fruit set to harvest (in a similar manner as achieved with the permanent structures with retractable nets). Drape nets are designed to be a "throw over netting" to provide *single row* drape-over canopy cover. The drape net company in South Africa provides the machine (which is hired out and is available for sale) that attaches to a tractor that is used to drape the net (sold on a roll) on single rows and it is used to take the net off before harvest. The drape nets are attached to the branches of the tree with cable ties and can be attached to the soil beneath the trees with tent pens.

We propose a three-year project

During the 2018 growing season: It is proposed to investigate the effect of drape nets (white Knittex 20% shading) on fruit size (diameter), total yield, marketable yield, sunburn and wind damage, incidence of diseases and pests on 'Hass'. The open field will be utilised for comparison. It was intended to include the permanent shading net-structure (used during the 2015-2017 seasons) with white Knittex nets (20% shading). However, due to excessive pruning in 2017, there will be no fruit in the 2018 season. A second trial will investigate if the current high incidence of sunburn obtained with 'Pinkerton' in Tzaneen can *effectively be reduced* using drape-nets. White (Knittex 20%) as well as black (Knittex 40%) drape nets will be included. Open field fruit without nets will be used for comparison.

During the 2019 growing season, as the retractable nets will be erected during the middle of 2018, it is proposed that these would be included in the investigation during 2019. Therefore, we will be investigating the effect of non-permanent drape shading nets (white Knittex 20% shading), permanent shading net structures (used during the 2015-2017 seasons, the white Knittex net tunnel, 20% shading, will be used in the proposed trial), as well as non-permanent retractable shading net structures and the open field for comparison of fruit size (diameter), total yield, marketable yield, sunburn and wind damage, and the incidence of diseases and pests on cv. Hass.

During the 2020 growing season, the trials on 'Hass' of 2019 will be *replicated,* including the three types of the mentioned shading net.

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