RESEARCH TOWARDS REDUCING THE INCIDENCE OF LENTICEL DAMAGE OF SOUTH AFRICAN 'HASS' EXPORT AVOCADO FRUIT

Lemmer, D., Viljoen, H.W. and Fourie, J.F.

ExperiCo, Agri-Research Solutions
PO Box 4022, Idas Valley, Stellenbosch 7609, SOUTH AFRICA
danie@experico.co.za

ABSTRACT

Orchards of optimum leaf N exhibited less lenticel damage compared to high nitrogen orchards. As more than 80% South African 'Hass' orchards are high nitrogen orchards (more nitrogen is applied to increase fruit size and yield), this alone complicates the objective towards reducing lenticel damage of 'Hass'. It would be wise to look for alternative ways to increase fruit size and yield to optimally reduce lenticel damage in 'Hass'. An orchard used in 2019 that obtained the least lenticel damage of all orchards visited in the last three years, with optimum leaf N, Ca, Mg and B, accumulated B in the fruit skin to a value 114% higher than the leaf B value. This partly explains the remarkable resistance of this orchard in developing lenticel damage. The extremely high skin B content could only have been obtained with optimum photosynthetic output in place, to ensure the availability of Perseitol (a C7 sugar) that acts as carrier of B during phloem transport. In contrast, a 2020 orchard with optimum leaf N, Ca, Mg and B similar to the 2019 orchard which showed the least lenticel damage, could only accumulate B in the fruit skin to a value of 10.7% higher than the leaf B value. This implies that photosynthetic output was inhibited during fruit development and hence less Perseitol was available to act as a carrier, resulting in less effective phloem transport of B to the fruit skin. The consequent reduced fruit skin integrity explains the higher sensitivity to develop lenticel damage. Suboptimal irrigation may limit the root uptake of Ca and B through transpiration and hence limit the integrity of the fruit skin, adding to increased sensitivity to lenticel damage. This emphasises the importance of optimum irrigation during the first 6-7 weeks of fruit development to ensure that Ca and B accumulate optimally in the fruit skin from early fruit development. However, sustained optimum irrigation is needed in the months following until harvest to obtain maximum fruit pulp and skin B content for optimum fruit skin integrity when fruit are harvested. A newly selected orchard in 2021, with optimum leaf N, Ca, Mg but lower leaf B with optimum irrigation applied, resulted in a 142.9% increase in fruit skin B content. This orchard obtained lenticel damage of 39.5% and received intermediate wind damage as an additional negative attributing factor to damaging lenticels. This demonstrates the utmost importance of optimum irrigation to maintain optimum phloem transport of B to the fruit skin for optimum fruit skin integrity and the influence of wind damage in managing lenticel damage effectively. Since the research done in 2020 indicated that the absorption of Ca and B into the fruit skin and pulp was a problem, the 2021 spray trials were planned to improve the absorption of these nutrients into avocado fruit. The new tests include a wetter with additional penetrating function (WetCit), as well as a wetter (PANAF 5) that contains a lipid-amino acid, proven to be a good carrier of fungicides into plant cells of other commodities. The results indicated that both WetCit and PANAF 5 were able to significantly increase B and Si in the fruit skin. However, the skin Ca content was not increased by inclusion of Wetcit and PANAF 5. In further research, penetrators like BREAK-THRU® SP 133 (Alchem Group) and Tronic (AECI) with the ability to move active ingredients through the wax layer into the plant, needs to be tested on avocado. These penetrators can dissolve the plant's protective waxy layers, allowing fertilizers and herbicides to move more effectively into the plant cells. In 2019, 2020 and 2021, the spray trial aimed at increasing Ca into the fruit skin during the late season was not effective. The need for improved Ca absorption into the fruit skin during the first 6 weeks of fruit development remains a priority for future trials.

INTRODUCTION

The avocado industry identified the need for research solutions to reduce lenticel damage. Lenticel damage, a disorder of the peel of avocados, manifests as brown or black spots on the fruit skin. This disorder occurs when the fruit skin is damaged in the region around the lenticels. When the fruit skin is fully turgid (not wilted), the lenticels become sensitive and

highly susceptible to handling damage. It was requested that time be spent on farms to identify pre-harvest factors as well as harvest practices that could possibly contribute to the occurrence of lenticel damage. Furthermore, the influence of harvest practices and pre-harvest nutritional factors in the expression of fruit skin and pulp nutrient composition differences in avocado needed to be established, to link nutrient composition to lenticel damage.

Lenticel damage was in the past mainly perceived to be a problem in 'Fuerte' avocado, showing unsightly brown or black speckles on ripe fruit that remained green. 'Hass', in contrast, was perceived to be at a lower risk of developing lenticel damage, since lenticel damage is hardly visible once the fruit has changed colour and ripened, despite possibly harbouring lenticel damage when green, prior to colour transformation. Competition in the market has changed the perception towards lenticel damage, with the buyer rather selecting 'Hass' with no visible lenticel damage. Results of the 3rd year's study of a 3 year project are reported on.

Three main objectives were identified for the 2021 season:

- To investigate if there is an effect of optimum and sub-optimum irrigation on high nitrogen and optimum nitrogen orchards on lenticel damage during storage of 'Hass' avocado.
- To ascertain if late foliar applications of AECI and Levity Crop Science of calcium, boron and silicon products 3 months prior to harvest, are effectively absorbed into the fruit skin and if this could assist in reducing lenticel damage in a high nitrogen orchard.
- To investigate if the addition of 2 adjuvants (PANAF 5 and WetCit) with penetrating properties, can improve the absorption of these nutrients into avocado leaves and fruit.

MATERIALS AND METHODS

Taking the results and important findings of 2020 into consideration, research for 2021 was directed at validating certain findings. Two trials were conducted.

TRIAL 1: The effect of optimum and sub-optimum irrigation on high nitrogen and optimum nitrogen orchards, on lenticel damage during storage of 'Hass' avocado - Objective 1.

A 2019 orchard with optimum leaf N, Ca, Mg and B was able to accumulate B in the fruit skin with a value that was ± 100% higher than the leaf B value obtained from an orchard with the least lenticel damage. This partly explains this orchard's remarkable resistance to develop lenticel damage. The very high skin B content could only have been obtained with optimum photosynthetic output in place, to ensure the availability of Perseitol (a C7 sugar) that acts as carrier of B during phloem transport. A 2020 orchard with optimum leaf N, Ca, Mg and B was very similar to the 2019 orchard but obtained the least lenticel damage, as B accumulation in the fruit skin was only ± 6% higher than the leaf B value of 13%, leading to increased lenticel damage. This implies that photosynthetic output was inhibited during fruit development. This led to less Perseitol available to act as a carrier, which influenced the effective and optimum phloem transport of B to the fruit skin. Further research is needed to verify this important finding. This possibly led to reduced fruit skin integrity that explains the higher lenticel damage. Suboptimal irrigation may limit the root uptake of Ca and B through transpiration, and hence limit the integrity of the fruit skin adding to the increased sensitivity to lenticel damage. This emphasises the importance of optimum irrigation during the first 6-7 weeks of fruit development to ensure that Ca and B accumulate optimally in the fruit skin. Sub-optimal irrigation leads to water stress during which stomata on leaves close to limit transpiration as well as photosynthesis. However, optimum irrigation in the months thereafter also needs to be maintained to ensure maximum B translocation from the tips of old leaves through phloem transport. Taking this in consideration, it was decided to identify 2 optimum nitrogen and 2 high nitrogen orchards with both optimum and sub-optimum irrigation under these two nitrogen regimes. Hypothetically this orchard was sub-optimally irrigated, resulting in inhibited photosynthetic output of Perseitol, leading to less B translocated to the skin although optimum B was present. This needed to be shown in the 2021 trials. Therefore two high nitrogen as well as two optimum nitrogen orchards were chosen to include both optimum irrigation and sub-optimum irrigation in these two nitrogen regimes.

Treatments

Four orchards of Producer I were visited, harvested and evaluated in 2021:

2 x high nitrogen orchards of Producer I (2021):

- Orchard I S3A (leaf nutritional composition: N = 2.7%, Mg = 0.57%, Ca = 1%, B = 38 mg/kg)
  - The nutritional composition was: high N, optimum Ca and Mg, slightly low B.
  - Full sprinkler irrigation, dry as well as wet soil moisture prior to harvest (it was visited twice) and sub-optimal irrigation.

- Orchard I M5 (leaf nutritional composition: N = 2.6%, Mg = 0.57%, Ca = 0.5%, B = 20 mg/kg)
  - This orchard had high nitrogen with Ca and B deficiency and was therefore more sensitive towards lenticel damage.
  - Full sprinkler irrigation, dry soil moisture prior to harvest and optimal irrigation.

2 x optimum nitrogen orchards of Producer I (2021):

- Orchard I S1B (leaf nutritional composition: N = 2.85%, Mg = 0.60%, Ca = 1.21%, B = 43 mg/kg)
  - This orchard was an optimum nitrogen orchard in 2020, but changed to a high nitrogen orchard in 2021.

- Full sprinkler irrigation, dry as well as wet soil moisture prior to harvest (it was visited twice) and sub-optimum irrigation.

- Orchard I M3 (leaf nutritional composition: N = 2.2%, Mg = 0.6%, Ca = 1%, B = 35 mg/kg)
  - The leaf nutritional composition of optimum N, optimum Mg and optimum Ca was very similar to PF1 2019.
  - Full sprinkler irrigation, dry soil moisture prior to harvest and optimum irrigation.

The research data of 4 other orchards were included for study purposes, where fruit was harvested in 2019 and 2020.

1 x optimum nitrogen orchard of Producer F (selected in 2019):
- F1 2019 (leaf nutritional composition: N = 2.3%, Mg = 0.50%, Ca = 1.2%, B = 50 mg/kg)
  - The nutritional composition was optimum N, optimum Ca, Mg and B (fruit from this orchard could not be harvested in 2021, since the orchard was harvested very early this season).
  - Full sprinkler irrigation, dry soil moisture prior to harvest (7 days no rain).
  - Optimum irrigation until 1 month prior to harvest, after that it only relied on rainfall as irrigation water was not available.

1 x optimum nitrogen orchard of Producer I (for study purposes the 2020 results of this orchard were also included):
- I S1B 2020 (leaf nutritional composition: N = 2.25%, Mg = 0.57%, Ca = 1.01%, B = 56 mg/kg)
  - The nutritional composition was optimum N, Ca, Mg and B.
  - Full sprinkler irrigation, dry soil moisture prior to harvest and optimum irrigation.
  - Orchard with sub-optimum irrigation.

1 x high nitrogen orchard of Producer H (for study purposes the 2019 results of this orchard were also included):
- H2 (leaf nutritional composition: N = 2.68%, Mg = 0.60%, Ca = 1.21%, B = 54 mg/kg)
  - The nutritional composition was high nitrogen and optimum Ca, Mg and B.
  - Full sprinkler irrigation, wet as well as dry soil moisture prior at harvest (was visited twice) and optimum irrigation were applied on specific days on a weekly basis. Irrigation is managed very precisely and the producer makes sure that the orchards are irrigated timely at the prescribed soil moisture of +5 mm which leads to no water stress periods during the season.

1 x high nitrogen orchard of Producer I (for study purposes the 2020 results of this orchard were also included):
- Orchard I S3A (leaf nutritional composition: N = 2.55%, Mg = 0.55%, Ca = 1%, B = 60 mg/kg)
  - The nutritional composition was high nitrogen, optimum Ca and Mg, slightly low B.
  - Full sprinkler irrigation, dry as well as wet soil moisture prior to harvest (it was visited twice) and sub-optimal irrigation is suspected as the fruit skin B did not increase as needed in 2020.
  - It was visited again in 2021.

Harvest and cold storage
- Samples were taken from 4 sampling points during the handling chain (5 box replicates, count 16).
- The first sample was box-picked in the orchard, representing fruit handled with the utmost care / minimal damage, of the lowest possible incidence of lenticel damage.
- The second sample was taken at harvest, directly from crates or bins of fruit picked by the farm personnel, to establish the level of lenticel damage occurring as a result of commercial harvest by farm pickers.
- The third sample set was drawn upon arrival of the fruit at the packhouse, to verify the extent of damage manifesting during transport between orchard and packhouse.
- The fourth sample was taken directly from the pack-line, to ascertain the level of lenticel damage relating to the packing process.
- The samples were sent to Stellenbosch via refrigerated truck and stored in an ExperiCo cold room at 5.5 ºC for 25 days to simulate export.

Fruit ripening and evaluation
- The fruit were ripened at 20 ºC.
- The evaluation comprised a full fruit quality examination, including physiological disorders (grey pulp, black cold damage, lenticel damage, vascular browning, vascular staining) and pathological disorders (anthracnose and stem-end rot).

TRIAL 2: The effect of late season foliar nutrient sprays in a high nitrogen orchard, 3 months prior to harvest, on lenticel damage of 'Hass' avocado - Objective 2.

Background to trial conducted

Generally, increased lenticel damage occurred on fruit from high N orchards compared to fruit from trees with optimum N in 2019 and 2020. This implies that Ca sprays need to be very effective to rectify the Ca : N ratio and to give improved cell wall integrity to trees with high nitrogen. Fruit skin cells of trees with high N are known to be bigger with thinner cell walls. The need existed to determine if foliar sprays of Ca, B and Si can reduce sensitivity towards lenticel damage in high nitrogen orchards. Furthermore, if the Ca : N ratio can be improved, then lenticel damage can be reduced.

Site selection

One high nitrogen 'Hass' orchard in the Soekmekaar area was selected for trial purposes in 2021. Full sprinkler irrigation was applied in this orchard and

the trial started 6 weeks prior to expected harvest time.

Products used
Calcium, boron and silica products of 2 suppliers were used:
- AECI Plant Health:
  - Calcium (Calcimax 500 mℓ//100 L)
  - Boron (FloBor 150 mℓ/100 L)
  - Silica (EcoKsil 250 mℓ/100 L)
- Levity Crop Science:
  - Calcium (Albina 1 L/ha)
  - Boron (Damu 2 L/ha)
  - Silica (Zeme 1 L/ha).

As the thick wax layer on the leaves and fruit of avocado inhibits effective absorption of nutrients, two additional treatments were done, including 2 adjuvants with penetrating properties to possibly assist in improved absorption through the wax layer barrier:
- PANAF 5 (1 L/h) consists of a lipid-amino acid that is known to increase the absorption of fungicides
- WetCit (70 mℓ/100 L), a very affective wetter with penetrating properties.

Foliar applications
In total 5 sprays were conducted with a mist blower, comprising:
- 3 sprays of a boron + calcium combination (7-day intervals over a period of 21 days)
- 2 sprays of silicon a day before and a day thereafter (2 sprays)
- 5 tree replicates were included for each treatment.

Spray treatments:
As the orchards were not uniform, AECI Plant Health and Levity Crop Science products were applied as two trials with a separate untreated control.

- Treatment 1 (T1)
  Untreated control.

- Treatment 2 (T2)
  Foliar applications of boron, calcium and silicon. For the AECI Plant Health products, Biodew was included as wetter and the Levity Crop Science products were applied with no adjuvant included.

- Treatment 3 (T3)
  Foliar application of boron, calcium applied in combination. For all AECI Plant Health and Levity Crop Science products, WetCit was added as an adjuvant.

- Treatment 4
  Foliar application of boron, calcium applied in combination. For all AECI Plant Health and Levity Crop Science products, PANAF 5 was added as an adjuvant.

Harvest and cold storage
- Fruit were harvested for storage purposes 6 weeks after the last spray treatment.
- For each treatment 8 boxes of Count 16 (160 fruit) sized fruit were harvested with care to minimise lenticel damage:
  - 4 boxes were rolled in a 10 L bucket according to the "Jostling method"
  - The remaining 4 boxes were not "Jostled", acting as an untreated control
- The samples were sent to Stellenbosch via refrigerated truck and stored at the ExperiCo facilities at 5.5 °C for 25 days to simulate export.

Fruit ripening and evaluation
- The fruits were ripened at 20 ºC and subsequently evaluated.
- The evaluation comprised a full fruit quality examination, including the following physiological disorders: grey pulp, black cold damage, lenticel damage, vascular browning, vascular staining; and pathological disorders (anthracnose and stem-end rot).

Statistical analyses
Statistical analyses were conducted on 4 replicates per treatment. The data were subjected to two-way analyses of variance (ANOVA), using Statistica (statistical software).

RESULTS AND DISCUSSION
TRIAL 1: To determine the influence of handling 'Hass' fruit in an orchard of high and optimum nitrogen levels, utilising different irrigation regimes, on the occurrence of lenticel damage after storage - Objective 1.

Adherence to soil moisture protocol
The SAAGA protocol recommends: "Avoid picking from orchards with soils at field capacity (tensiometer reading of 20-30 kPa, 500 mm deep, topsoil containing most roots), as this will increase susceptibility to lenticel damage". Fruit skin cells will be more turgid and, as such, avocado is not suitable for harvest if soils are at field capacity, or wet due to rain, or fruit are wet when harvested directly after irrigation. In general, during 2019 one of the most important industry protocols as far as control of lenticel damage is concerned was not adhered to.

Producers either use tensiometers (kPa) or probes (mm) to measure soil moisture to plan and manage their irrigation cycles (Table 1):
- An orchard of Producer I, visited in 2020 and 2021, made use of a tensiometer. This orchard (No. 3, PI S1B 2020 and No. 4, PI S1B 2021) complied with the industry protocol with tensiometer readings of 72 kPa and 60 kPa respectively, during both visits.
- However, the same orchard (No. 9, PI S1B 2021) was visited twice in 2021. With the first visit, due to a misunderstanding, it was irrigated and fruits harvested at a soil moisture of 20 kPa.
  - The protocol advises to dry out soil higher than 30 kPa, as field capacity is obtained between 20-30 kPa. In the case of orchard No. 8, PI S1B

CHOOSE PRECISION IRRIGATION
TO GROW MORE AVOCADOS WITH LESS.

Netafim can help you combat alternate bearing, support higher densities, prevent fruit drop and compensate for shallow root-zones.

Contact us today.

NETAFIM™
GROW MORE WITH LESS

Tel: +27 21 987 0477 • infoza@netafim.com • www.netafim.co.za

Find us on social media

Table 1: Harvesting practices followed at 10 orchards according to soil moisture parameters or harvesting schedules according to days allowed after rain

Orchard number	Producer code	Tensiometer reading (if used) kPa	Probe reading (if used) mm	Number of days allowed after last rain (days)	Other comments
1	F 1 2019	(-)	(-)	7d	Irrigation stops 5 weeks prior to picking due to shortage of water on the farm
2	I M3 2021	(-)	+4 mm		Optimum full irrigation, sprinklers
3	I S1B 2020	72 kPa	(-)		Sub-optimum full irrigation, sprinklers
4	I S1B 2021	60 kPa	(-)		Sub-optimum full irrigation, sprinklers
5	H 2 2019	(-)	+4 mm		Optimum full irrigation, sprinklers
6	I S3A 2021	32 kPa	(-)		Sub-optimum full irrigation, sprinklers
7	I M5 2021	(-)	+4 mm		Optimum full irrigation, sprinklers
8	I S3A 2020	20 kPa	(-)		Sub-optimum full irrigation, sprinklers
9	I S1B 2021	20 kPa(-)	(-)		Sub-optimum full irrigation, sprinklers
10	H 2 2019	(-)	-5.5 mm		Optimum full irrigation, sprinklers

Table 2: The incidence of lenticel damage on fruits of 10 'Hass' orchards, sampled at 4 points; (a) after personalised box-pick and pack, (b) in the orchard from bins after farm-picked, (c) upon arrival at the packhouse, and (d) from the pack-line, representing Two-way ANOVA for 10 orchards

	QUALITY PARAMETER – INCIDENCE of LENTICEL DAMAGE (%)											
	Factor A (Orchard) x Factor B (Sampling points)					Factor A (Orchard)			Factor B (Sampling points)			
	Orchard	(a) Picked into boxes directly	(b) Farm pickers	(c) Upon arrival at pack-house	(d) Packed on pack-line				(a) Picked into boxes directly	(b) Farm pickers	(c) Upon arrival at pack-house	(d) Packed on pack-line
1.	PF 1 2019	32.5a	30.0a	32.5a	30.0a	1.	PF 1 2019	31.25	47.29	54.2	63.5	68.25
2.	PI M3 2021	34.5ab	34.5ab	38.4bc	39.5c	2.	PI M3 2021	36.71				
3.	PI S1B 2020	40.0c	40.0c	45.0d	47.5def	3.	PI S1B 2020	43.13				
4.	PI S1B 2021	46.7de	50.0efg	58.0hi	62.0ijk	4.	PI S1B 2021	54.18				
5.	PH 2 2019	47.5def	51.3efg	65.0kl	67.5lm	5.	PH 2 2019	57.81				
6.	PI S3A 2021	47.5def	52.2fg	65.0kl	67.9lm	6.	PI S3A 2021	58.15				
7.	PI M5 2021	52.0fg	58.8ij	70.0m	75.0n	7.	PI M5 2021	63.93				
8.	PI S3A 2020	57.5hi	63.8jkl	85.0o	92.5p	8.	PI S3A 2020	74.69				
9.	PI S1B 2021	53.8gh	69.0m	84.0o	100.0q	9.	PI S1B 2021	79.20				
10.	PH 2 2019	60.0ij	85.0o	90.0p	100.0q	10.	PH 2 2019	83.75				
	P < 0.0000					P < 0.0000			P < 0.0000			

* Letters that are dissimilar are significantly different based on the Fisher LSD (α = 0.05)

2021 with a soil moisture of 22 kPa, the orchard was too wet as it falls very close to the wetter than field capacity range (0-20 kPa) of tensiometer readings.
  - By not adhering to the dry soil moisture protocol there was an increase of 61.3% in lenticel damage.
- A high nitrogen orchard of Producer I was visited in 2020 and 2021 (No. 6, PI S3A 2021 and No. 8, PI S3A 2020), harvested at 50 kPa and 32 kPa respectively, and both results obtained indicated increased susceptibility to developing lenticel damage (Table 2).
  - The protocol advises to dry out soil higher than 30 kPa, as field capacity is obtained between 20-30 kPa.
  - As the soil moisture reading of 32 kPa in the case of No. 8, PI S3A 2020 was still close to field capacity margin of 30 kPa and resulted in a high incidence of lenticel damage, it is recommended to pick closer to the next irrigation as this will ensure that drying out of the soil is adequate. The producer indicated that they usually irrigate these medium texture soils at a soil moisture of 40 kPa.
  - Literature indicates that for medium texture soils, irrigation is required between 40 to 55 kPa to avoid damage that occurs at too dry soil moisture values of 60-80 kPa. Heavy clay soils on the other hand need to be dried out further and irrigation is desirable as soil suction values reach 70-80 kPa.
  - High nitrogen orchards that are harvested during the late season are still quite susceptible to developing lenticel damage that was also noted in 2019. Therefore it is important to use the soil moisture readings of orchards to be harvested as closely monitored measures to decide when to harvest.
- Producer F did not make use of probes or tensiometers in orchard No. 1, PF1 in 2019 and the last rain was 7 days before the harvest date and the dry-out period was adequate to safely say that the soil moisture was within protocol.
- The cumulative lenticel damage incidence of orchard H2 (producer H, 2019) was visited and sampled twice during harvest when the soil probe moisture reading was too wet (No. 5, PH2 2019, -6 mm) and dry (No. 10, PH2 2019, +4 mm) (2019) and differed by almost 40%, with the highest level exhibited for orchard No. 10, H2 2019. This can be ascribed to the difference in soil moisture levels at harvest for the two sets of fruit samples. *Adherence to the industry soil moisture protocol resulted in much lower lenticel damage*. Furthermore, lenticel damage increased as a result since fruit of both soil moisture treatments were subjected to additional handling, however, more so for orchard No. 10, H2B 2019, that was harvested at too wet soil moisture.
  - To dry out the soil to +4 mm until the day before, the next irrigation that took place at +5 mm in the case of medium texture soils is advisable.
  - However, for soil consisting of a higher clay content that dries out slower, irrigation is needed between 10 to 16 days later for soils that vary between +10 mm to +16 mm soil moisture. In a similar way it is advised to dry out the soil until 1 day before the expected day of irrigation, which entails the proper management of probe data that must be checked on a daily basis.
- 2 orchards of Producer I that make use of soil moisture probes (No. 2, PI M3 2021 and No. 7, PI M5 2021) adhered to the dry soil moisture protocol, and both were harvested at +4 mm.
  - When harvested dry, the high nitrogen orchard (No. 7, PI M5 2021) obtained significant higher lenticel damage of 75% compared to the 30% of the optimum nitrogen orchard (No. 2, PI M3 2021). Although both adhered to the dry soil moisture protocol, a high nitrogen orchard has increased sensitivity towards developing lenticel damage.
- The findings of adherence to or applying the stipulation to avoid harvesting at field capacity at orchard level by the 10 orchards, are summarised in Tables 1 and 3.

Lenticel damage (Table 2)

Comparison of the level of lenticel damage as influenced by the handling chain, by sampling fruit at different points related to activities completed in the handling chain, was done.

Two-way analyses of variance (ANOVA) were applied by analysing the data in Statistica (statistical software) and using the LSD test ($\alpha = 0.05$) to compare treatment means (Table 2) for Factor A (10 orchards) and Factor B (4 sampling points). A significant interaction occurred between Factor A (orchard) and Factor B (4 sampling points).

<u>Comparison between different orchards for each of the sampling points</u>

- Sampling points a, b, c and d
  - A common result occurred for each of the 4 sampling points for the level of lenticel damage occurring between orchards. Significantly lower lenticel damage was recorded on fruit for 6 of the 10 producers / orchards (No 1, PF1 2019; No. 2, PI M3 2021; No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019 and No. 6, PI S3A 2021), compared to fruit from producers / orchards (No. 8, PI S3A 2020; No. 9, PI SB1 2021 and No. 10, PH2 2019).
    - These 6 orchards were harvested in adherence to the soil moisture protocol.
    - In 3 of these 6 orchards exhibiting lower lenticel damage, optimum leaf N levels were present, with 2 of the 3 orchards exhibiting optimum leaf Ca, Mg and B levels (No. 1, PF1 2019 and No. 3, PI S1B 2020).
  - The shared feature of the orchards exhibiting significant higher lenticel damage is the presence

of high leaf N levels in 4 orchards that adhered to the soil moisture protocol (No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021) and low leaf B in 3 orchards, while 3 of the 10 orchards did not adhere to the soil moisture protocol for harvesting (No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021).
  - Furthermore, fruit sampled for each of the 4 sampling points exhibited significantly lower lenticel damage for 3 producers / orchards (No. 1, PF1 2019; No. 2, PM3 2021; No. 3, IS1B 2020) compared to 4 orchards (No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021). The common feature of the orchards exhibiting lower lenticel damage is the presence of optimum leaf N, as opposed to high leaf N.

Discussion

- For only one (No. 1, PF1 2020) of 10 orchards, no significant differences in incidence of lenticel damage occurred between the four sampling points, with the incidence varying very close to each other (between 30-32.5%), which differed significantly for the other 9 orchards (No. 3, PI S1B 2020; [3] PI M3 2021; [4] PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2).
- This implies that lenticel damage was not induced by additional steps in the handling chain for producer PF1.
  - Initially, the five weeks of no irrigation prior to harvest were pointed out as a possible reason for the low incidence of lenticel damage. However the reduced irrigation was replicated in a high nitrogen orchard in an attempt to reduce the incidence of lenticel damage and this proved not be the case in 2020.
  - A nutritionally optimum orchard (No. 1, PF1) with optimum leaf N (1.3%), optimum leaf Ca (1.2%) and optimum leaf B (50 mg/kg) was most resistant towards developing lenticel damage.
- Orchard No. 2, PI M3 2021 of optimum nitrogen and chosen for its known optimum irrigation, as well as harvested in adherence to the dry soil moisture protocol, showed no significant difference in incidence of lenticel damage between the first two sampling points (box-picked and picker crates). Both sampling points obtained values of 34.5%, which indicates some resistance to development of lenticel damage. Lenticel damage increased significantly upon arrival at the packhouse and for the pack-line sampling point, reaching levels of 38.4% and 39.5% respectively.
  - This orchard's lenticel damage levels did not differ significantly from orchard No. 1, PF1 at sample point a (box-picked) and sample point b (farm-picked). This proves optimum nitrogen orchards are less sensitive to developing lenticel damage with minimal handling.
  - This orchard unfortunately exhibited low wind damage, that explains the significant increase in lenticel damage at sample point d (pack-line fruit). In this regard, fruit with no wind damage were chosen in the box-pick sample point a, as well as at the farm-picked sample point b. It was also mentioned in 2019 that late wind damaged fruit are not removed on the pack-line during sorting. This results in increased lenticel damage being recorded, as the two disorders produce damage resulting in very similar lesions, especially in the case of late season wind damage.
- For orchard No. 3, PI S1B 2020, which is nutritionally similar to optimum orchard No. 1, PF1 2020, a significant difference in incidence of lenticel damage occurred between the first two sampling points (box-picked and farm-picked), with both sampling points exhibiting values at 40%, indicating some resistance to development of lenticel damage. Upon arrival at the packhouse, lenticel damage increased to 45% and to 47% at the pack-line sampling points.
  - Unfortunately this orchard had intermediate wind damage, which explains the 17.5% higher lenticel damage when compared to orchard No. 1, PF1 2019 (pack-line values). In this regard it can be added that [1] PF1 2019 is a small orchard surrounded by big trees that provided 100% protection against wind damage.
- Grade 3 damage, according to the PPECB lenticel grading protocol, only occurred on fruit that had passed over the pack-line, especially if harvested in orchards with ***wet soil moisture*** as was also pointed out in 2019 and 2020 (Fig. 1).
  - This emphasises the importance in adhering to the industry soil moisture protocol. In this regard, three orchards (No. 6, PI S3A 2020; No. 7, PI S2A 2020; No. 10, PH2 2019) exhibited grade 3 lenticel damage of 16-30%. By not adhering to the industry soil moisture protocol, fruit from these orchards packed as Class 1 are at ***risk*** of not passing the 10% maximum allowed by PPECB's grading system for Class 1 export fruit.
- Results of the same 'Hass' orchard (No. 5, PH2 2019 and No. 10, PH2 2019 [Fig. 1d]) when harvested at a "drier" soil moisture (probe reading +4 mm) one day before starting the next irrigation, exhibited fruit with much less lenticel damage compared to fruit harvested from the same orchard at a soil moisture content of -5.5 mm (No. 10, PH2 19).
- The 3 optimum nitrogen orchards (No. 1, PF1 2019; No. 2, PI M3; No. 3, PSI S1B) harvested in adherence to the industry soil moisture protocol, obtained significantly less lenticel damage (30-47.5%) than the 4 high nitrogen orchards (62-75%) that complied with the soil moisture protocol (No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021) as well as the high incidence recorded (92.5-100%) for the three remaining high nitrogen orchards (No. 8, PI S3A 2020; No. 9, PI S1B 2021; No. 10, PH 2B 2019) where non-compliance to the industry soil moisture protocol led to increased lenticel damage.
- The high nitrogen orchard which adhered to soil

TEST THE ENERGY STATUS OF YOUR AVOCADO TREE WITH ITEST™ CARBOHYDRATES

Agri Technovation offers the world class, ITEST™ CARBOHYDRATES, testing service to avocado producers, which measures the carbohydrate status of your avocado orchards.

Knowing the carbohydrate status of your trees throughout the season is the critical first step in being able to manage carbohydrates and yield. The ITEST™ CARBOHYDRATES analysis program is a new tool with which sugars and starch concentrations in leaves and roots can be monitored accurately and continuously at the appropriate phenological stage of the crop. This can lead to the timely development of management practices that will help producers to ensure optimal plant growth, yield and high fruit quality.

Agri Technovation PLANTPHYSIOLOGY™ RESEARCH CENTRE

Samples are tested at the world-class Agri Technovation Plant Physiology Research Centre.

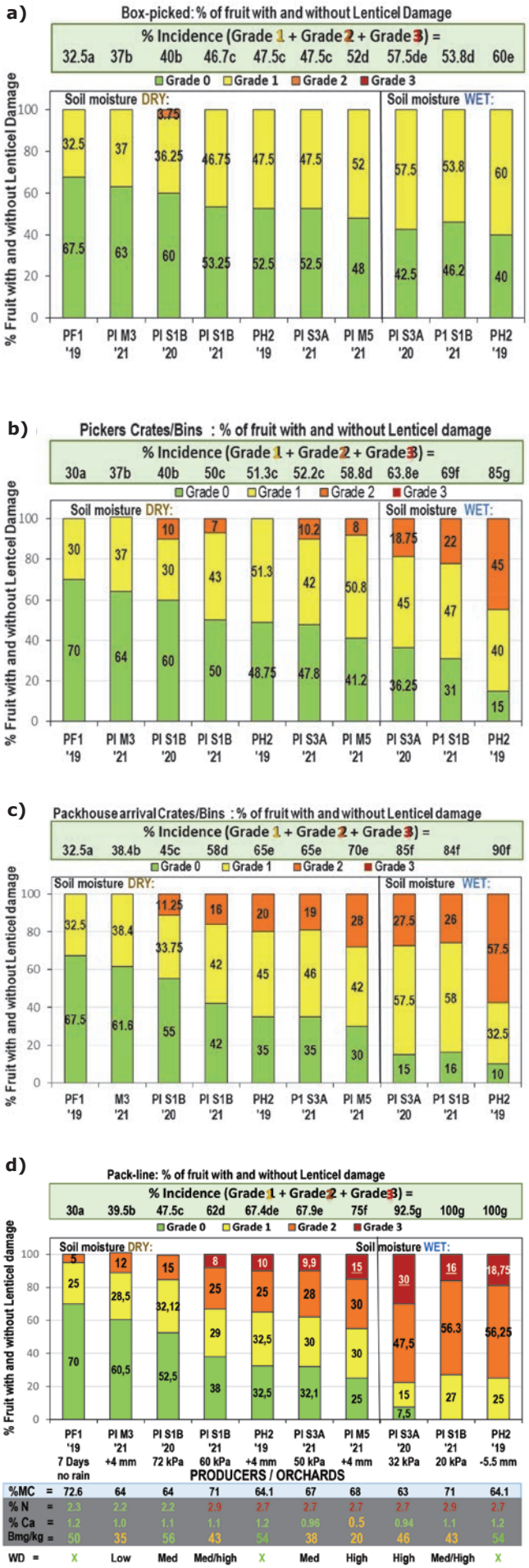
Bringing AT-ness to every Farmer

Agri Technovation
Specialized to succeed

+27 21 300 0543
info@agritechnovation.co.za
www.agritechnovation.co.za

+27 12 940 4398
info@laeveld.co.za
www.laeveld.co.za

LAEVELD AGROCHEM Since 1991



moisture protocol, with deficient leaf Ca and B (No. 7, PI M5 2021) and optimally irrigated, exhibited the highest lenticel damage of 75% at the pack-line sampling points, compared to the 3 other high nitrogen orchards (No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021) which also adhered to the soil moisture protocol (62-67.9%).

- The findings implicated:
  - That optimum leaf nutrition (N, Ca and B levels) reduces the level of postharvest lenticel damage of 'Hass' avocado.
  - That suboptimal irrigation may limit the root uptake of Ca and B through transpiration and hence limit the integrity of the fruit skin, adding to increased sensitivity to lenticel damage.
  - The sensitivity of high N orchards towards developing lenticel damage is indicated.

<u>Comparison between sampling points for the different orchards</u>

- Sampling point a vs. d (Table 5)
  - Fruit sampled directly after being picked by an individual into boxes (box-picked = a) exhibited significantly less lenticel damage compared to fruit picked on the farm and packed after being placed on the pack-line (packed on pack-line = d), for 9 (= 90%) of the 10 orchards / producers (No. 2, PI M3 2021; No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2).
  - The findings implicated:
    - That exposing avocado to accumulative handling practices from picking by the farm labour force, travel to the packhouse and subjecting the fruit to the pack-line, resulted in higher lenticel damage than subjecting avocado to minimal handling by picking and packing directly into a box and no further handling thereafter.
    - Accumulative handling was the dominant factor influencing the level of lenticel damage and not nutrition (N, Ca, Mg and B levels) or the irrigation regime,

Figure 1: Percentage fruits with lenticel damage for samples procured from 9 'Hass' avocado orchards from (a) box-picked fruit (b) picking teams harvest (c) from the bins upon arrival at the packhouse and (d) from the pack-line. The intensity of the disorder was quantified using PPECB's grading system (Grade 0, 1, 2 & 3). The producer code, soil moisture, leaf nutrient content (N, Ca and B), incidence of wind damage and sampling point are indicated. Stats: ANOVA; Fisher LSD P<0.05

Table 3: Rationale behind dividing 10 'Hass' producers / orchards into two main groups, according to pre-harvest practices followed prior to, during and at picking, relating to the level of lenticel damage recorded after storage

Groups		Orchard	Soil moisture at picking: Producers with probes (mm) or Tensiometers (kPa)	Days no rain	Comments / Other factors that played a role	Incidence of late wind damage	Leaf N (%)	Leaf Ca (%)	Leaf B (mg/kg)
Group A	Dry soil moisture	1. PF 1 2019	-	7	No probes; **Irrigation stopped 1 m prior to harvest; rain thereafter,** however **7 d no rain** prior to picking = **adhere to soil moisture protocol; dry picking, optimum leaf N, Ca and B, No wind damage. Effective phloem transport of B to fruit skin and pulp;** good photosynthetic output of **Perseitol** (C7 Sugar) **leads to high skin B. Optimum irrigation**	No	**2.30**	**1.2**	**50**
		2. I M3 2021	+4 mm		Probes, **Adherence to soil moisture protocol; dry picking, Optimum leaf N and Ca, B. Effective phloem translocation of B to fruit pulp and skin.** Low **wind damage**	Low	**2.2**	**1.0**	**35**
		3. I S1B 2020	72 kPa		Tensiometer; **Adherence to soil moisture protocol; Dry picking. Inhibited B phloem transport** to fruit pulp and skin. **Intermediate wind damage. Sub-optimum irrigation**	Med	**2.25**	**1.0**	**56**
		4. I S1B 2021	60 kPa	-	Tensiometer; **High N and low B,** though **optimum Ca,** assisting with cell wall strength / properties; but **low leaf B,** Intermediate **wind damage. Sub-optimum irrigation**	Med/ high	**2.85**	**1.1**	**43**
		5. PH 2A 2019	+4 mm	-	Probes; **Adherence to soil moisture protocol; dry picking, optimum leaf and skin Ca and B, though high N.** Effective **phloem translocation of B from old leaf tips to fruit pulp and skin. No wind damage. Optimum irrigation**	No	**2.70**	**1.2**	**56**
		6. PI S3A 2021	50 kPa		Tensiometer; **Adherence to soil moisture protocol; Dry picking, Inhibited phloem transport of B to fruit pulp and skin. Sub-optimum irrigation. Intermediate wind damage**	Med	**2.7**	**1.0**	**38**
		7. I M5	+4 mm		Probes; **Adherence to soil moisture protocol; Dry picking, High leaf N and low Ca and B. Inhibited B phloem translocation to fruit pulp and skin** although **optimum irrigation** was present; **Leaf B-deficient leads to low skin B. High wind damage**	High	**2.6**	**0.5**	**20**
Group B	Wet soil moisture	8. PI S3A 2020	32 kPa	-	Tensiometer; **No adherence to soil moisture protocol; Wet picking; High leaf N** and **slightly low leaf B** though **optimum Ca;** Intermediate **incidence of wind damage. Sub-optimum irrigation**	High	**2.70**	**0.94**	**46**
		9. PI S1B 2021	20 kPa	-	Tensiometer; **No adherence to soil moisture protocol; Wet picking; High N,** though **optimum Ca;** Intermediate **incidence of wind damage. Sub optimum irrigation**	Med/ high	**2.85**	**1.1**	**43**
		10. PH 2B 2019	-6 mm	-	**Probes; No adherence to soil moisture protocol; Wet picking; High N,** though **optimum leaf and skin Ca and B; No wind damage,** Effective **phloem translocation of B** to fruit pulp and **skin. Optimum irrigation**	No	**2.68**	**1.2**	**56**

Group A included orchards that were harvested within SAAGA soil moisture recommendation to minimise lenticel damage
Group B included orchards that were harvested with soils too wet, or other factors influencing the incidence of lenticel damage negatively, such as high nitrogen and low calcium content, as well as the incidence of late wind damage

since increased lenticel damage occurred in fruit sampled from most orchards (all except 1 orchard, [1] F1 2019, with optimum nutrition and irrigation by sprinklers).

- Sampling point a vs. c (Table 4)
  - Fruit sampled directly after being picked by an individual into boxes (box-picked = a) exhibited significantly lower lenticel damage compared to fruit picked on the farm and sampled upon arrival at packhouse (packhouse arrival = c) for 8 (= 80%) of the 10 orchards / producers (No. 2, PI M3 2021; No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2).
  - The findings implicated:
    - As previously indicated, exposing avocados to accumulative handling practices from picking by the farm labour force and travel to the packhouse and packing without placing the fruit onto the pack-line, resulted in higher lenticel damage than avocados subjected to minimal handling by picking and packing directly into a box and no further handling thereafter.
    - That handling was the dominant factor influencing the level of lenticel damage and not nutrition (N, Ca, Mg and B levels) in combination with the irrigation regime, since increased lenticel damage occurred in fruit sampled from most orchards (all except 2 orchards - No. 1, F 2019 and No. 2, PI M3 2021).
    - That to some extent if N, Ca, Mg and B occur at optimal levels (orchard No. 1, F1 2019 and orchard No. 2, PM3 2020), then subjecting the fruit to more radical handling practices is of lesser concern and will not exacerbate the occurrence of lenticel damage.

Table 4: Incidence of lenticel damage on fruits of 10 'Hass' orchards, sampled at 2 points; (a) after personalised box-pick and pack and (b) in the orchard from bins after being farm-picked as well as (a) after personalised box-pick and pack, and (c) upon arrival at the packhouse, presenting Two-way ANOVA results on 10 orchards and Group A and Group B

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(a) After box-pick	(b) After farm-pick			(a) After box-pick	(b) After farm-pick
Group A	1. PF 1 2019	32.5a	30.0a	1. PF 1 2019	31.3	47.2	54.4
	2. PI M3 2021	34.5a	34.5a	2. PI M3 2021	34.5		
	3. PI S1B 2020	40.0b	40.0b	3. PI S1B 2020	40.0		
	4. PI S1B 2021	46.7c	50.0cde	4. PI S1B 2021	48.4		
	5. PH 2 2019	47.5cd	51.3cde	5. PH 2 2019	49.4		
	6. PI S3A 2021	47.cd5	52.2de	6. PI S3A 2021	49.9		
	7. PI M5 2021	52.0de	58.8fgh	7. PI M5 2021	55.4		
Group B	8. PI S3A 2020	57.5fg	63.8h	8. PI S3A 2020	60.6		
	9. PI S1B 2021	53.8ef	79.0i	9. PI S1B 2021	66.4		
	10. PH 2 2019	60.0gh	85.0j	10. PH 2 2019	72.5		
	P<0.0000			P<0.0000		P<0.0000	

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(a) After box-pick	(c) Upon arrival at packhouse			(a) After box-pick	(c) Upon arrival at packhouse
Group A	1. PF 1 2019	32.5a	32.5a	1. PF 1 2019	32.5	47.2	63.3
	2. PI M3 2021	34.5ab	38.4bc	2. PI M3 2021	36.4		
	3. PI S1B 2020	40.0c	45.0d	3. PI S1B 2020	42.5		
	4. PI S1B 2021	46.7d	58.0gh	4. PI S1B 2021	52.4		
	5. PH 2 2019	47.5de	65.0i	5. PH 2 2019	56.3		
	6. PI S3A 2021	47.5de	65.0i	6. PI S3A 2021	56.3		
	7. PI M5 2021	52.0ef	70.0i	7. PI M5 2021	61.0		
Group B	8. PI S3A 2020	57.5gh	85.0k	8. PI S3A 2020	68.9		
	9. PI S1B 2021	53.8fg	84.0k	9. PI S1B 2021	71.3		
	10. PH 2 2019	60.0h	90.0l	10. PH 2 2019	75.0		
	P<0.0000			P<0.0000		P<0.0000	

* Letters that are dissimilar are significantly different based on the Fisher LSD (α = 0.05)

ons gekonsentreerde formulasie wérk

- AGRIMEC® Gold is die enigste waterbasis en viermaal gekonsentreerde abamektien formulasie op die mark
- Die unieke formulasie het 'n verlaagde koolstofspoor en dus minder impak op die omgewing
- Bied onmiddelike beskerming teen vreetskade maar is veilig vir natuurlike vyande

AGRIMEC® Gold. Die slim keuse.

SmartFarm
Inspired

Agrimec® Gold

syngenta®

LEES DIE ETIKET VIR VOLLE BESONDERHEDE.
AGRIMEC® Gold bevat abamektien 84 g/l (Reg. nr. L9235, Wet nr. 36 van 1947). SKADELIK.
AGRIMEC® Gold is die geregistreerde handelsmerk van 'n Syngenta Groepmaatskappy.
Syngenta Suid-Afrika (Edms) Beperk, Privaatsak X60, Halfway House, 1685. Tel. (011) 541 4000. www.syngenta.co.za

@SyngentaSA

- Sampling point a vs. b (Table 4)
  - Fruit sampled directly after being picked by an individual into boxes (box-picked = a) exhibited significantly lower lenticel damage compared to fruit sampled after being picked by the farm harvesting team and placed in lug boxes or bins (farm-picked = b) for 4 (= 40%) of the 10 orchards / producers (No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2).
  - The findings implicated:
    - In contrast to other comparisons, handling seemed to not be the dominant factor influencing the level of lenticel damage, but rather nutrition, since increased lenticel damage occurred in fruit sampled from less than 30% of the orchards (only No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021, 2019) with all three of the orchards having high N and Mg but low B.
    - Irrigation may have contributed to the exacerbation of lenticel damage, along with the nutrient imbalances (No. 8, PI S3A 2020; No. 9, PI SB1 2021), since increased damage occurred on fruit from trees that were irrigated using sprinklers, but not subjected to drying prior to harvest.

- Sampling point b vs. d (Table 6)
  - Fruit sampled after being picked by the farm harvesting team and placed in lug boxes or bins (farm-picked = b) exhibited significantly lower lenticel damage compared to fruit picked on the farm and packed after being placed on the pack-line (packed on pack-line = d), for 8 (= 80%) of the 10 orchards / producers (No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2).

Table 5: Incidence of lenticel damage on fruits of 10 'Hass' orchards, sampled at 2 points; (a) after personalised box-pick and packed, and (d) from the pack-line and (b) in the orchard from bins after farm-picked, and (c) upon arrival at the packhouse, presenting Two-way ANOVA on 10 orchards, and Group A and Group B orchards

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(a) After box-pick	(d) From pack-line			(a) After box-pick	(d) From pack-line
Group A	1. PF 1 2019	32.5a	30.0a	1. PF 1 2019	31.3	47.2	68.2
	2. PI M3 2021	34.5a	39.5b	2. PI M3 2021	37.0		
	3. PI S1B 2020	40.0b	47.5cd	3. PI S1B 2020	43.8		
	4. PI S1B 2021	46.7c	62.0g	4. PI S1B 2021	54.4		
	5. PH 2 2019	47.5cd	67.5h	5. PH 2 2019	57.5		
	6. PI S3A 2021	47.5cd	67.9h	6. PI S3A 2021	57.7		
	7. PI M5 2021	52.0de	75.0i	7. PI M5 2021	63.5		
Group B	8. PI S3A 2020	57.5fg	92.5j	8. PI S3A 2020	75.0		
	9. PI S1B 2021	53.8ef	100.0k	9. PI S1B 2021	76.9		
	10. PH 2 2019	60.0g	100.0k	10. PH 2 2019	80.0		
	P<0.0000			P<0.0000		P<0.0000	

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(a) After farm-pick	(c) Upon arrival at pack-house			(b) After farm-pick	(c) Upon arrival at pack-house
Group A	1. PF 1 2019	30.0a	32.5a	1. PF 1 2019	31.3	54.446	63.29
	2. PI M3 2021	34.5ab	38.4b	2. PI M3 2021	36.4		
	3. PI S1B 2020	40.0bc	45.0cd	3. PI S1B 2020	42.5		
	4. PI S1B 2021	50.0de	58.0f	4. PI S1B 2021	54.0		
	5. PH 2 2019	51.3e	65.0hi	5. PH 2 2019	58.1		
	6. PI S3A 2021	52.2e	65.0hi	6. PI S3A 2021	58.6		
	7. PI M5 2021	58.8fg	70.0i	7. PI M5 2021	64.4		
Group B	8. PI S3A 2020	63.8gh	85.0kl	8. PI S3A 2020	74.4		
	9. PI S1B 2021	79.0j	84.0jk	9. PI S1B 2021	81.5		
	10. PH 2 2019	85.0kl	90.0	10. PH 2 2019	87.5		
	P<0.0001			P<0.0000		P<0.0000	

* Letters that are dissimilar are significantly different based on the Fisher LSD (α = 0.05)

- The findings implicated:
  - That exposing avocados to accumulative handling practices from picking by the farm labour force, travel to the packhouse and placing the fruit on the pack-line resulted in higher lenticel damage than avocados subjected to only handling from picking and packing by farm labour.
  - Handling seemed to be the dominant factor influencing the level of lenticel damage and not leaf nutrition (N, Ca, Mg and B levels) or the irrigation regime, since increased lenticel damage occurred in fruit sampled from most orchards (all except 2 orchards: No. 1, PF1 2019; No. 2, PI M3 2021, optimum N, Mg and Ca nutrition and irrigation by sprinklers and acceptable period of drying prior to harvest).

- Sampling point b vs. c (Table 5)
  - Fruit sampled after being picked by the farm harvesting team and placed in lug boxes or bins (farm-picked = b), exhibited significantly lower lenticel damage compared to fruit picked on the farm and sampled upon arrival at the packhouse, including transport to the packhouse (packhouse arrival = c), for 8 (= 80%) of the 10 orchards / producers (No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI S1B; No. 10, PH2).
  - The findings implicated:
    - That exposing avocados to accumulative handling practices from picking by the farm labour force, including travel to the packhouse, resulted in higher lenticel damage than avocados subjected to only handling from picking and packing by farm labour.
    - Handling seemed to be the dominant factor influencing the level of lenticel damage and not nutrition (leaf N, Ca, Mg and B levels) or the irrigation regime, since increased lenticel damage occurred in fruit sampled from most orchards (all except 2 orchards).

- Sampling point c vs. d (Table 6)
  - Fruit picked on the farm and sampled upon arrival at the packhouse (packhouse arrival = c), exhibited significantly lower lenticel damage compared to fruit picked on the farm and packed after being placed on the pack-line (packed on pack-line = d), for 3 (= 30%) of the 10 orchards / producers (No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2 2019).
    - In contrast to other comparisons, handling seemed not to be the dominant factor influencing the level of lenticel damage, but rather nutrition and non-compliance to the soil moisture protocol, since these three orchards did not adhere to the soil moisture protocol (No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2 2019). Two of these orchards had high leaf N and optimum soil N and Mg, but low B and Ca.

Analyses of data after the primary analyses

To emphasise differences in lenticel damage more clearly between picking and handling practices on a producer level, orchards were sorted according to the average level of lenticel damage (from low to high) obtained by the first two-way ANOVA assessment, with pre-harvest and at harvest practices listed as possible reasons for differences in lenticel damage. Consequently it was evident that lenticel damage was associated with specific orchards and practices followed and could be divided into two main groups:

- Group A: picking according to the criteria of "dry soil moisture conditions",
- Group B: picking according to "wet soil moisture conditions or other factors influencing superficial damage to the fruit skin" (Table 3).

After the first analyses, data were subjected to the following analyses:

(i) Two-way ANOVA of 9 orchards, for comparison between the sampling points "a = box-picked" and "b = farm-picked" (Table 4)
(ii) Two-way ANOVA of 9 orchards, for comparison between the sampling points "a = box-picked" and "c = packed upon arrival at packhouse" (Table 4)
(iii) Two-way ANOVA of 9 orchards, for comparison between the sampling points "a = box-picked" and "d = packed on the pack-line" (Table 5)
(iv) Two-way ANOVA of 9 orchards, for comparison between the sampling points "b = farm-picked" and "c = packed upon arrival at packhouse" (Table 5)
(v) Two-way ANOVA of 9 orchards, for comparison between the sampling points "b = farm-picked" and "d = packed on the pack-line" (Table 6)
(vi) Two-way ANOVA of 9 orchards, for comparison between the sampling points "c = packed upon arrival at the packhouse" and "d = packed on the pack-line" (Table 6).

DISCUSSION

Two-way ANOVA for the 9 orchards indicated a significant interaction for each of the six comparisons between different sampling points (two-at-a-time, as shown in the layout for statistical analyses above).

- "a = box-picked" vs. "b = farm-picked" (Table 4)
- "a = box-picked" vs. "c = farm-picked and travel to the packhouse" (Table 4)
- "a = box-picked" vs. "d = farm-picked, travel to the packhouse and subjected to the pack-line" (Table 5)
- "b = box-picked" vs. "c = farm-picked and travel to the packhouse" (Table 5)
- "b = box-picked" vs. "d = farm-picked, travel to the packhouse and subjected to the pack-line" (Table 6)
- "c = farm-picked and travel to the packhouse" vs. "d = farm-picked, travel to the packhouse and subjected to the pack-line" (Table 6).

A common result occurred across the 10 orchards for comparing handling practices to another (6 comparisons)

- Higher lenticel damage occurred on avocados with the addition of handling practices to the previous (i.e., lenticel damage on farm-picked fruit > lenticel damage on box-picked fruit; lenticel damage on farm-picked fruit transported to the packhouse > lenticel damage compared to farm-picked fruit packed directly into boxes; farm-picked fruit transported to the packhouse and placed on the pack-line > lenticel damage on farm-picked fruit transported to the packhouse.
- The occurrence of higher lenticel damage levels was most prominent for comparing packed avocados with more handling to those with less or minimal handling. Farm-picked fruit transported to the packhouse and placed on the pack-line (sample point d) exhibited higher lenticel damage than fruit subjected to minimal handling (a = box-picked) for 9 (= 90%) of the 10 orchards (Table 5). If practice c = farm-picked and transported to the packhouse is compared to practice a (c comprising one less step than d), then higher lenticel damage occurred for 8 (= 80%) of the 10 orchards (Table 4), while if practice b = farm-picked is compared to practice a (b comprising two less handling steps than d, or one step more than a), then higher lenticel damage occurred for only 4 (= 40%) of the 10 orchards (Table 4).

The findings implicated:

- The more practices involved in harvesting and packing of avocado (e.g., d vs. a, 4 vs 1 practices respectively), the higher the likelihood for the occurrence of lenticel damage on fruit of a greater number / percentage of orchards, with nutrition not influencing the levels of lenticel damage to a major extent. In contrast, with less differences in the number of practices (e.g., d vs. c and b vs. a, 2x vs. 1x practice for both comparisons), the lower the likelihood that the occurrence of lenticel damage on fruit is related to a high number of orchards, with

Table 6: Incidence of lenticel damage on fruits of 10 'Hass' orchards, sampled at 2 points; (b) in the orchard from bins after farm-picked, and (d) from the pack-line, as well as c) upon arrival at the packhouse, and (d) from the pack-line, presenting Two-way ANOVA results

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(a) After farm-pick	(d) From pack-line			(a) After farm-pick	(b) From pack-line
Group A	1. PF 1 2019	30.0a	30.0a	1. PF 1 2019	30.0	54.5	68.2
	2. PI M3 2021	34.5ab	39.5bc	2. PI M3 2021	37.0		
	3. PI S1B 2020	40.0c	47.5d	3. PI S1B 2020	43.8		
	4. PI S1B 2021	50.0d	62.0e	4. PI S1B 2021	56.0		
	5. PH 2 2019	51.3d	67.5f	5. PH 2 2019	59.4		
	6. PI S3A 2021	52.2d	67.9f	6. PI S3A 2021	60.1		
	7. PI M5 2021	58.8e	75.0g	7. PI M5 2021	66.9		
Group B	8. PI S3A 2020	63.8ef	92.5i	8. PI S3A 2020	78.1		
	9. PI S1B 2021	79.0g	100.0j	9. PI S1B 2021	89.5		
	10. PH 2 2019	85.0h	100.0j	10. PH 2 2019	92.5		
	P<0.0000			P<0.0000		P<0.0000	

QUALITY PARAMETER – LENTICEL DAMAGE							
	Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Group	Orchard	(c) Upon arrival at packhouse	(d) From pack-line			(c) Upon arrival at packhouse	(d) From pack-line
Group A	1. PF 1 2019	32.5a	30.0a	1. PF 1 2019	31.3	63.3	68.2
	2. PI M3 2021	38.4b	39.5b	2. PI M3 2021	39.0		
	3. PI S1B 2020	45.0c	47.5c	3. PI S1B 2020	46.3		
	4. PI S1B 2021	58.0d	62.0de	4. PI S1B 2021	60.0		
	5. PH 2 2019	65.0ef	67.5f	5. PH 2 2019	66.3		
	6. PI S3A 2021	65.0ef	67.9f	6. PI S3A 2021	66.5		
	7. PI M5 2021	70.0fg	75.0g	7. PI M5 2021	72.5		
Group B	8. PI S3A 2020	85.0hi	92.5j	8. PI S3A 2020	88.8		
	9. PI S1B 2021	84.0h	100.0k	9. PI S1B 2021	92.0		
	10. PH 2 2019	90.0ij	100.0k	10. PH 2 2019	95.0		
	P<0.0001			P<0.0000		P<0.0000	

* Letters that are dissimilar are significantly different based on the Fisher LSD (α = 0.05)

AIM TO PREVENT DAMAGE WITH RUNNER® 240 SC

PRESIDENTIAL GREEN CHEMISTRY CHALLENGE

- Target-specific control with unique insect growth regulating mode of action
- Acts effectively against eggs and larvae with its ovicidal and larvacidal action
- Larvae stop feeding within 4-8 hours after ingestion
- Not photo sensitive; does not degrade under direct sunlight
- Recommended rates will provide long lasting residual control
- Low risk to beneficial insects, mites, bees and brood
- Suitable for use in IPM systems

Runner® 240 SC

INSECTICIDE

AVOCADOS | Control of false codling moth
(Thaumatotibia leucotreta)

Presidential Green Chemistry Challenge Award
EPA classification as a "Reduced Risk Pesticide" in U.S.A

CortevaZA on Facebook
CortevaAME on Twitter
@Corteva on Instagram

FOR MORE INFORMATION CONTACT THE REGISTRATION HOLDER: Dow AgroSciences Southern Africa (Pty) Ltd Reg. No. 1967/007147/07 • **Paarl** +27 (0) 21 003 8259 **Centurion** +27 (0) 12 683 5700 • **Local Emergency No** +27 (0) 82 895 0621 (SA only) • **24 Hour Emergency No** +32 3 575 5555 • Maxwell Office Park, Magwa Building, Ground Floor, Magwa Crescent, Waterfall City, Midrand, 1686, South Africa

ALWAYS USE AS PER LABEL RECOMMENDATION • Runner® 240 SC contains methoxyfenozide (Caution) Reg. No. L7779 | Act No. 36 of 1947 • ™ ® Trademarks of Corteva Agriscience and its affiliated companies.

CORTEVA™ agriscience

Visit us at **corteva.co.za**

nutrition more dominant in influencing the level of lenticel damage. This scenario was applicable for only three orchards (No. 7, 1 MP5; No. 8, PI S3A 2020; No. 9, PI SB1 2021) which showed high leaf N levels and low leaf B.
- Handling seemed to be the dominant factor influencing the level of lenticel damage and not nutrition (leaf N, Ca, Mg and B levels) or the irrigation regime, since increased lenticel damage occurred in fruit sampled from most orchards (all except three orchards: No. 1, F 2019 optimum leaf N, Mg, Ca and boron and irrigation by sprinklers and period of drying prior to harvest, and No. 2, IMP3 optimum leaf N, Mg and Ca and irrigation by sprinklers and period of drying prior to harvest, and No. 3, I S1B20 optimum leaf N, Mg, Ca and boron and irrigation by sprinklers and period of drying prior to harvest). Differences between these 3 orchards can be attributed to wind damage, optimum irrigation and fruit skin B nutrition (see Table 7 and relevant discussion).

A common result occurred for comparing each of the 9 orchards for the individual handling practices (a, b, c and d)
- Higher lenticel damage occurred on avocado for each of the four handling practices (a, b, c and d) for four orchards (No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021; No. 10, PH2 2019) compared to lower levels of lenticel damage on the remaining five orchards (No. 2, PI M3 2021; No. 3, PI S1B 2020; No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021).
- Furthermore, lenticel damage was lower on fruits of orchards for three orchards (No. 1, PF1 2019; No. 2, PI M3 2021; No. 3, PI S1B 2020) compared to four others (No. 4, PI S1B 2021; No. 5, PH2 2019; No. 6, PI S3A 2021; No. 7, PI M5 2021) for sampling points / handling practices a, b, c and d.

The findings implicated:
- When comparing individual orchards for a specific handling practice, whether comprising minimal handling (a) or extensive handling (d), the higher the likelihood for the occurrence of lenticel damage on fruits from nutrition sub-optimal orchards. Higher lenticel damage occurred on avocado for each of the four handling practices (a, b, c and d) for three orchards (No. 6, IS 3A 2020; No. 7, PI M5 2021; No. 8, PI S3A) which had high leaf N and low leaf B, compared to lower levels of lenticel damage on the three other orchards (No. 1, F 2019; No. 2, IS1B 2020; No. 5, H2A 2019) which had optimal leaf N, Ca, Mg and B.
- In contrast, the smaller the differences in the number of practices (e.g., d vs. c and b vs. a, 2 vs. 1 practices for both comparisons), the lower the likelihood that lenticel damage on fruit is present in a high number of orchards, as nutrition was more dominant in influencing the level of lenticel damage. This scenario was applicable for four orchards (No. 6, PI S3A 2021; No. 7, PI M5 2021; No. 8, PI S3A 2020; No. 9, PI SB1 2021), all of which had high N levels and low B.
- Exposing avocados to accumulative handling practices, from picking by the farm labour force, transport to the packhouse and placing the fruit on the pack-line, resulted in higher lenticel damage than avocados subjected to only handling from picking and packing by farm labour.
- Handling seemed to be the dominant factor influencing the level of lenticel damage and not nutrition (leaf N, Ca, Mg and B levels), since increased lenticel damage occurred in fruits sampled from most orchards (all except three orchards: No. 1, PF1 2019; No. 2, PM3; No. 3, PI S1B) which had optimum leaf N, Ca, Mg and B and a period of drying prior to harvest, although No. 2, PM3 had optimum leaf N, Ca, Mg but lower B.

Leaf, fruit skin and fruit pulp nutrient content in relation to lenticel damage (Table 7)

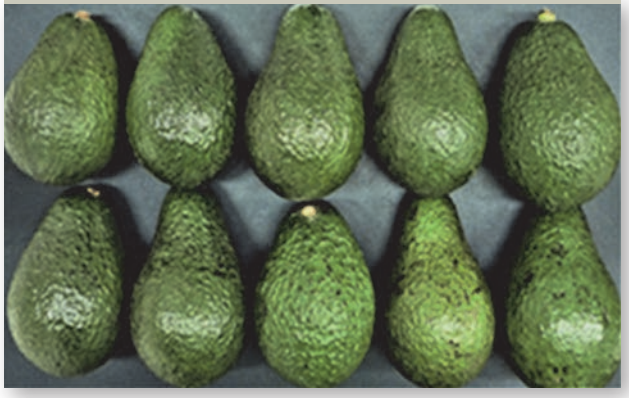
It is known that calcium provides improved cell wall integrity and hence reduces lenticel damage (Polevoiy, 1989). Furthermore chelated calcium, magnesium and boron are needed for cell wall development and fruit set and boron encourages the uptake and movement of cation nutrients such as Mg and Ca within the plant (Plich & Wojcik, 2008). Taking this into consideration, leaf nutrient content (sampled in May each year), as well as fruit pulp and skin samples (taken at harvest from fruit sampled at each orchard for Ca, Mg and B nutrient content), were used as parameters of potential differences in sensitivity to develop lenticel damage. Orchards were identified according to their difference in N content, as the 2019 results indicated that high N orchards were more sensitive than optimum N orchards to developing lenticel damage.

To enable the interpretation of leaf, fruit pulp and fruit skin nutrient results, knowledge of nutrient absorption by the roots and translocation thereof is needed. To increase Ca concentration in fruit by increasing soil applications has often yielded inconsistent results, primarily due to the relatively immobility of Ca in the soil and plant and its dependence on water for distribution into plant tissue with transpiration (Lahav and Whiley, 2002). Transpiration is the main driving force for the xylem stream (White and Broadley, 2003) in which Ca seems to move relatively freely, while this ion is also well-known to be substantially immobile in phloem (Buckowak and Wittwer, 1957). Along with the observation that fruit are largely phloem fed, calcium's well-known xylem mobility and phloem immobility explains in part why fruit are generally low-Ca organs and also why higher fruit transpiration rates are occasionally associated with increased fruit Ca levels (Cline and Hanson, 1992; Montanaro *et al.,* 2006; 2010; Tromp and Van Vuure, 1993). Because Ca moves passively, it tends to concentrate in those tissues that lose more water. Therefore, leaves tend to accumulate more Ca at the expense of developing fruit. The latter author indicated that Ca absorption and regulation in fruit require a holistic approach which should consider

a) Optimum N orchard PF1: Dry soil 2019

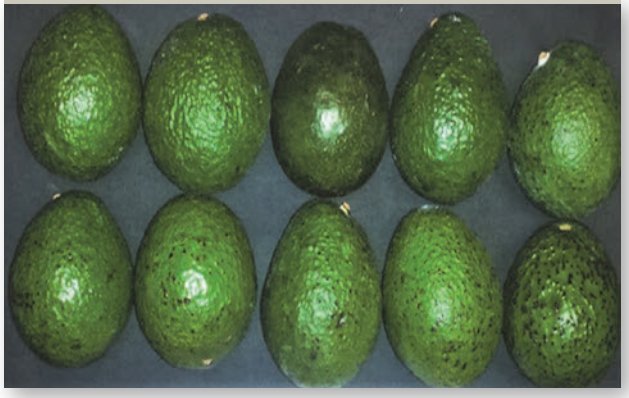
b) Optimum N orchard: Dry soil PI M3 2021

c) Optimum N orchard PI S1B: Dry soil 2020



d) High N orchard PI M5: Dry soil 2021

e) High N orchard PH2: Dry soil 2019



f) High N orchard PI S1B: Wet soil 2021

g) High N orchard PI S3A: Wet soil 2020

Figure 2: Visual appearance class 1 export quality fruits (25 days cold storage) from different producers that were procured from the pack-line.

- Optimum N orchards, dry soil:
  a) PF1 (2019) b) S1B (2020) c) PI M3 (2021)
- High N orchard, dry soil:
  d) PI M5 (2021)
- PH High nitrogen orchard, dry soil:
  e) H2 (2019)
- PI High N orchards, wet soil:
  f) S1B g) S3A

rootstock, soil type, water availability to the roots, and the potential for excess vegetative vigour (which can be promoted by N fertilization) to compete with Ca accumulation in the fruit.

Calcium reached a maximum concentration within fruit 7 weeks after fruit set, declining rapidly until 16 weeks after fruit set, remaining fairly stable until picking (Bower, 1985). Avocado fruit only have stomata during the first 7 weeks of fruit development whereafter these become lenticels, which limits optimum xylem transport of Ca and B because of the reduced transpiration stream. Bower (1985) stated that concentration differences due to irrigation regimes were only evident between 7 and 16 weeks after fruit set. Irrigation at a soil moisture tension of 55 kPa resulted in the highest calcium concentration, while very frequent (replenishment at 35 kPa soil moisture tension) and occasional (replenishment at 80 kPa) irrigation had lower calcium concentrations, particularly the latter which showed the most rapid decline (Bower, 1985). It was indicated that any influence of calcium concentration on fruit quality seems to occur early in fruit development, and it is suggested that optimal irrigation be practiced at this time to ensure maximum Ca absorption into fruit.

Plants take up boron via the roots, predominantly in the form of boric acid. It is a small, soluble, undissociated and uncharged molecule, which easily migrates across the lipid bilayers. Boron is the only element which is not taken up from the soil as an ion. Boron is transported by passive diffusion and without protein catalysis and energy consumption. Because of the cell's high permeability to boron, characteristic patterns of flux along the xylem transpiration stream, and accumulation in the tips of the leaves, passive diffusion was long considered as the only mechanism of transport (Nable, 1988; Raven, 1980). Phloem mobility of B was demonstrated in avocado fruit, proving the translocation from mature leaves into inflorescences, new leaves and developing fruit (Minchin *et al*., 2012), concluding that B is phloem mobile in avocados and that translocation of B will depend upon the amount of Perseitol (a C7 sugar) in the phloem sap.

Discussion

The results of leaf and fruit pulp and N, Ca, Mg and B nutrient content of the current trial indicated several observations that could possibly relate to differences in lenticel damage (Tables 7 and 8):

- Orchard No. 1, PF1 2019, with optimum leaf N (2.3%), optimum Ca (1.2%), optimum Mg (0.5%) and optimum B (50 mg/kg), harvested in adherence with soil moisture protocol, exhibited the lowest lenticel damage (30%).
  - This orchard exhibited the highest fruit skin Ca content (0.18%). The producer irrigated the orchard optimally on a weekly basis, from flowering until 5 weeks prior to harvest. The volume of water was halved, so as not to stress the plants after no irrigation was applied during the following 5 weeks.
  - The lower fruit Ca content values compared to the high leaf Ca content value confirms literature that Ca is only transported to the fruit via xylem with the transpiration stream as the driving force.
  - It is known that calcium provides improved cell wall integrity (Polevoiy, 1989) and protection against lenticel damage.

Table 7: Leaf, fruit pulp and fruit skin nutrient values, including nitrogen (N), calcium (Ca), magnesium (Mg) and boron (B) of 10 orchards

LEAF (May 2021) as well as fruit PULP and fruit SKIN nutrient content at harvest														
			N (%)			Ca (%)			Mg (%)			B (mg/kg)		
	Orchard	% Lenticel damage	Leaf	Pulp	Skin	Leaf	Pulp	Skin	Leaf	Pulp	Skin	Leaf	Pulp	Skin
			(2.2-2.3)			(1-2)			(0.4-0.8)			(50-80)		
Group A: Dry soil moisture	1. PF 1 '19	30	2.3	0.45	0.76	1.2	0.1	0.18	0.5	0.14	0.18	50	82.4	107.6
	2. PI MP3 '21	39.5	2.2	0.56	0.78	1	0.09	0.16	0.6	0.12	0.17	35	65.5	85.0
	3. PI S1B '20	47.5	2.25	0.56	0.7	1.1	0.12	0.17	0.55	0.11	0.13	56	67.0	62.0
	4. PI S1B '21	62	2.85	0.9	1.2	1.1	0.12	0.16	0.57	0.11	0.12	43	53.0	58.0
	5. PH 2 '19	67.5	2.68	0.94	0.95	1.21	0.09	0.16	0.60	0.12	0.16	54	99.0	116.4
	6. PI S3A '21	67.9	2.7	0.9	0.95	1.0	0.12	0.16	0.57	0.14	0.15	38	49.0	40.0
	7. PI MP5 '21	75	2.6	0.7	0.98	0.5	0.09	0.06	0.45	0.9	0.11	20	46.0	42.0
Group B: Wet soil moisture	8. PI S3A '20	92.5	2.55	0.89	1.21	1.0	0.08	0.16	0.55	0.13	0.13	46	60.0	61.0
	9. PI S1B '21	100	2.85	0.9	1.2	1.1	0.12	0.16	0.57	0.11	0.12	43	53.0	58.0
	10. PH 2 '19	100	2.68	0.94	0.95	1.21	0.09	0.16	0.6	0.12	0.16	54	99.0	116.4

DIE ENIGSTE DING WAT ONS BETER AS BOERDERY VERSTAAN IS HOE OM DIT TE VERSEKER.

Boere en produsente lê Santam baie na aan die hart. Dis waarom ons grondige navorsing doen en 'n wetenskaplike benadering volg om al jou bates op en weg van die plaas af te beskerm. Dis net nóg 'n faset van ons **regte, egte versekering.**

Gaan na www.santam.co.za/products/agriculture of bel jou tussenganger vir meer inligting.

Santam landbou

- The fruit pulp and skin B values were much higher (82.4 and 107 mg/kg respectively) compared to the leaf optimum boron value (50 mg/kg). This confirms that B is also translocated via leaves through the phloem to the developing fruit.
- As the skin B content increased to its maximum, compared to the other orchards (114% increase; Table 8), there was clearly no limiting factor that minimised phloem transport of B from the leaves to the fruit. To achieve this, optimum irrigation applied by this producer was in place to make sure photosynthetic output remained optimum throughout the season until 5 weeks before harvest when the availability of water became an issue. Five weeks prior to harvest, optimum cell wall integrity was already achieved.
- This orchard also obtained the highest fruit skin Mg value of 0.18%.
- As Mg, Ca and B are related to cell wall integrity, it can be assumed that high values of these three nutrients in the fruit skins of this orchard contributed towards resistance in developing lenticel damage.
- Furthermore, this orchard was surrounded by rows of big gum trees on 2 sides that provided an effective wind barrier.

- Orchard No. 2, PI M3, had optimum leaf N (2.2%), optimum Ca (1.1%), optimum Mg (0.6%) but low B (35 mg/kg).
  - With a low leaf B value of 35 mg/kg, this orchard surprisingly showed the expected trend of increased B for fruit pulp and skin (65.5 mg/kg and 85 mg/kg), compared to low leaf value. This resulted in a 142.9% increase in skin B content (Table 8).
  - Furthermore, the skin Mg content of 0.17% is very close to the 0.18% of PF1, while the skin Ca content of 0.16% is also close to 0.18 of PF1. Literature also indicates that Mg is translocated via phloem to the fruit and roots.
  - This proves that optimum irrigation enables optimum skin wall integrity and thereby ensures reduced lenticel damage.
  - The overall low leaf B content in 2021 for most avocado orchards was due to heavy rains during the season, resulting in leaching of B. Subsequently, soils needs to be replenished more frequently to ensure optimum absorption of B. However, phloem transport of B to the fruits comes from the tips of older leaves and apparently there was still enough available from older leaves to translocate to the fruit skin. Currently the fifth leaf of new shoot growth during May, just prior to when harvest starts, does not give a true reflection of the nutrient status of older leaves on the tree.
  - Intermediate wind damage was an additional factor that increased lenticel damage of fruit, with a contribution of 39.5%, compared to the significantly lower value of 30% for orchard No. 1, PF1.

- Orchard No. 3, PI S1B 2020, with optimum leaf N (2.25%), optimum Ca (1.1%), optimum Mg (0.55%) and optimum B (56 mg/kg), was similar to orchard No. 1, PF1 2019, however, this orchard exhibited a significantly higher level of lenticel damage (47.5%) compared to orchard No. 1, PF1 2019. Attributing factors that could have increased the sensitivity towards lenticel damage include:
  - An intermediate incidence of wind damage that masked the positive protective effect of high skin Ca and skin B on lenticel damage.
  - In contrast to the nutritionally optimum orchard No. 1, PF1 2019, fruit pulp and skin B values (67 and 62 mg/kg respectively) did not increase to the same extent compared to the optimum leaf B value (56 mg/kg). In this orchard, the skin B value increased by only 10.7%, compared to the ± 114% increase of orchard No. 1, PF1 2019 (Table 8).
  - This indicates that B was not effectively translocated via leaves through the phloem to the developing fruit, and a stress factor resulted in reduced photosynthetic output, which limited the amount of Perseitol 9 (a C7 sugar) required for phloem translocation of B from the leaves to the fruit.
  - Phloem translocation was not as effective as for orchard No. 1, PF1 2019, which possibly resulted in reduced cell wall integrity, possibly contributing as an additional factor in explaining the occurrence of higher lenticel damage. Although the reason is unknown, the amount of Perseitol that carries B was less in this orchard.
  - This orchard had high fruit skin Ca content (0,17%) that was comparable to orchard PF1 2019. This indicates that the transpiration stream was sustained with optimum irrigation during the first 6-7 weeks of fruit development.
- In a high nitrogen orchard, No. 5, PH2 2019, with optimum leaf Ca and B content (1.2% and 54 mg/kg respectively) similar to the optimum N orchard No. 1, PF1 2019, the fruit pulp and skin B (99 and 116.4 mg/kg respectively) were equivalent to a 115.6% increase (Table 8), which is very similar to the optimum nitrogen orchard No. 1, PF1 2019.
  - It is known that high nitrogen inhibits the absorption of Ca and B in soils, therefore higher dosages or more soil applications of B and Ca that needed to be applied were done in this orchard.
  - However, high N orchards need increased Ca content to keep the N : Ca ratio comparable, as high nitrogen orchards are more sensitive towards lenticel damage. High nitrogen is related to increased cell division and growth. Fruits of high N orchards usually have bigger cells with thinner cell walls, therefore hypothetically more skin Ca is needed to ensure maximum cell wall integrity and reduce sensitivity towards lenticel damage.
  - During the 3 years of the project, only five

orchards showed this trend of increased skin boron compared to the leaf B. The need exists to verify why photosynthetic outputs are inhibited in most orchards.

- Optimum irrigation was applied by producer H (orchard No. 5, PH2) on a weekly basis throughout the season. Two groups of 'Hass' are irrigated either on Thursdays or Fridays. Water stress was never a factor. During water stress, the soil moisture is dried out further than the +5 mm when the producer usually irrigates. Stomatal closure when soils are too dry inhibits photosynthetic output in the long run, as optimum gas exchange is needed through open stomata to ensure optimum photosynthetic output. Furthermore, the stress conditions exposed to on regular basis divert Perseitol (needed as a B carrier through phloem transport) towards other photosynthetic outputs to handle the stress.
- When the same orchard was picked at a soil moisture of -5 mm, lenticel damage increased by 100%, indicating that wet soil moisture masks the positive effect of higher fruit skin Ca, B and Mg, that ensure high skin wall integrity. This shows the utmost importance to adherence to the soil moisture protocol to minimise lenticel damage.
- Potentially this orchard could have obtained less lenticel damage than orchard No. 4, PI S1B 2021, that only showed a skin boron increase of 34.9%. However, fruit from orchard No. 5, PH2 2019 also had to contend with more transport vibrations, resulting in increased lenticel damage as the distance to the packhouse is 80 km compared to the 7 km of orchard No. 4, PI S1B.

- In a high nitrogen orchard, No. 7, PI M5 that was chosen for optimum irrigation applied, significantly higher lenticel damage was obtained at sampling point d when compared to the other high nitrogen orchard that also adhered to the soil moisture protocol.
  - This orchard showed a 110% increase in skin B content compared to the leaf B content (values of 42 mg/kg and 20 mg/kg respectively). Although photosynthetic output was optimum as a result of optimum irrigation applied, a deficiency of B was present and there was not enough B available to translocate with Perseitol as a carrier from older leaves to the fruit skin.
  - Furthermore there was a deficiency of Ca present with a leaf B content value of 0.5%, showing the

Table 8: All the factors that either reduced or increased lenticel damage that could be derived from leaf, skin and pulp nutrient values, factors of pre-harvest practices followed prior to, during and at picking, relating to the level of lenticel damage recorded after storage of pack-line fruit are included

FACTORS THAT REDUCED OR INCREASED LENTICEL DAMAGE : From orchards from 2019 - 2021										
	GROUP A: DRY SOIL MOISTURE							GROUP B: WET SOIL MOISTURE		
	Optimum Leaf Nitrogen			High Leaf Nitrogen						
Producers	1. PF 1 '19	2. PI M3 '21	3. PI S1B '20	4. PI S1B '21	5. PH 2 '19	6. PI S3A '21	7. PI M5 '21	8. PI S3A '20	9. PI S1B '21	10. PH 2 '19
% Lenticel damage	30	39.5	47.5	62	67.5	67.5	75	92	100	100
% Increase	0.0	31.7	58.3	106.7	125.0	125.0	150.0	206.7	233.3	233.3
Optimum irrigation	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes
Leaf N (%)	2.3	2.2	2.25	2.9	2.7	2.7	2.7	2.7	2.9	2.7
Leaf B (mg/kg)	50	35	56	43	54	38	20	46	43	54
Skin B (mg/kg)	107.5	85	62	58	116.4	40	42	60	58	116.4
Skin B: % increase	114	142.9	10.7	38.1	115.6	5.2	110	30.4	38.1	115.6
Leaf Ca (%)	1.2	1	1.1	1.1	1.21	1	0.5	1	1.1	1.21
Fruit skin Ca (%)	0.18	0.16	0.17	0.16	0.16	0.16	0.06	0.16	0.16	0.16
Leaf Mg (mg/kg)	0.5	0.6	0.55	0.57	0.6	0.57	0.45	0.55	0.57	0.6
Fruit skin Mg (mg/kg)	0.18	0.17	0.13	0.12	0.16	0.13	0.11	0.13	0.12	0.16
Km from packhouse	30	5	6	6	80	6	5	6	6	80
Wind damage	none	low	med/high	med	none	med	high	high	med/high	none

importance of optimum fruit skin Ca, B and Mg in ensuring maximum skin cell wall integrity. A deficiency in two of these nutrients (Ca and B) resulted in poor cell wall integrity that could not protect the fruit against lenticel damage.

Incidence of lenticel damage in relation to anthracnose decay (Table 9)

No interaction occurred between Factor A (orchard) and Factor B (handling stage) for anthracnose development. Significant differences were indicated between orchards.

- The sampling point of fruit related to additional handling when sourcing from the pack-line, compared to minimal handling when sourcing in the orchard, did not influence anthracnose.
- The incidence of anthracnose is highly dependent on the inherent inoculum load in the orchard and the application of timeous fungicide sprays, as indicated by significant differences between orchards.

Incidence of lenticel damage in relation to stem-end rot (Table 9)

- No interaction occurred between Factor A (orchard) and Factor B (handling stage) for stem-end rot development. Significant differences were indicated between orchards.
- Sampling point of fruits, related to additional handling when sourced from the pack-line, compared to minimal handling when sourced in the orchard, did not influence stem-end rot.

Incidence of bruising (Table 10)

- A significant interaction occurred between Factor A (orchard) and Factor B (handling stage) for bruising. As expected, there was no bruising present in box-picked fruit.
- Generally, bruising is a function of how careful picking is done.
- Sampling point of fruits, related to additional handling when sourced from the pack-line, compared to minimal handling when sourced in the orchard, was generally comparable with no major increase in bruising levels, indicating that most pickers picked in a careful manner.
- Bruising differed between orchards for fruit sampled from the pack-line.
  - The incidence of bruising was significantly higher for fruit from three orchards (No. 5, PH2 2019; No. 7, PI M5; No. 10, PH2 2019) compared to

Table 9: Incidence of anthracnose and stem-end rot of 'Hass' avocado fruits of 10 orchards for the difference between box-picked at harvest and fruit sampled from the pack-line in 2019, 2020 and 2021

QUALITY PARAMETER – ANTHRACNOSE						
Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Handling)	
Orchard	Box-picked	Pack-line			Box-picked	Pack-line
1. PF 1 2019	5	5.0	1. PF 1 2019	5bc	3.3	4.3
2. PI M3 2021	3.8	3.8	2. PI M3 2021	3.8ab		
3. PI S1B 2020	1.3	1.3	3. PI S1B 2020	1.3a		
4. PI S1B 2021	1.3	1.3	4. PI S1B 2021	1.3a		
5. PH 2 2019	5.0	3.8	5. PH 2 2019	4.4b		
6. PI S3A 2021	1.3	1.3	6. PI S3A 2021	1.3a		
7. PI M5 2021	5	10	7. PI M5 2021	7.5c		
8. PI S3A 2020	1.3	1.3	8. PI S3A 2020	1.3a		
9. PI S1B 2021	3.8	5.0	9. PI S1B 2021	4.4b		
10. PH 2 2019	5	10.0	10. PH 2 2019	7.5c		
P<0.3765			**P<0.0000**		P<0.1345	
QUALITY PARAMETER – STEM-END ROT						
Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Sampling points)	
Orchard	Box-picked	Pack-line			Box-picked	Pack-line
1. PF 1 2019	0.0	5.0	1. PF 1 2019	2.5abc	2.6	3.2
2. PI M3 2021	0.0	0.0	2. PI M3 2021	0.0a		
3. PI S1B 2020	0.0	0.0	3. PI S1B 2020	0.0a		
4. PI S1B 2021	0.0	6.3	4. PI S1B 2021	3.1bc		
5. PH 2 2019	3.8	5.0	5. PH 2 2019	4.4bcd		
6. PI S3A 2021	3.8	0.0	6. PI S3A 2021	1.9ab		
7. PI M5 2021	6.3	6.3	7. PI M5 2021	6.3d		
8. PI S3A 2020	0.0	0.0	8. PI S3A 2020	0.0a		
9. PI S1B 2021	5.0	5.0	9. PI S1B 2021	5a		
10. PH 2 2019	6.3	6.3	10. PH 2 2019	6.3d		
P<0.1304			**P<0.0000**		P<0.3154	

* Letters that are similar do not differ significantly, according to Fisher LSD (α = 0)

Knowledge grows

YaraLiva™ NITRABOR™

improving shelf life

With high Ammonium-N products

With YaraLiva™ Nitrabor solution

+27 (0)21 877 5300 infosa@yara.com www.yara.co.za

most other orchards. This indicates that there is room for improvement with these picking teams, as rough handling that leads to bruising of the fruit pulp will definitively also contribute to lenticel damage.

Number of days for fruit to ripen (Table 10)

- No interaction occurred between Factor A (orchard) and Factor B (handling stage) for days for fruit to ripen. Significant differences were indicated between orchards.
- Fruit from four optimum N orchards (No. 5, PH2 2019; No. 8, PI S3A; No. 7, PI M5; No. 10, PH2) ripened significantly faster compared to the other orchards, which can be related to fruit maturity (late season fruit that usually ripens faster).
- Fruit which had more lenticel damage seemed to change colour faster during ripening, but there was no correlation with number of days to ripen.

Incidence of grey pulp (Table 11)

- No grey pulp was recorded on avocados from any orchard.

Incidence of vascular browning (Table 11)

- A significant interaction occurred between Factor A (orchard) and Factor B (handling stage) for vascular browning.
- Vascular browning was significantly higher for fruit of two orchards (No. 6, PI S3A 2021; No. 7, PI M5 2021) box-picked and pack-line handled, compared to most other orchards.

TRIAL 2: Ca, B and Si foliar sprays (Table 12)

Lenticel damage: Two-way ANOVA of foliar application and jostling

Two-way analyses of variance (ANOVA) was applied by analysing the data in Statistica (statistical software) using the LSD test (α = 0.05) to compare treatment means, for Factor A (jostling) and Factor B (foliar application). A significant interaction occurred between Factor A (jostling of fruit) and Factor B (foliar application).

- Jostling of avocados resulted in significantly higher levels of lenticel damage for the UTC [T1] and foliar applications of Ca + B followed by Si applications a day before and after, with the addition of PANAF 5 [T4] in both the AECI and Levity Crop Science product combinations.
- The non-jostled treatments exhibited a similar result for the AECI product, with significantly lower lenticel damage for the PANAF 5 adjuvant [T4]

Table 10: Incidence of bruising and number of days for fruit to ripen (DTR) of 'Hass' avocado fruits of 9 orchards for the difference between box-picked at harvest and fruit sampled from the pack-line in 2019, 2020 and 2021

QUALITY PARAMETER – BRUISING						
Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Handling)	
Orchard	Box-picked	Pack-line			Box-picked	Pack-line
1. PF 1 2019	0.0a	0.0a	1. PF 1 2019	0.0	0.0	1.5
2. PI M3 2021	0.0a	0.0a	2. PI M3 2021	0.0		
3. PI S1B 2020	0.0a	0.0a	3. PI S1B 2020	0.0		
4. PI S1B 2021	0.0a	0.0	4. PI S1B 2021	0.0		
5. PH 2 2019	0.0a	5.0b	5. PH 2 2019	2.5		
6. PI S3A 2021	0.0a	0.0a	6. PI S3A 2021	0.0		
7. PI M5 2021	0.0a	3.8b	7. PI M5 2021	1.9		
8. PI S3A 2020	0.0a	0.0a	8. PI S3A 2020	0.0		
9. PI S1B 2021	0.0a	0.0	9. PI S1B 2021	0.0		
10. PH 2 2019	0.0a	6.3b	10. PH 2 2019	3.1		
P<0.0003			**P<0.0003**		**P<0.0003**	
QUALITY PARAMETER – No OF DAYS TO RIPEN (DTR)						
Factor A (Orchard) x Factor B (Handling)			Factor A (Orchard)		Factor B (Handling)	
Orchard	Box-picked	Pack-line			Box-picked	Packhouse
1. PF 1 2019	5.4	5.3	1. PF 1 2019	5.3c	5.3	5.4
2. PI M3 2021	5.3	5.4	2. PI M3 2021	5.4c		
3. PI S1B 2020	6.1	6.1	3. PI S1B 2020	6.1e		
4. PI S1B 2021	6.1	6.1	4. PI S1B 2021	6.1e		
5. PH 2 2019	4.3	4.6	5. PH 2 2019	4.5a		
6. PI S3A 2021	5.9	5.8	6. PI S3A 2021	5.8d		
7. PI M5 2021	5.0	5.0	7. PI M5 2021	5.0b		
8. PI S3A 2020	5.0	4.9	8. PI S3A 2020	4.9b		
9. PI S1B 2021	5.9	5.8	9. PI S1B 2021	5.8d		
10. PH 2 2019	4.6	4.7	10. PH 2 2019	4.6a		
P<0.8708			**P<0.0000**		P<0.8512	

* Letters that are similar do not differ significantly, according to Fisher LSD (α = 0.05)

than the UTC [T1], however no differences occurred for the Levity Crop Science product.
- In the 2020 trial, the application of Ca + B + Si nutrient combination foliar spray treatment applied 2.5 months prior to sampling, resulted in ± 10% reduction in the total incidence of lenticel damage compared to the untreated control (62.7% and 72% respectively). It can be noted that the 2021 orchard had a very low fruit skin Ca value of 0.06% (UTC), although the leaf Ca content was 1.1%, and the 2020 orchard had a skin Ca value of 0.1% (leaf Ca content of 1%).

Incidence of lenticel damage in relation to anthracnose decay (Table 12)

No interaction occurred between Factor A (orchard) and Factor B (handling stage) for the incidence of anthracnose. Significant differences were indicated between orchards.

- Jostling of avocados resulted in significantly higher levels of anthracnose decay for both products.
  - In the case of AEC1, the values of the jostled fruit were 9.2% compared to the non-jostled fruit of 4.2%, while jostled fruit treated with Levity Crop Science exhibited 8.2%, compared to 3.9% anthracnose in non-jostled fruit.
  - Lenticel damage can lead to anthracnose which is dependent on the spore load present on the fruit surface. The spores can more readily enter fruits if damaged lenticels are present.

Fruit skin and pulp nutrient analysis (Table 13)

AECI Plant Health products:

- The 3 combination sprays of Ca + B and Si a day before and thereafter the three Ca + B combination sprays, exhibited higher SI content with the three different adjuvants in the pulp [T2A], [T3A] and [T4A] (2 426 mg/kg, 2 436 mg/kg, 2 507 mg/kg) and in the fruit skin (3 290 mg/kg, 3 391 mg/kg, 3 458 mg/kg) compared to 2 301 mg/kg and 3 201 mg/kg for the UTC [T1A] in pulp and skin, respectively.
  - Both WetCit and PANAF 5 expressed higher absorption of Si into the skin (6% and 8% respectively) compared to 3% increase for Biodew in relation to the UTC.
  - Similar increases were expressed for Si in the fruit skin for the different adjuvants compared to the UTC.
- The three combination sprays of Ca + B and Si a day before and thereafter exhibited higher B content with the three different adjuvants in the pulp

Table 11: Incidence of grey pulp and vascular browning of 'Hass' avocado fruits of 9 orchards for the difference between box-picked at harvest and fruit sampled from the pack-line

QUALITY PARAMETER – GREY PULP						
Factor A (Orchard) x Factor B (Sampling points)			Factor A (Orchard)		Factor B (Handling)	
Orchard	Box-picked	Pack-line			Box-picked	Pack-line
1. PF 1 2019	0.0	0.0	1. PF 1 2019	0.0	0.0	0.0
2. PI M3 2021	0.0	0.0	2. PI M3 2021	0.0		
3. PI S1B 2020	0.0	0.0	3. PI S1B 2020	0.0		
4. PI S1B 2021	0.0	0.0	4. PI S1B 2021	0.0		
5. PH 2 2019	0.0	0.0	5. PH 2 2019	0.0		
6. PI S3A 2021	0.0	0.0	6. PI S3A 2021	0.0		
7. PI M5 2021	0.0	0.0	7. PI M5 2021	0.0		
8. PI S3A 2020	0.0	0.0	8. PI S3A 2020	0.0		
9. PI S1B 2021	0.0	0.0	9. PI S1B 2021	0.0		
10. PH 2 2019	0.0	0.0	10. PH 2 2019	0.0		
-			-		-	
QUALITY PARAMETER – VASCULAR BROWNING						
Factor A (Orchard) x Factor B (Handling)			Factor A (Orchard)		Factor B (Handling)	
Orchard	Box-picked	Pack-line			Box-picked	Packhouse
1. PF 1 2019	0.0a	5.0c	1. PF 1 2019	2.5	0.5	0.9
2. PI M3 2021	0.0a	1.3ba	2. PI M3 2021	0.7		
3. PI S1B 2020	0.0a	0.0a	3. PI S1B 2020	0.0		
4. PI S1B 2021	0.0a	0.0a	4. PI S1B 2021	0.0		
5. PH 2 2019	1.3b	3.8bc	5. PH 2 2019	0.7		
6. PI S3A 2021	0.0a	0.0a	6. PI S3A 2021	0.0		
7. PI M5 2021	5.0c	6.40c	7. PI M5 2021	5.7		
8. PI S3A 2020	0.0a	0.0a	8. PI S3A 2020	0.0		
9. PI S1B 2021	0.0a	0.0a	9. PI S1B 2021	0.0		
10. PH 2 2019	0.0	0.0a	10. PH 2 2019	0.0		
P<0.0010			**P<0.0000**		P<0.196	

* Letters that are similar do not differ significantly, according to Fisher LSD (α = 0.05)

[T2A], [T3A] and [T4A] (48 mg/kg, 55 mg/kg, 56 mg/kg) and in fruit skin (67 mg/kg, 72 mg/kg, 73 mg/kg) compared to 40 mg/kg and 53 mg/kg for the UTC [T1A] in pulp and skin respectively.
  - Both WetCit and PANAF 5 expressed higher absorption of B into the skin (39% and 41% respectively) compared with a 22% increase for Biodew, in relation to the UTC.
  - Similar increases were expressed for B in the fruit skin for the different adjuvants compared to the UTC.
- However, the three combination sprays of Ca + B and Si a day before and thereafter, by using the three adjuvants, could not increase the fruit skin and pulp Ca content in relation to the UTC.

Levity Crop Science products:
- The three combination sprays of Ca + B and Si a day before and thereafter the three Ca + B combination sprays, exhibited higher SI content with the three different adjuvants in the pulp [T2B], [T3B] and [T4B] (2 493 mg/kg, 2 492 mg/kg, 2 546 mg/kg) and in fruit skin (3 379 mg/kg, 3 423 mg/kg, 3 569 mg/kg), compared to 2 436 mg/kg and 3 269 mg/kg for the UTC [T1B] in pulp and skin respectively.
  - Both WetCit and PANAF 5 expressed higher absorption of Si into the skin (5% and 9% respectively) compared to 3% increase for Biodew, in relation to the UTC.
  - Similar increases were expressed for Si in the fruit skin for the different adjuvants compared to the UTC.
- The three combination sprays of Ca + B and Si a day before and thereafter exhibited higher B content with the three different adjuvants in the fruit skin [T2B], [T3B] and [T4B] (53 mg/kg, 63 mg/kg, 77 mg/kg) compared to 47 mg/kg for the UTC [T1B].

Table 12: Fruit quality for samples procured from a high nitrogen orchard where Ca, B and Si sprays (T1-T4) of AECI Plant Health and Levity Crop Science products were applied and subsequently at harvest the fruit were either subjected to a treatment of "jostling" to induce lenticel damage or left intact prior to packing. The intensity of the disorder was quantified using PPECB's grading system (Grade 0 = sound, Grade 1, Grade 2 and Grade 3)

QUALITY PARAMETER – LENTICEL DAMAGE : AECI PRODUCTS										
Factor A (Jostle) x Factor B (Ca - B - Si foliar sprays)					**Factor A (Jostle)**		**Factor B (Ca - B - Si foliar sprays)**			
	T1 UTC	**T2 (Ca + B) + Si Biodew**	**T3 (Ca + B) + Si WetCit**	**T4 (Ca + B) + Si PANAF 5**			**T1 UTC**	**T2 (Ca + B) + Si No adjv.**	**T3 (Ca + B) +Si WetCit**	**T4 (Ca + B) + Si PANAF 5**
1. Not jostled	52.3b	52ab	51.5ab	50.5a	1. Not jostled	51.6	65.1	65.8	64.1	61.6
2. Jostled	78.0de	79.0e	77.0d	72.8c	2. Jostled	76.8				
	P<0.0016				**P<0.000**		**P<0.000**			
QUALITY PARAMETER – LENTICEL DAMAGE : LEVITY CROP SCIENCE PRODUCTS										
Factor A (Jostle) x Factor B (Ca - B - Si foliar sprays)					**Factor A (Jostle)**		**Factor B (Ca - B - Si foliar sprays)**			
	T1 UTC	**T2 (Ca + B) + Si No wetter**	**T3 (Ca + B) + Si WetCit**	**T4 (Ca + B) + Si PANAF 5**			**T1 UTC**	**T2 (Ca + B) + Si No wetter.**	**T3 (Ca + B) + Si WetCit**	**T4 (Ca + B) + Si PANAF 5**
1. Not jostled	53.0a	52.5a	51.5a	51.5a	1. Not jostled	52.1	65.6	65.9	64.0	62.3
2. Jostled	78.3c	79.3c	78.33c	73.0b	2. Jostled	76.8				
	P<0.0014				**P<0.0000**		P<0.2880			
QUALITY PARAMETER – ANTHRACNOSE : AECI PLANT HEALTH										
1. Not jostled	4.7	4.7	3.4	4.1	1. Not jostled	4.2a	6.7	5.2	6.4	6.2
2. Jostled	8.7	9.5	9.9	8.7	2. Jostled	9.2b				
	P<0.8452				**P<0.0001**		P<0.9034			
QUALITY PARAMETER – ANTHRACNOSE : LEVITY CROP SCIENCE										
1. Not jostled	3.8	4.1	3.8	4.1	1. Not jostled	3.9a	5.5	6.4	6.3	5.9
2. Jostled	7.2	8.7	8.7	7.8	2. Jostled	8.2b				
	P<0.9887				**P<.0.0058**		P<0.9364			

* Letters that are dissimilar are significantly different based on the Fisher LSD (α = 0.05)

KARTONNE VIR DIE LANDBOU

Sedert 1982

HOUERS

Tel: 015 345 8100
1 Valenciastraat,
Letsitele

www.houers.co.za

- Both WetCit and PANAF 5 expressed higher absorption of B into the skin (33% and 61%, respectively) compared to an 11% increase for Biodew, in relation to the UTC.

- However, the three combination sprays of Ca + B and Si a day before and thereafter, by using the three adjuvants, could not increase the fruit skin and pulp Ca content in relation to the UTC.

The findings implicated

PANAF 5 proved to be an excellent adjuvant in most cases and its penetrating capability towards improved absorption and movement of nutrients, including B and Si, into avocado pulp and fruit of both Levity Crop Science and AECI Plant Health products is noteworthy. However neither PANAF 5 nor the other adjuvants could assist in improved absorption of Ca into the fruit skin. Research towards improving the absorption of Ca into avocado leaves and fruit skin is needed. The following other penetrators should be considered for specific mode of action:

- BREAK-THRU® SP 133 (Alchem Group) and Tronic (AECI) with the possible ability to move active ingredients through the wax layer into the plant. These penetrators can dissolve the plant's protective waxy layers, allowing fertilizers and herbicides to move more effectively into the plant cells. This, however, has not been tested on avocado.

CONCLUSIONS

- A drastic increase occurred in lenticel damage when the soil moisture protocol is not adhered to in high nitrogen orchards, as was also noted in the 2019 and 2020 trials. Unfortunately, no optimum nitrogen orchards could be harvested at wet soil moisture to make a full comparison during the three years of research.
- Optimum leaf B, Ca and Mg values of an optimum nitrogen orchard can be indicative of resistance to developing lenticel damage, but the extent to which these nutrients accumulate in the fruit is influenced by different factors:
  - Fruit B and Ca are dependent on an optimum transpiration stream that can only be obtained with optimum irrigation during the first 6 weeks of fruit development. In the case of Ca which is only transported via the transpiration stream, this is very important to ensure optimum cell wall integrity.
  - However, B is also transported through the phloem from older leaves during the whole fruit development period after the initial important 6 weeks, which enables B to accumulate to much

Table 13: Ca, B and Si nutrient content in fruit pulp and fruit pulp and skin 6 weeks after conducting the foliar nutrient sprays with AECI Plant Health and Levity Crop Science products in an orchard of high nitrogen including Biodew, WetCit and PANAF 5 as adjuvants

		Fruit skin and pulp Nutritional composition					
	Treatments	Fruit pulp			Fruit skin		
		Ca	B	Si	Ca	B	Si
		%	mg/kg	mg/kg	%	mg/kg	mg/kg
AECI Plant Health	T1A UTC	0.05	53	2301	0.07	40	3201
	T2A (Ca + B & Si) + Biodew	0.04	67	2426	0.09	48	3290
	T3A (Ca + B & Si) + WetCit	0.04	72	2436	0.06	55	3391
	T4A (Ca + B & Si) + PANAF 5	0.03	73	2507	0.05	56	3458
		% Increase			% Increase		
	T1A UTC	-	-	-	-	-	-
	T2A (Ca + B & Si) + Biodew	-20	25	5	30	22	3
	T3A (Ca + B & Si) + WetCit	-30	35	6	-10	39	6
	T4A (Ca + B & Si) + PANAF 5	-42	37	9	-32	41	8
Levity Crop Science	T1B UTC	0.04	78	2436	0.06	47	3269
	T2B (Ca + B & Si) no wetter	0.03	83	2493	0.06	53	3379
	T3B (Ca + B & Si) + WetCit	0.04	80	2492	0.05	63	3423
	T4A (Ca + B & Si) + PANAF 5	0.03	78	2546	0.05	77	3569
		% Increase			% Increase		
	T1B UTC	-	-	-	-	-	-
	T2B (Ca + B & Si) no wetter	-18	7	2	-13	11	3
	T3B (Ca + B & Si) + WetCit	-2	3	2	-30	33	5
	T4A (Ca + B & Si) + PANAF 5	-14	1	5	-17	61	9

higher values in the fruit skin when compared to Ca.

- Sub-optimal irrigation may limit the root uptake of Ca and B through transpiration, and hence limit the integrity of fruit skin, adding to increased sensitivity to lenticel damage.
  - This emphasises the importance of optimum irrigation during the first 6-7 weeks of fruit development to ensure that Ca and B accumulate optimally in the fruit skin, as well as optimum irrigation during the months thereafter to ensure optimum phloem transport to the fruit to reach maximum B content in the fruit skin.
  - To ensure that orchards are not subjected to water stress during the season, the goal of obtaining maximum B in the fruit skin leading to optimum cell wall strength and integrity will minimise lenticel damage.
- In this regard, an orchard (PF1 2019) with optimum leaf N, Ca, Mg and B, accumulated B in the fruit skin to a value of 114% higher than in the leaf, resulting in the least lenticel damage of 30%.
  - This partly explains this orchard's remarkable resistance to developing lenticel damage. The very high skin B content could only have been obtained with optimum photosynthetic output in place, ensuring enough available Perseitol (that acts as carrier of B during phloem transport) and that could only be achieved by optimum irrigation (3 hour weekly sprinkler irrigation).
  - Furthermore, this orchard is surrounded by rows of big gum trees that acted as an effective wind barrier, hence no wind damage occurred that could affect lenticel damage data negatively.
- An orchard (PI S1B 2020) with optimum leaf N, Ca, Mg and B very similar to PF1 2019, in contrast could only accumulate B in the fruit to a value of ± 10.7% higher than the leaf B value.
  - This explains the sensitivity of this orchard to developing lenticel damage when compared to orchard No. 1, PF1 2019, as this orchard had sub-optimum irrigation.
  - This implies that photosynthetic output was inhibited during fruit development and led to less Perseitol available. This influenced the effective and optimum phloem transport of B to the fruit skin, possibly leading to reduced fruit skin integrity that explains the higher sensitivity to developing lenticel damage.
- A new 2021 orchard (No. 2, PI M3) with optimum leaf N, Ca, Mg and low leaf B where optimum irrigation was applied, resulted in a 142.9% increase in fruit skin B content although it had a low leaf B value of 35%. This orchard had lenticel damage of 39.5%.
  - This orchard had intermediate wind damage, contributing as an additional factor towards damaging lenticels.
  - This proves the importance of optimum irrigation to maintain optimum phloem transport of B to the fruit skin to ensure optimum fruit skin integrity to effectively manage lenticel damage, but only if other factors can be negated.
  - Optimum irrigation is needed to ensure the elimination of water stress conditions that will have a negative effect on the photosynthetic output as well as maximum phloem transport of B from the leaves to the fruit. This implies that the important 6-7 weeks as well as the weeks thereafter during fruit development, require optimum irrigation to ensure maximum fruit skin B content.
  - The overall low leaf B content in 2021 for most avocado orchards was due to heavy rains during the season, resulting in leaching of B. Subsequently the soil needed to be replenished more frequently to ensure optimum absorption of B. However, phloem transport of B to the fruits comes from the tips of older leaves and apparently there was still enough available from older leaves to translocate to the fruit skin. Currently the fifth leaf of new shoot growth during May, just before harvest starts, does not give a true reflection of the nutrient status of older leaves on the tree.
  - It can be pointed out that there was an additional factor of intermediate wind damage that increased lenticel damage on the pack-line fruit, which contributed to the lenticel damage of 39.5%, compared to the significantly lower value of 30% for orchard No. 1, PF1.
- Results of the Ca, B and Si spray trials indicated that both WetCit and PANAF 5 were able to significantly increase levels of the B and Si in the fruit skin.
- However, the skin Ca content could not be increased by the inclusion of WetCit and PANAF 5.
  - In further research, penetrators like BREAK-THRU® SP 133 (Alchem Group) and Tronic (AECI), with the effective ability to move active ingredients through the wax layer into the plant, need to be tested on avocado. These penetrators are able to dissolve the plant's protective waxy layers, allowing fertilizers and herbicides to move more effectively into the plant cells. In 2019, 2020 and 2021, the spray trials aimed to increase Ca in the fruit skin during the late season were not effective. The need exists for further research that focuses on improved Ca absorption into the fruit skin during the first 6 weeks of fruit development.

AKNOWLEDGEMENTS

- Thank you to SAAGA and PHI for funding the project.
- Thank you to the 9 producers that were visited in 2019 and 2020 and that also provided the fruit for the project.
- Thank you to the Westfalia Packhouse Politsi that provided cold storage space for the 2021 research samples and for their cooperation during sample collection from the pack-line.

REFERENCES

BOWER, J.P. 1985. The Calcium accumulation pattern in avocado fruit as influenced by long term irrigation regime. *SAAGA Yearb.* 8: 97-99.

BUKOVAC, M.J. & WITTWER, S.H. 1957. Absorption and mobility of foliar applied nutrients. *Plant Physiol.* 32: 428-435.

CLINE, J.A. & HANSON, E.J. 1992. Relative humidity around apple fruit influences its accumulation of calcium. *J. Amer. Soc. Hort. Sci.* 117: 542-546.

ISLAM, M.Z., MELE, M.A., CHOI, K-Y. & KANG, H-M. 2018. The effect of silicon and boron foliar application on the quality and shelf life of cherry tomatoes. *Zemdirbyste-Agric.* 105: 159-146.

KHALAJ, K., AHMADI, N. & SOURI, M.K. 2017. Improvement of postharvest quality of Asian pear fruits by foliar application of boron and calcium. *Horticulturae* 3: 1-8.

KIDANE, E.G. 2008. Management of Fusarium wilt disease using no-pathogenic *Fusarium oxysporum* and silicon. PhD Thesis, University of Stellenbosch.

KOBAYASHI, M., MATOH, T. & AZUMA, J. 1996. Two chains of rhamnogalacturonan II are cross-linked by borate-diol ester bonds in higher plant cell walls. *Plant Physiol.* 10: 1017-1020.

LAHAV, E. & WHILEY, A.W. 2002. Irrigation and mineral nutrition. In: A.W. Whiley, B. Schaffer and B.N. Wolstenholme (eds.). *The Avocado: botany, production and uses*. CABI Publishing, Oxon, UK. pp. 259-297.

MINCHIN, P.E.H., THORP, T.G., BOLDINGH, H.L., GOULD, N., COONEY, J.M., NEGM, F.B., FOCHT, E., ARPAIA, M.L., HU, H. & BROWN, P. 2012. A possible mechanism for phloem transport of boron in 'Hass' avocado (*Persea americana* Mill.) trees. *J. Hortic. Sci. Biotech.* 87: 23-28.

MONTANARO, G., DICHIO, B. & XILOYANNIS, C. 2010. Significance of fruit transpiration on calcium nutrition in developing apricot fruit. *J. Plant Nutrit. Soil Sci.* 173: 618-622.

MONTANARO, G., DICHIO, B., XILOYANNIS, C. & CELANO, G. 2006. Light influences transpiration and calcium accumulation in fruit of kiwifruit plants (*Actinidia deliciosa* var. *deliciosa*). *Plant Sci.* 170: 520-527.

MORRIS, E.R., POWELL, D.A., GIDLEY, M.J. & REES, D.A. 1982. Conformations and interactions of pectins I. Polymorphism between gel and solid states of calcium polygalacturonate. *J. Mol. Biol.* 155: 507-516.

NABLE, R.O. 1988. Resistance to boron toxicity amongst several barley and wheat cultivars: A preliminary examination of the resistance mechanism. *Plant Soil* 112: 45-52.

PLICH, H. & WOJCIK, P. 2001. The effect of calcium and boron foliar application on postharvest plum fruit quality. *Int. Symp. Fol. Nutr. Perenn. Fruit Plants* 594: 445-451.

POLEVOIY, V.V. 1989. Calcium-related physiological disorders of plants. *Ann. Rev. Phytopathol.* 17: 97-122.

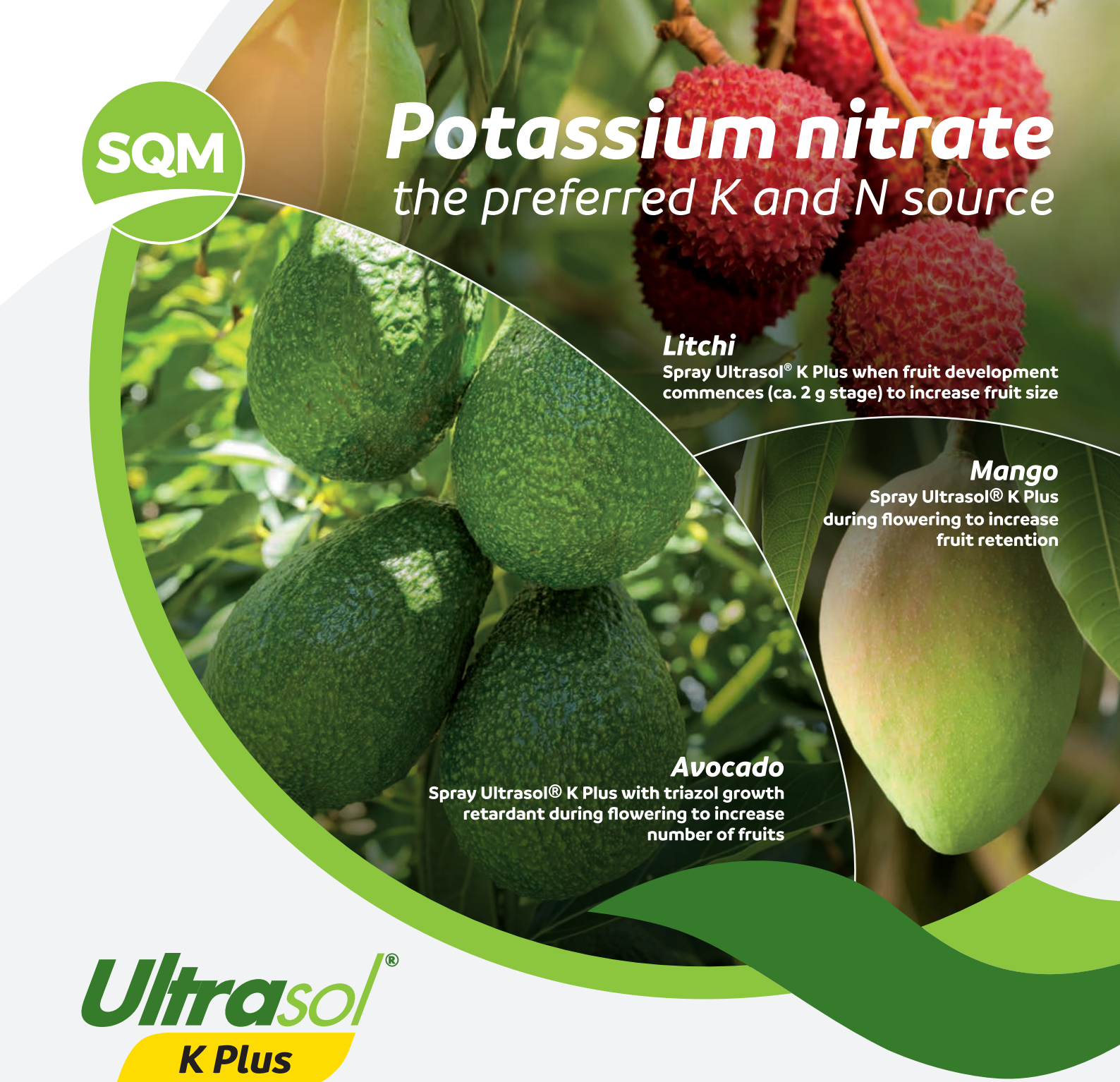
RAVEN, J.A. 1980. Short- and long-distance transport of boric acid in plants. *New Phytol.* 84: 231-249.

TROMP, J. & VAN VUURE, J. 1993. Accumulation of calcium, potassium and magnesium in apple fruits under various conditions of humidity. *Physiol. Plant*. 89: 149-156.

WEERAHEWA, D. & DAVID, D. 2015. Effect of silicon and potassium on tomato anthracnose and on the postharvest quality of tomato fruit (*Lycopersicon esculentum* Mill.). *J. Nation. Sci. Found. Sri Lanka* 43: 273-280.

WHITE, P. & BROADLEY, M.R. 2003. Calcium in plants. *Ann. Bot.* 92: 487-511.

Potassium nitrate
the preferred K and N source



Litchi
Spray Ultrasol® K Plus when fruit development commences (ca. 2 g stage) to increase fruit size

Mango
Spray Ultrasol® K Plus during flowering to increase fruit retention

Avocado
Spray Ultrasol® K Plus with triazol growth retardant during flowering to increase number of fruits

Ultrasol® K Plus

Foliar fertilization is an important tool for the sustainable and productive management of crops:

- When soil conditions limit availability of soil applied nutrients;
- In conditions when high loss rates of soil applied nutrients may occur
- When the stage of plant growth, the internal demand and the environment conditions interact to limit a delivery of nutrients to critical plant organs
- When certain foliar applications are tested and proved to result in measurable and positive plant parameter responses.

- Cronje, R.B. and Mostert, P.G. 2008. A management program to improve yield and fruit size in litchi - third season's report. S.A. Litchi Growers' Assoc. Yearbook 20:6-12.
- Cronje, R.B. and Mostert, P.G. 2009. A management program to improve yield and fruit size in litchi - final report. S.A. Litchi Growers' Assoc. Yearbook 1 21 :6-15.
- Oosthuyse, S.A. 1993. Effect of spray application of KNO_3, urea and growth regulators on the yield of Tommy Atkins mango. S.A. Mango Growers Assoc. Yearbook 13: 58-62.
- Oosthuyse, S.A. 1996. Effect of KNO_3 sprays to flowering mango trees on fruit retention, fruit size, tree yield, and fruit quality. S.A. Mango Growers Assoc. Yearbook 16:27-31.
- Oosthuyse, S.A. and Berrios, M. 2014. Effect of spray and/or soil application of paclobutrazol, and spray application of potassium nitrate during flowering on new shoot growth and cropping of "Mendez" avocado. In proceedings of the 29th Horticultural Congress, Brisbane, August 17-22, 2014 (in press).

SQM AFRICA

Contact details:
Mr. Duncan Napier: (082) 772 2207

E-mail: spn-emea@sqm.com

Registered by: SQM Africa (Pty) Ltd. / Act 36/1947: K5020 N= 130g/kg; P=0g/kg; K=380g/kg

sqmnutrition.com