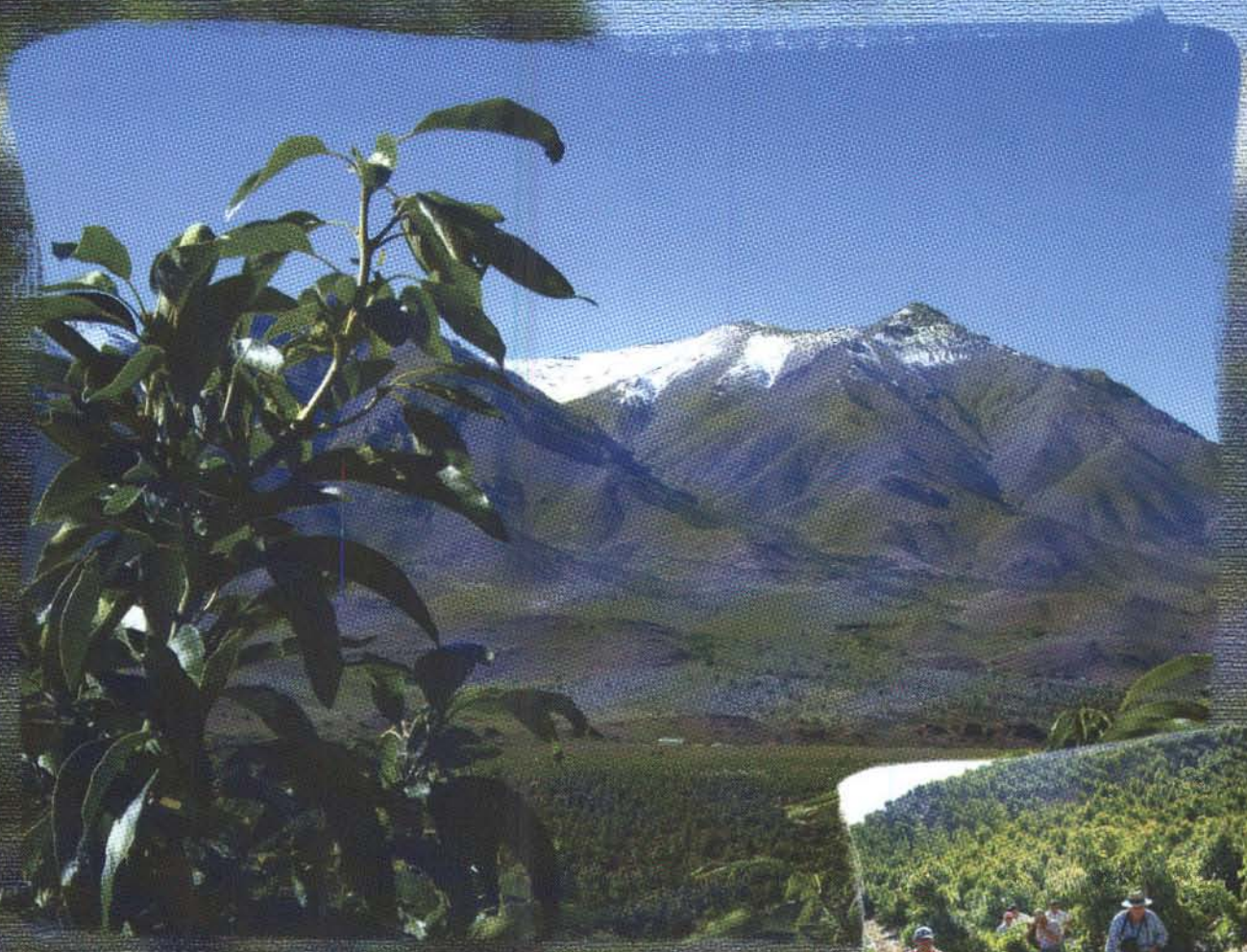
Talking Avocados

FEATURE - CHILEAN AVOCADO INDUSTRY



The Australian Newsline

AUTUMN 2003 ISSUE

VOL 14 No. 1 Print Post Approved – 44307/0006
Sponsored by AAGF and HAL

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TALKING AVOCADOS

Talking Avocados is the official publication of the Australian Avocado Growers' Federation and published in conjunction with Horticulture Australia Ltd.

Published: Quarterly - Autumn (March/April), Winter (June/July), Spring (September/October) and Summer (December/January).

Produced by: *Marketing Line Consultancy*, PO Box 58, Sydney Markets NSW 2129 – Phone: 02 9648 0136, Fax: 02 9648 0135, Mobile: 0407 589 445, Email: colscotney@bigpond.com, Delivery Address: First Floor, Suite B12, Sydney Market Plaza Building, Sydney Markets, Flemington NSW 2129. (AUF Office – off Paramatta Road)

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Distribution: Mailed directly to avocado growers and those associated with the Australian Horticultural Industry.

Circulation: 1,400 Copies

Printed by: Glovers Printing Works Pty Ltd, PO Box 144, Bundaberg Qld 4670 – Phone: 07 4152 0999, Fax: 07 4152 2001, Email: glovers@bigpond.net.au, Delivery Address: 210-212 Bourbong Street, Bundaberg Qld 4670.

Subscriptions: Australian Avocado Growers' Federation, PO Box 19, Brisbane Markets, Qld 4106 – Phone: 07 3213 2477, Fax: 07 3213 2480 Email: a.allen@aagf.org.au

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We all make mistakes: If we make a mistake please let us know so a correction may be made in the next issue.

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PRESIDENT'S PERSPECTIVE

The Industry Manager and I recently visited the South African avocado industry accompanied by John Tyas from Horticulture Australia. Attendance at the South African Avocado Growers Association (SAAGA) annual Research Symposium was the primary focus of the visit. The opportunity was also taken to meet with the leadership and management of SAAGA and visit a number of orchards in the region.

Research Symposium

Over two days a range of research and extension workers reported to the industry a wide range of research work which is being conducted, normally with support from the industry, on various aspects of avocado production and handling. Much of the work was of interest to the Australian industry with field issues such as new rootstocks, potential new cultivars and the evaluation of alternative pesticides for the control of their pest and disease complexes, which are similar to those we face here, being reported in detail.

Of particular interest was their focus on the importance of an understanding of the fruit mineral content during development and the effect this can have on fruit quality. As their industry has a strong focus on the European export market, it was important to note that all their fruit quality evaluations were conducted after storage, replicating normal transit conditions to Europe.

A significant portion of their research effort involves the improvement of systems used to transport the fruit to Europe and improving the external and internal quality of fruit available in Europe.

The South African industry is steadily increasing its Hass production with current levels of 41% Hass expected to reach 50% by 2005. Of interest to me was the fact that Fuerte still accounts for some 26% of their production. A number of European markets were claimed to still prefer "greenskins" although the returns we were advised of indicate that this situation is changing.

The South African domestic market has a strong preference for "greenskins". Other important cultivars include Ryan, which is grown as a "late" variety and Pinkerton which was initially grown due to its high yield capacity. The industry has invested heavily in addressing the problems associated with Pinkerton after cool storage/transit and are now developing guidelines on "Do's" and "Don'ts" for Pinkerton.

Farm Visits

The farms that we visited in the Tzaneen, Mooketsi, Kiepersol and Nelspruit areas were medium to large operations which were also growing other crops such as Mangoes, Lychees, Bananas, Citrus, Sugarcane, Pecans and Macadamias.

Of particular interest to me was the range of canopy management systems being utilized. We saw a range of systems being used with varying levels of satisfaction, ranging from regular pruning combined with the use of Sunny® to staghorning, with strategic limb removal being popular particularly in Fuerte plantings.

The system being used depended, as in Australia, on a range of factors such as topography, access for mechanical pruners, tree vigour and growth habit. My interpretation of the situation was that many growers in SA are still as uncertain about what to do, as many are in Australia. One advantage they have in South Africa is they have access to a large unskilled but cheap labour force which enables them to do quite a lot of hand pruning/tipping.

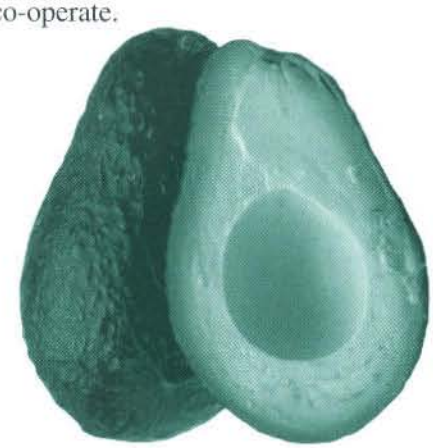
The level of mechanization is quite low on most orchards with much of the spraying done with hand lances and harvesting done using ladders and poles. Westfalia Estates are now doing much of their spraying using large airblast units with high volume application rates.

Conclusion

The South African and Australian industries share many of the same agronomic challenges as much of our production is in warm sub-tropical environments. The SA industry has extensive experience in the export of avocados and in the future, as the Australian industry increases its level of exports, I am sure there will be benefits in working more closely with them.

I have recommended to the AAGF Board that increased communication between the industries should be encouraged as there are excellent researchers working with each industry who at times are somewhat isolated. The industry organisations can play a role in improving the levels of communication and co-operation and the SAAGA is keen to co-operate.

By Rod Dalton



FROM YOUR FEDERATION

South Africa

With this issue ends a very busy period for myself and the Federation. Along with Rod Dalton (AAGF President) and John Tyas (Horticulture Australia) I attended the South African Avocado Industry's Annual Research and Development Symposium near Tzaneen in the north east of South Africa. You will read in Rod's "President's Perspective" more detail of the Symposium content and the farms we had the opportunity to visit in the short time we had available. I will comment on the great potential for our industries to increase communication and co-operation to the benefit of all. I look forward to an ongoing exchange with the South African Avocado Growers Association's General Manager Derek Donkin.

Board and Committee Business

In January AAGF was pleased to accept from the Bundaberg/Childers region a new Director, Lachlan Donovan. Lachlan replaces Russell Proudfoot who has sold his orchard. We again thank Russell for his time and contributions within AAGF. The AAGF Directors and I look forward to working with Lachlan.

Along with a new Director, AAGF has a newly elected Vice President, Peter Molenaar. Peter has accepted the new role which includes representing the Board on the AAGF R&D Committee. We are all happy to have both Peter's and Lachlan's years of experience injected into AAGF.

A number of AAGF meetings took place during February and March. The Variety, R&D and Marketing Committees all met during this period, each considering matters in the related areas and making recommendations to the AAGF Board for action. Two of the actions the Board voted to undertake were a constitutional review and a regional R&D roadshow, both to be completed during the second half of 2003.

Regional R&D Roadshow

The Roadshow will visit seven areas across the country. These being Atherton (July), Bundaberg (August), South East Queensland (August), Far North NSW (August), Mid North Coast NSW (August), Remark SA (Nov) and Pemberton WA (Nov). It will be an on-farm, one day event, making it easier to break away from the orchard jobs to be updated on the latest outcomes from the Avocado R&D Program and local issues. Attendance will be free of charge. We will all keep you posted with details for your area.

AAGF Constitutional Change

Constitutional change is being proposed. Currently we operate under a Federation structure with no direct membership of growers to the "Peak Industry Body". This Federation was established over 30 years ago and with the passing of time, the Board has recognised the need to update the structure. At the March meeting the Board voted unanimously to move towards a new Constitution based on direct membership of growers across the country. This direction would allow the members/growers to participate directly at AGM's and general meetings.

Reminder

For those receivers of Talking Avocados, please complete the "Mailing List Update" that was forwarded in the last issue. The winner of the "The Avocado" book will be announced in the next issue.

By Antony Allen

Growers Note:

Free Advertisements are available (depending on content) on request to AAGF.

Talking Avocados

AUSTRALIAN ROUNDUP...

Atherton Tablelands

Following on from the AAGF Export Development Forum held in Brisbane late last year, interested growers from the Tablelands had a meeting in January to look at export potential from this area. Although not formally approved and not sponsored by any association, the group's role was to advance the interest and document a process by which this could go forward using the experience from last years trial shipment. Denis Howe agreed to act as a conduit on a needs basis. This will need board support from other growers to achieve long term outcomes.

The first of the Shepard fruit was on the market floor in late January with an estimate of volume being revised downward as the weeks have progressed making it less likely to achieve the projected increase in total production for the year 2003.

As your elected representative, I believe one of my roles is to help all growers achieve maximum returns on their investment by way of communicating relevant issues that can impact on the bottom line.

Last year I suggested that Shepard and Hass growers work together to ensure that the overlap of supply did not impact adversely on price and that opportunistic supply ie early picking did not affect quality. Growers and Marketers have a duty not to present poor quality fruit to the public. A buyer discarding a piece of fruit because it was picked too early, is a buyer lost, look beyond the front fence - plantings are increasing, production is going up.

This year we have had fruit on the market floor early - is it ready!! We have marketers who previously have never handled Avocados selling fruit. Logic says this must impact on the price you receive. If you or your neighbour are a first time producers, establish who in the market is experienced in handling avocados and use them.

Network with your peers and get to know who can service you best.

Congratulations to Don Lavers on his Australian Day Award - reflecting his long and beneficial efforts to the Industry.

By Col Cummings

South Australia

After one of the best avocado seasons for a long time, most growers are into harvesting other crops (grapes & citrus). The coming season is going to be a light crop similar to 2001/2002.

There is a study group of northern NSW avocado growers coming for a look around the Riverland and Sunraisia areas in early April. Not only looking at avocados and how they grow here but also irrigation practices and methods of controlling salinity in the Murray.

Our AGM will be held sometime in May, day and place still to be finalized.

By Colin Fechner

Western Australia

The harvesting has finished and it has been another good year for most growers. The markets have been very stable and prices have been good.

This coming year will see a decrease in the volume of fruit in Perth due to a cooler spring and the fruit set has not been so good. The South West is shaping up to have a large crop with what looks like up to a 70% rise in production.

Our Grower Association is looking at doing some research on an IPM program for the control of Thrips.

By Wayne Franceschi

New South Wales

It has been a much more favourable start to the year, weather wise, than last year with most areas across the state receiving good rainfall during the past month.

The majority of growers are expecting a marked increase in production compared to last year – possibly even double.

We are happy to report that the 'Draft proposal' of the alliance between the NSW Avocado Growers Association Inc. and NSW Farmers' Association has been received. The alliance will be operational in 2004. Apologies to members at the slow progression of this matter, however perseverance has eventually paid off.

Reminder! Membership fees are now due. Please forward your payment ASAP. *Thank you* to all those who responded promptly.

A decision will be reached at our AGM as to the plight of the Northern Branches. Amalgamation is the logical way to go.

By Chris Nelson

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Talking Avocados?

If your answer is YES, then you MUST COMPLETE the *Mail List Form* and MAIL or FAX back the form to AAGF.

The first 300 forms received will go into a DRAW for a copy of Dr Tony Whiley's book –

The Avocado: Botany, Production and Uses
CABI Publishing 2002

Valued at over $200

New ACIAR Project to Investigate Natural Defence Compounds in Avocado

A new project entitled "Management of postharvest diseases of subtropical and tropical fruit using their natural resistance mechanisms" commenced in July 2002. The 3 year project is funded by the Australian Centre for International Agricultural Research (ACIAR) and involves collaboration between researchers in Australia (DPI and University of Queensland) and Sri Lanka (University of Peradeniya and Department of Agriculture), with guidance from Professor Dov Prusky (Volcani Center, Israel).

In Australia, the project is focusing on postharvest diseases of avocado and mango, and involves input from DPI Indooroopilly (Lindy Coates, Sonia Willingham, Liz Dann, Tony Cooke and Jan Dean), DPI Mareeba (Ian Bally), DPI Nambour (Peter Hofman), UQ Gatton (Donald Irving, Zainuri) and UQ St Lucia (Craig Williams).

In Sri Lanka, emphasis is on postharvest diseases of banana and mango. The Sri Lankan team is led by Professor Nimal Adikaram, an expert on natural defence compounds in tropical fruit.

Project Aim

The aim of the project is to develop and optimize sustainable strategies for managing postharvest diseases in these fruit crops using their natural resistance mechanisms.

In developing disease management strategies for fruit, little attention has been given to the fact that plants have evolved powerful defence mechanisms to limit and prevent disease on developing fruit. These include biochemical (ie. antifungal compounds) and physical barriers to pathogen invasion.

In avocado for example, it is already known that antifungal compounds called dienes are present in high concentration in the peel of unripe fruit. These dienes normally prevent pathogens such as the anthracnose fungi from causing symptoms of disease in developing "Hass" fruit in the orchard. During fruit ripening however, diene levels drop and as a result disease symptoms develop.

In this project we will investigate treatments (chemical, biological and physical treatments) which will enhance the production of dienes and/or other compounds produced naturally by avocado fruit, with a view to delaying disease development. We also plan to investigate the role of natural defence compounds in the development of pepper spot in "Hass" avocado.

Pepper spot is an important disease of developing avocado fruit in the orchard, and is caused by the same fungus which causes anthracnose. We would like to find out if the development of pepper spot is linked in any way to preharvest changes in diene levels. Such knowledge would help us to devise ways of preventing pepper spot development through modulation of diene levels in the orchard.

Project to benefit from expert input

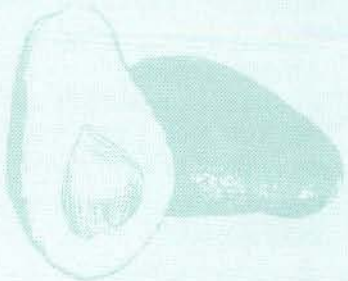
The project will benefit greatly from the input of Professor Dov Prusky (Volcani Center, Israel), who is an international expert on antifungal dienes in avocado. Professor Prusky was recently in Brisbane to attend out Project Commencement Workshop.

Latest research from his group suggests that the anthracnose pathogen produces ammonia which results in an increase in tissue alkalinity. This in turn makes conditions more favourable for the production of pathogen-produced enzymes which accelerate disease development. Compounds which suppress ammonia production by the fungus therefore reduce disease. We will be investigating this further in collaboration with Professor Prusky.

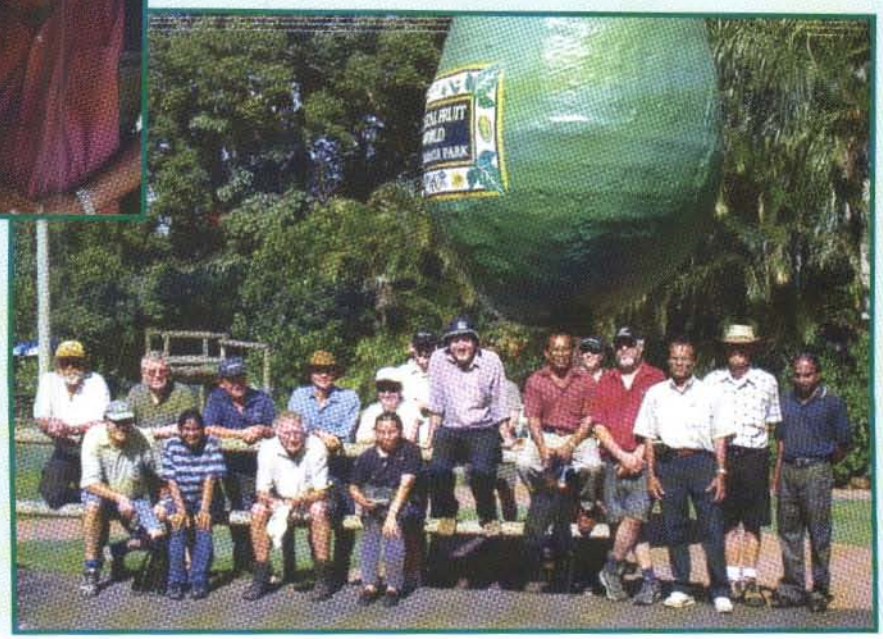
Research compliments similar studies

The research conducted in this project will complement similar studies currently underway in the HAL/AAGF project on "New strategies for the control of avocado fruit diseases" and the CRC Tropical Plant Protection project on "Plant defence mechanisms – Responses of tropical fruit to *Colletotrichum* infection". These projects are focusing on the interaction of antifungal dienes, rootstock and nutrition and susceptibility of "Hass" avocado fruit to disease.

For further information, please contact Dr Lindy Coates on Lindy.Coates@dpi.qld.gov.au



Left: From left: Dr Sarananda Hewage (Department of Agriculture, Sri Lanka), Ken Pegg (DPI), Vivienne Anderson and Professor Nimal Adikaram (University of Peradeniya, Sri Lanka) at Graham & Vivienne Anderson's Farm, Duranbah.



Right: ACIAR Project Workshop participants on a tour of Tropical Fruit World (Duranbah) with Bob Brinsmead and Graham Anderson.

Update on Canopy Management of Avocados

By J. Leonardi, *Queensland Horticulture Institute, Maroochy Research Station, Nambour*

Trials established in the Childers/Bundaberg region in 2000/01 to investigate the effect of pruning and growth retardant application on shoot growth, flowering, yield and fruit quality of 'Hass' avocado were continued during 2001/02. Trees were mechanically pruned at an angle of 15-20° to form a pyramid following the harvest (Jun-Aug) and during the summer following maturation of the spring growth flush (Dec-Feb). Foliar applications of the growth retardant Sunny® were made at flowering and when regrowth following summer pruning reached a maximum of 10 cm in length. Agral® at 0.05% was added to all Sunny® applications.

At each experimental site fruit was harvested at maturity and the number and weight from each tree recorded. Mean fruit size was calculated from the data. The effect of pruning and Sunny® application on postharvest quality was also studied over the two seasons.

Results...

YIELD AND FRUIT SIZE

Site 1:

Seven-year-old trees were harvested by May 2000 and pruned at an angle of 18° on the 15th June 2000. All trees at this site were pruned after harvest. A 1% Sunny® spray was applied at flowering at a rate of 3 L per tree on the 14th Sep 2000. Trees were either left unpruned or pruned again on the 14th Dec 2000 or the 19th Jan 2001. Regrowth in trees pruned in December and January was treated with Sunny® at a rate of 3.5 L per tree on the 9th Jan and 19th Feb 2001, respectively.

Trees were harvested by the 14th May 2001. There was no significant effect of summer pruning and Sunny® treatment on yield (17.5-20.9 t/ha) (Table 1). However, a 1% Sunny® treatment applied at flowering significantly increased mean fruit size by 6.7% (17.1g) compared with untreated trees.

In the 2001/02 season, all trees were re-pruned after harvest at an angle of 18° on the 15th June. A 1% Sunny® spray was applied at flowering at a rate of 3 L per tree on the 13th Sep 2001. Trees were either left unpruned or pruned again on the 21st Dec 2001 or the 19th Jan 2002.

Regrowth in trees pruned in December and January was treated with Sunny® at a rate 3 L per tree on the 28th Jan and 22nd Feb 2002, respectively. Trees were harvested by the 11th June 2002. There was again no significant ($P \leq 0.05$) effect of summer pruning and Sunny® treatment on yield (12.7-16.2 t/ha) (Table 1). A 1% Sunny® treatment applied at flowering increased mean fruit size by 4.0% (8.9g) compared with untreated trees.

Site 2:

Six-year-old trees were harvested by Aug 2000 and pruned at an angle of 15° on the 11th Sep 2000. A 1% Sunny® spray was applied at flowering at a rate of 2.25 L per tree on the 25th Sep 2000. Trees were either left unpruned or pruned again on the 18th Dec 2000. Regrowth in trees pruned in December was treated with Sunny® at a rate of 2.5 L per tree on the 15th Jan 2001.

Trees were harvested on the 3rd Jul 2001. Pruning significantly reduced yield compared with unpruned trees (10.2-13.5 vs 23.4 t/ha) (Table 2). Mean fruit size was greatest in trees pruned after harvest and treated with 1% Sunny® at flowering (267.4 vs 206.1g in unpruned trees).

In the 2001/02 season, trees were re-pruned at an angle of 15° after harvest on the 25th Aug 2001. A 1% Sunny® spray was applied at flowering at a rate of 2.25 L per tree on the 17th Sep 2001. Trees were either left unpruned or pruned again on the 18th Dec 2001. Regrowth in trees pruned in December was treated with Sunny® at a rate of 2.25 L per tree on the 18th Jan 2002.

Trees were harvested on the 1st Aug 2002. There was no significant effect of pruning after harvest on yield compared with unpruned trees (both 14.9 t/ha). However, yield was least in trees pruned twice (after harvest and again during summer) with 10.3-10.5 t/ha (Table 2). Mean fruit size was greatest in trees pruned after harvest and treated with 1% Sunny® at flowering (228.4 vs 192.4g in unpruned trees).

Table 1. Effect of pruning and foliar applications of Sunny® on Hass yield and fruit size at Site 1 in the 2000/01 and 2001/02 fruiting seasons. Data in columns are mean values of six trees. Values in each column followed by the same superscript letters are not significantly different ($P \leq 0.05$) as tested by ANOVA.

Treatments	Yield (t/ha)		Mean fruit size (g)	
	2001	2002	2001	2002
Pruned after harvest	19.1[a]	16.2[a]	253.6[bc]	224.3[ab]
Pruned after harvest + Sunny® at flowering	18.8[a]	14.3[a]	270.7[a]	233.2[a]
Pruned after harvest and again in December	17.5[a]	14.1[a]	247.5[c]	211.4[bc]
Pruned after harvest and again in December + Sunny® on regrowth	17.9[a]	12.7[a]	250.4[bc]	210.8[bc]
Pruned after harvest and again in January	20.9[a]	12.8[a]	243.4[c]	207.9[c]
Pruned after harvest and again in January + Sunny® on regrowth	18.2[a]	13.1[a]	265.5[ab]	207.0[c]

*t/ha was calculated from the tree spacing of 9 x 6 m (185 trees/ha).

Table 2. Effect of pruning and foliar applications of Sunny® on Hass yield and fruit size at Site 2 in the 2000/01 and 2001/02 fruiting seasons. Data in columns are mean values of six trees. Values in each column followed by the same superscript letters are not significantly different ($P \leq 0.05$) as tested by ANOVA.

Treatments	Yield (t/ha)*		Mean fruit size (g)	
	2001	2002	2001	2002
Unpruned	23.4[a]	14.9[a]	206.1[d]	192.4[b]
Unpruned + 1% Sunny® at flowering	20.7[a]	15.4[a]	230.0[bc]	221.6[a]
Pruned after harvest	10.2[b]	14.9[a]	246.7[b]	201.0[b]
Pruned after harvest + 1% Sunny® at flowering	13.5[b]	13.0[a]	267.4[a]	228.4[a]
Pruned after harvest and again in December	10.4[b]	10.5[a]	231.8[bc]	204.1[b]
Pruned after harvest and again in December + 1% Sunny® on regrowth	10.5[b]	10.3[a]	218.8[cd]	199.3[b]

*t/ha was calculated from the tree spacing of 5 x 6 m (333 trees/ha).

Table 3. Effect of pruning on Hass yield and fruit size at Site 3 in the 2001/02 fruiting season. Data in columns are mean values of four trees. Values in each column followed by the same superscript letters are not significantly different ($P \leq 0.05$) as tested by ANOVA.

Treatments	Yield (t/ha)*	Mean fruit size (g)
Unpruned	20.7[a]	191.3[a]
Pruned after harvest and again in December	12.6[b]	203.7[a]
Pruned after harvest and again in January	10.3[bc]	202.0[a]
Pruned after harvest and again in February	5.5[c]	210.6[a]

*t/ha was calculated from the tree spacing of 10 x 5 m (200 trees/ha).

Site 3:

Six-year-old trees were pruned at an angle of 20° on the 2nd Aug 2001. Trees were either left unpruned or pruned again on the 21st Dec 2001, 22nd Jan 2002 or 19th Feb 2002.

Trees were harvested by the 17th Jun 2002. Pruning reduced yield compared with unpruned trees (5.5-12.6 vs 20.7 t/ha) (Table 3). The reduction of yield was greatest in trees pruned in February. Mean fruit size tended to be larger in those trees pruned in summer compared with non-pruned trees (202.0-210.6 vs 191.3g). This increase is fruit size is due to the reduction in fruit number associated with summer pruning.

FRUIT QUALITY

The effect of pruning and Sunny® application on fruit quality was investigated at three sites in the Childers/Bundaberg region. At each site 20 fruit were sampled at maturity from each tree. Fruit was stored under simulated commercial conditions, ripened at 20°C and assessed for quality. The incidence (% of fruit affected) of fruit rots and disorders was recorded. Examples of some of the postharvest disorders are shown in Plates 1-4.

Site 1:

Eight-year-old trees were pruned at an angle of 18° after harvest on the 15th Jun 2001. A 1% Sunny spray was applied at flowering at a rate of 3 L per tree on the 13th Sep 2001. Trees were either left unpruned or pruned again on the 21st Dec 2001. Regrowth in trees pruned in December was treated with Sunny at a rate 3 L per tree on the 28th Jan 2002. Fruit was sampled from 6 trees from each of the following treatments:

1. pruned after harvest
2. pruned after harvest + 1% Sunny® at flowering
3. pruned after harvest and again in December
4. pruned after harvest and again in December + 1% Sunny® on regrowth

Additional pruning in December tended to increase the incidence of body rots, stem-end rots and vascular browning with 44.2, 10.8 and 14.2% of the fruit, having at least 10% of the flesh affected, compared with 37.5, 6.8 and 7.5% in trees pruned only after harvest (Figure 1). A trend towards a reduction in the incidence of body rots, stem-end rots and vascular browning was observed in fruit sampled from trees that received a 1% Sunny® treatment at flowering with 33.3, 2.5 and 5.8% of the fruit, having at least 10% of the flesh affected, respectively.

At this site the high incidence of fruit rots and disorders may be due to the amount of regrowth present at the time of flowering and early fruit set. Trees were pruned immediately after harvest (mid-June) and by flowering and early fruit-set (mid-Sep) there was 20-30cm of regrowth. This regrowth may compete with the developing fruit for resources resulting in reduced postharvest quality.

Site 2:

Six-year-old trees were pruned at an angle of 15° after harvest on the 11th Sep 2000. Trees were either left unpruned or pruned again on the 18th Dec 2000. Regrowth in trees pruned in December was treated with Sunny® at a rate of 2.5 L per tree on the 15th Jan 2001.

In the 2001/02 season, trees were re-pruned at an angle of 15° after harvest on the 25th Aug 2001. Trees were either left unpruned or pruned again on the 18th Dec 2001. Regrowth in trees pruned in December was treated with Sunny® at a rate of 2.25 L per tree on the 18th Jan 2002. Fruit was sampled from 6 trees from each of the following treatments:

1. unpruned
2. pruned after harvest
3. pruned after harvest and again in December
4. pruned after harvest and again in December + 1% Sunny® on regrowth

In 2000/01, pruning tended to increase in the incidence of fruit rots and flesh disorders. Trees pruned after harvest and again in summer had 11.7 and 10.0% of the fruit having at least 10% of the flesh affected by body rots and 17.1 and 24.2% of the fruit having at least 10% of the flesh affected by diffuse discolouration, respectively compared with 0 and 4.2% in unpruned trees (Figure 2). Application of 1% Sunny® to the regrowth following the summer prune tended to reduce the incidence of body rots and diffuse discolouration in the pruned trees to 4.2 and 14.2%, respectively.

In 2001/02, the incidence of fruit rots and disorders was significantly lower than in the 2000/01 season. Additional pruning in summer tended to increase the incidence of body rots with 3.3% of the fruit, having at least 10% of the flesh affected, compared with 1.7% in unpruned trees Application of Sunny® to the regrowth following the summer prune reduced the incidence of body rots in the pruned trees to 2.5%.

In the first year (2000/01), pruning tended to reduce fruit quality with increases in the incidence of body rots and diffuse discolouration of the flesh. These trees had not been previously pruned so a considerable amount (2-2 m) of growth was removed. This heavy pruning also reduced yield by more than 50%. In the second year the amount of growth removed was less (up to 1 m) as tree shape had been established the previous year and as a result there was less impact on yield and fruit quality.

Site 3:

Six-year-old trees were pruned at an angle of 20° on the 2nd Aug 2001. Trees were either left unpruned or pruned again on the 21st Dec 2001. A 1% Sunny® spray was applied at flowering at a rate of 2.25 L per tree for pruned trees and 2.5 L per tree for non-pruned trees on the 12th Sep 2001. Regrowth in trees pruned in December received a Sunny® application at a rate of 2.25 L per tree on the 22nd Jan 2002, unpruned or pruned at an angle of 20° on the 2nd Aug 2001. Fruit was sampled from 6 trees from each of the following treatments:

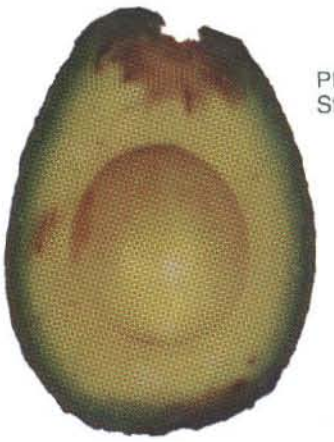


Plate 1:
Stem-end rot

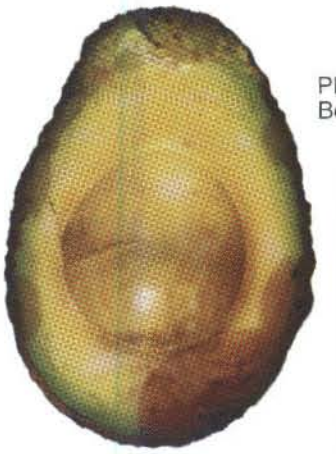
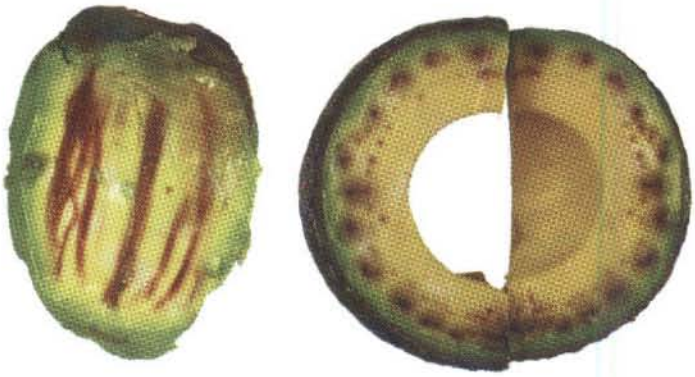


Plate 2:
Body rots

Plate 3:
Diffuse
discolouration

Plate 4: Vascular browning



1. unpruned
2. unpruned + 1% Sunny® at flowering
3. pruned after harvest
4. pruned after harvest + 1% Sunny® at flowering
5. pruned after harvest and again in December
6. pruned after harvest and again in December + 1% Sunny® on regrowth

At this site there was little effect of pruning on the incidence of fruit rots and disorders. There was a slight increase the incidence of body rots with 2.5% of the fruit sampled from trees that were pruned after harvest and again in December, having at least 10% of the flesh affected, compared with 0% in unpruned trees. In 2001/02 pruning was minimal

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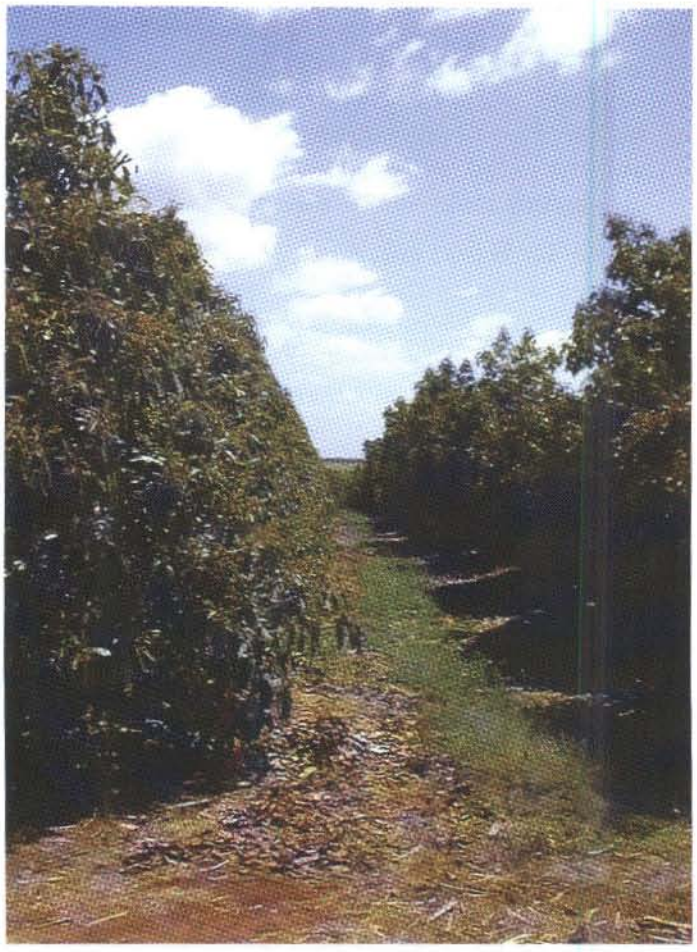

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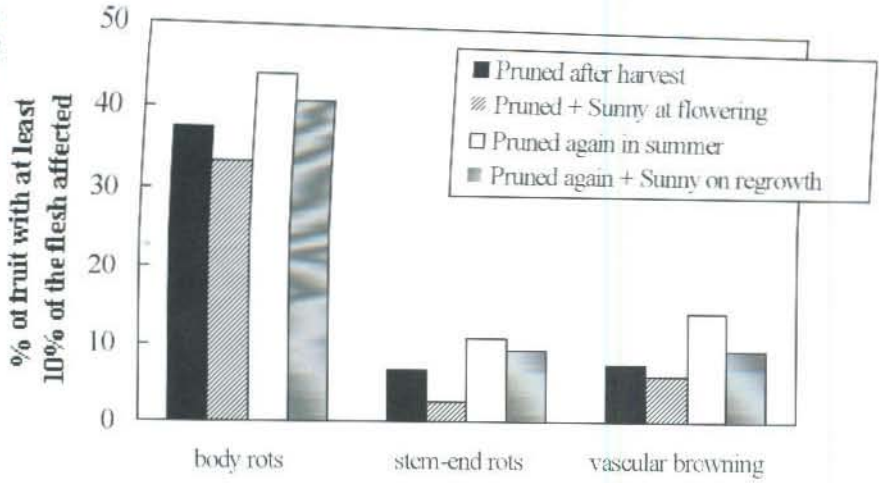


Figure 1:

Effect of pruning and Sunny® application (Site 1) on the incidence of body rots, stem-end rots and vascular browning in fruit stored under simulated commercial conditions and ripened at 20°C. There was no significant difference between treatments. However, pruning again in summer tended to increase the incidence while application of Sunny® either at flowering or to the regrowth following the summer pruning tended to reduce the incidence of the fruit disorders.

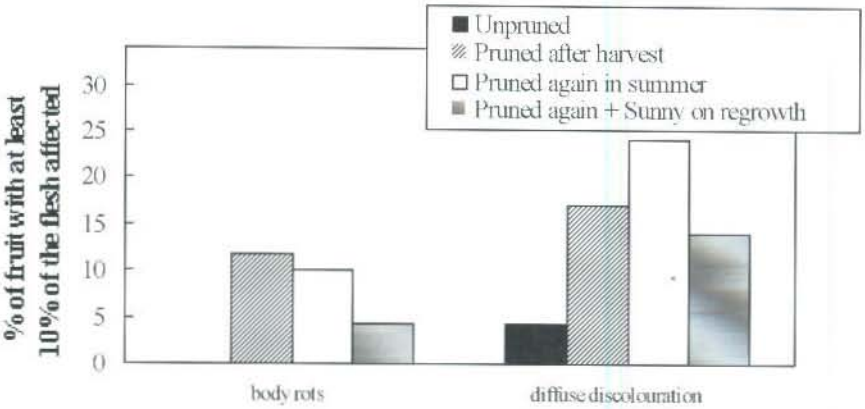


Figure 2:

Effect of pruning and Sunny® application (Site 2 in 2000/01) on the incidence of body rots and diffuse discolouration of the flesh in fruit stored under simulated commercial conditions and ripened at 20°C. There was no significant difference between treatments. Pruning tended to increase the incidence of the fruit disorders while application of Sunny® tended to reduce the impact of pruning on the incidence of these disorders.

(up to 1 m of growth was removed) as tree shape was established in the previous year. Also trees were pruned in early August (6 weeks after harvest) and there was little to no regrowth at the time of flowering and early fruit set thus reducing the potential for competition for resources between regrowth and developing fruits.

Conclusions...

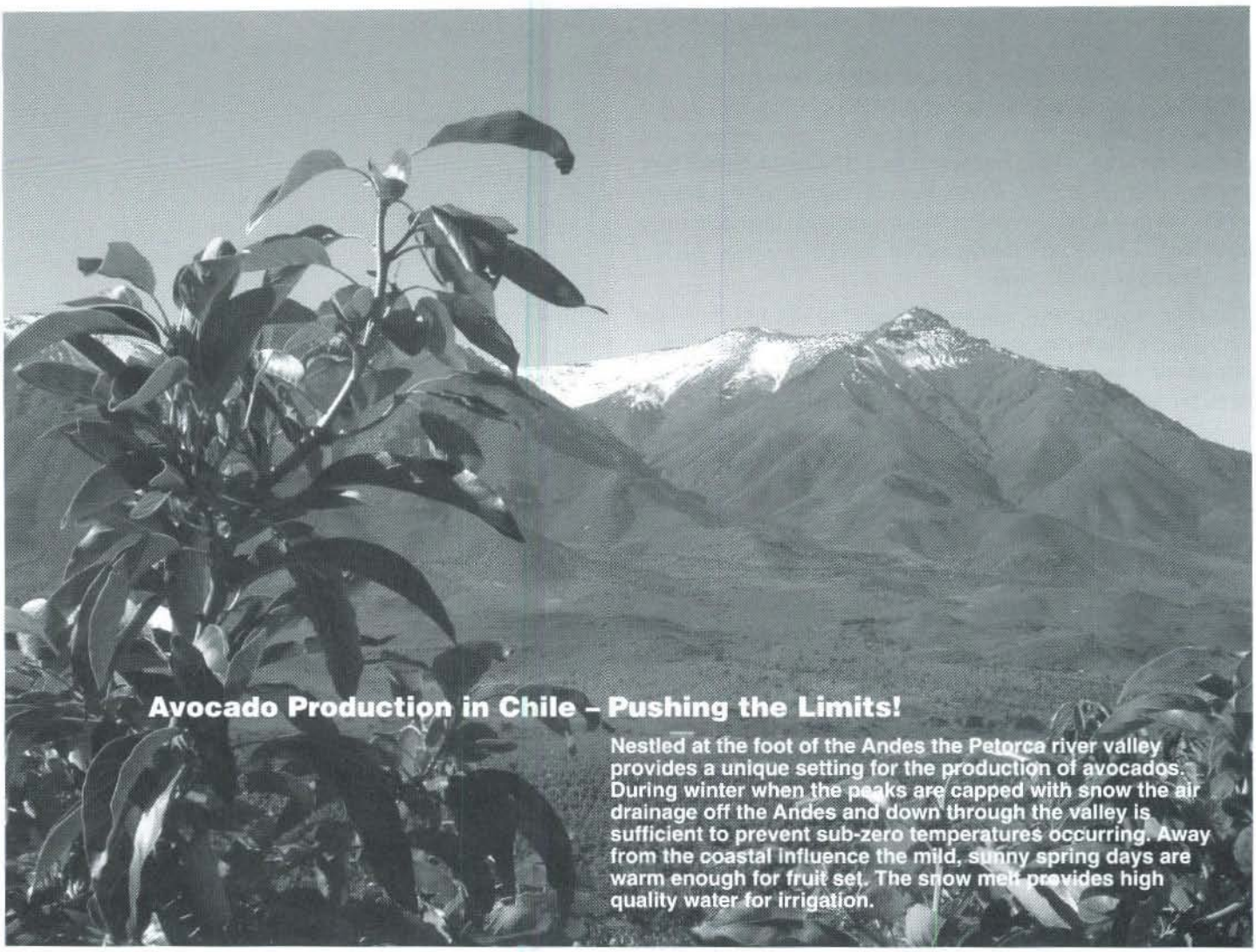
- **Trees should be pruned after harvest and prior to the onset of flowering to minimise yield losses due to flower removal.**
- **The timing of pruning after harvest is critical so to minimise the amount of regrowth during flowering and fruit set. Competition between developing fruits and shoot growth can affect fruit quality.**
- **Foliar application of Sunny® at flowering can significantly increase fruit size.**
- **Tree shape needs to be established after harvest to avoid fruit removal during the summer pruning.**
- **Pruning stimulates shoot growth and the timing of the summer pruning influences the length of this regrowth and the ultimate increase in tree size.**
- **Application of Sunny® at flowering and/or to regrowth following the summer prune tended to reduce the incidence of fruit rots and disorders compared to trees that were pruned only.**
- **Although this research was conducted on 'Hass' avocado at production sites located in warm sub tropical climates (Childers/Bundaberg), results should provide management strategies that can be implemented with some modifications in other production areas and on different varieties.**

Where to from here?

Trials investigating the effect of pruning and Sunny® application on shoot growth, flowering and yield in 'Hass' avocado are continuing during the 2002/03 fruiting season. Experiments have also been established to study the effect of the timing of the after harvest prune on yield and postharvest quality. The effect of pruning on fruit mineral content is also being examined.

ACKNOWLEDGEMENTS:

This project was funded by the AAGF, HAL and QDPI. Thanks to Peter Hofman, Barbara Stubbings and the postharvest team for their assistance and providing photographs of the various fruit disorders.



Avocado Production in Chile – Pushing the Limits!

Nestled at the foot of the Andes the Petorca river valley provides a unique setting for the production of avocados. During winter when the peaks are capped with snow the air drainage off the Andes and down through the valley is sufficient to prevent sub-zero temperatures occurring. Away from the coastal influence the mild, sunny spring days are warm enough for fruit set. The snow melt provides high quality water for irrigation.

The Chilean Avocado Industry, an Overview

Reuben Hofshi, Delroy Packers, Fallbrook, California, USA, editing and additional comment by A.W. Whiley, Sunshine Horticultural Services, Nambour, Australia

In recent years the presence of Chilean avocados in US markets has become a familiar sight. Most California avocado growers' knowledge of the Chilean avocado industry is limited, although they are familiar with its impact on the US market and on personal harvesting strategies. Inventory reports by the California Avocado Commission and pack house faxes are the primary sources of information on the flow of Chilean avocados into the market place. This overview is an effort to answer the questions interested growers may have about different aspects of the Chilean avocado industry and how it may eventually impact on the international trade of this crop.

Chilean avocado orchards are located in a range of latitudes similar to those in California (and the southern production areas in Australia), but due to southern hemisphere location the seasons are offset to California (but identical to southern Australia). La Serena, the northern limit of the Chilean industry is located at 29°53'S similar latitude to Lismore in NSW), while the southern limit of Melipilla is at 33°41'S (similar to Pemberton in WA). Contrast this with San Diego, CA at 32°45'N and Cambria in San Luis Obispo county at 35°33'N. Chilean fruit is mature when California is at the transition between the late and early season, from August onward. This unique situation gives the Chilean industry a market well primed by the momentum of California avocado sales. Historically, during this time of the year, demand for California avocados would exceed supplies and prices would rise dramatically. The Chileans recognised this window of opportunity and turned the US into the focus of their avocado exporting efforts.

The first significant shipment of 2700 tonnes of Chilean avocados arrived in the US in 1986 as the US avocado market, thanks to the California Avocado Commission (CAC) merchandising efforts and demographic changes, was in a growth phase. After some initial attempts at exporting avocados to the US through the usual produce channels, the Chilean industry quickly learned that the most efficient distribution method was by the same organisations that market

California avocados. This shift in marketing strategy provided the Chilean industry an infrastructure and a level of expertise that fostered the current expansion and success of their industry. The close relationship between California and Chilean marketers limited the flow of Chilean avocados to the months they were most needed, from mid-September through mid-December. Constraints of fruit maturity, on both ends of the spectrum, and a lack of dependable transportation have kept Chilean avocados out of the US markets during the remainder of the year.

The high returns for Chilean avocados in the US, in most years, have been phenomenal by any measure. This golden opportunity has generated a rush for continuous planting of new, predominantly 'Hass' orchards in Chile.

In the 2001-2002 season, the overall production of all varieties in Chile was about 120 000 tonnes of which 80 000 tonnes was 'Hass'. The majority of this, 54 000 tonnes was exported to the US, amounting to about 95% of the total Chilean avocado exports. The majority of these shipments are received and distributed by California handlers associated with one or more Chilean exporters. The exporting companies and their percentage of export volume, for the 2001-2002 export season are: Agricom 26.2%, Propal 22.6%, Santa Cruz 17.1%, CabilFrut 13.6% and Safex 5.6%. The remaining 14.9% is distributed among 20-25 other exporters.

Comité de la Palta is the equivalent of the California Avocado Commission ('Palta' is the term for 'avocado' in Chile). It is a private organisation formed in 1991 under the sponsorship of the National Federation of Fruit Producers (Fedefruta). It has a Board of Directors composed of seven producers, five marketers and two independents. Ninety-five percent of Chilean avocado exports are made under the umbrella of this organisation. In the last few years the Comité de la Palta has been levying growers approximately 2.5 cents US per kg for all avocados exported to the US by its members (in 2002 this has been increased to 5.5 cents US per kg).

Fig. 1: A new 100 ha orchard of 'Hass' avocados planted at Llay Llay, Chile in the spring of 2002. Currently the industry is expanding at the rate of 1000 ha of new trees per year.

There have been several attempts at joint promotion efforts between CAC and the Comité de la Palta. The voluntary agreement between the two organisations to promote avocados during the autumn of 2001 demonstrates that alliances between competitors are possible. All producers benefit from a full calendar year perspective, as opposed to fragmented, country specific, seasonal campaigns for promotion programs. Overall, both industries recognise that the existence of the other is a fact of life. An issue that concerns the Chilean Industry is the import duty of $US1.30 per 11.5 kg carton levied by the US government on Chilean avocados entering the US. These funds, over $US7 million in 2001-2002 alone, are put in the general government fund and do not help promote avocado sales. They hope that the new trade negotiations between both countries will result in the removal of such duties or at least direct some or all of these funds towards avocado promotion. Relations are likely to improve as both industries learn to understand each other and recognise their mutual needs and apprehensions. With closer ties and the similarity of production conditions of both countries, closer cooperation on research, technical management, variety development and other mutual interests, could produce a positive synergy between both industries.

The current area planted in Chile of approximately 20 000 ha is comprised of 30% newly planted, non-bearing trees, 40% not yet fully mature with increasing production, 26% mature trees in full production, and 3% older trees with declining production. New trees are being planted at a rate of 1000 ha/year (Fig. 1). It is expected that plantings of new orchards will slow once the industry reaches 20 000 ha of 'Hass'. California currently has 23 500 producing ha and 300 non-bearing ha, with a high percentage of trees over 15 years old and 'Hass' accounting for 95% of the total production.

Chile has the second highest per capita consumption of avocados in the world at 3.9 kg/person. Chile's population of 15.5 million will consume approximately 59 000 tonnes of the 2001-2002 production of all varieties. Due to increased production and the proliferation of exporting companies, there is pressure to expand the USA shipping period into January, February and even into March. This could be facilitated by the adoption of faster and more efficient transportation, and better postharvest handling techniques.

It usually takes 10-15 days for the 5435 mile voyage from Valparaiso, Chile to San Diego, California. One solution for increasing shelf life and thus the shipping season is the use of controlled atmosphere (CA) containers where fruit is kept in a controlled environment of reduced oxygen and increased carbon dioxide, similar to long-term apple storage. This may add $US0.80 - $US1.00 per carton in transportation costs but without CA it would be risky to ship late season avocados. February/March in Chile is equivalent to August/September in California, a period which, due to maturity and shelf life limitations, is not conducive to long distance shipping of avocados. Other options are being studied to improve shipping quality. One material that is likely to be used in the future is the simple organic compound 1-MCP, which is already registered for use on floral and edible products in some countries. This material, in quantities of less than 100 ppb and under regular refrigeration, can extend avocado shelf life. The compound attaches itself to the ethylene receptors in the avocado fruit and blocks ethylene action, thus delaying fruit ripening.

Chile is not the only country that exports avocados to the US during the August to February period. Chile, Mexico and New Zealand all have avocados at basically the same time and the day when supplies may exceed demand is lurking on the horizon. The Chileans are industrious, learn from both success and failure and adapt quickly. They are continually looking for new markets to help dampen the inevitable

competition for the market window on which they have focused their efforts.

The lack of available alternative markets is a major concern for the Comité de la Palta and all Chilean marketers. One option is the development of the European market by the Chilean industry. Europe has been neglected mainly due to the higher prices that can be obtained in the US. If increased production volumes cause prices to decline, Europe could become a viable additional market. The major foreign competition for Chile, particularly in the US during its traditional exporting months is Mexico. However, with a high domestic consumption and a tendency for alternate bearing, Mexico is not always a consistent source of fruit. The Chileans, although watchful and concerned, no longer feel threatened by the Mexican presence. Another alternative could be Japan, but again this is a small market and Chile would face competition from New Zealand and Mexico. Realistically, Europe and Japan are marginal options for Chile since the transit time to these markets is approximately 30 days. Such long transit would require optimum pre- and postharvest management and the use of expensive CA containers. It is possible, but at this stage very risky and costly. The reality is that Chile's natural export market is the US and that it will likely remain the principal market in the future. In the meantime the Chilean avocado industry is experiencing a boom.

The average FOB prices for the 1999-2000 season was $US22 per tray (11.5 kg). For the 2000-2001 season the average FOB returns were $US24 however, results in the 2002-2003 season suggest that the return has contracted to an average FOB of $US20 per 11.5 kg carton. The drop in prices is largely due to the poorer fruit quality from Chile this season due to record high winter rainfall, severe freeze conditions and entering the market too early before fruit had reached maturity levels required by Californian consumers. This led to fruit with poor shelf life and loss of consumer confidence in the fruit. Australian growers should be very aware of the negative impact of poor fruit quality on market prices and the difficulty in raising the return once they have slumped.

In the long term, the Chilean 'Hass' industry is hoping to find an important market alternative in South America, especially in Argentina. This option has been long contemplated, and test shipments have been made to that country. The high prices obtained in other markets, coupled with the economic problems and informal way of doing business in Argentina, have limited the development of this market. Compared with the high Chilean avocado consumption (3.9 kg/capita), Argentineans consume only about 0.2 kg/capita. With the population of metropolitan Buenos Aires and suburbs approaching 13 million, it is obvious that the growth potential of this market is enormous. Although Argentina, Peru and South Africa are in the same hemisphere as Chile, their avocado harvest season is different than Chile's and thus they complement each other. The availability of fruit throughout the year is a critical component in developing a new market. If suppliers such as Peru, South Africa, the small Argentine avocado industry, and Chile could share the marketing and development effort, there is potential for significant growth in the Argentina market.

Current returns to Chilean growers for domestic avocado sales range from $US0.80 to $US0.88 per kg for fruit over 170 gm. The Chilean market, however, can absorb only a certain volume with the current per capita consumption rate and distribution system. The Comité de la Palta, which is currently only an exporting organisation, is contemplating marketing 'Hass' avocados in Chile. An important step for increasing consumption in Chile is price moderation for consumers. This could be achieved by making the supply chain more efficient with more rational margins for all the middlemen involved.

During April/June the demand for 'Hass' avocados in Chile exceeds local supplies. California avocados were previously prohibited from Chile. Regulations have recently changed and export to Chile is now permitted. The fruit must meet certain phytosanitary requirements prior to embarkation.

POTENTIAL IMPACT OF CHILEAN PRODUCTION ON AUSTRALIA

While Chilean production has grown at a rapid rate over the past 6-8 years production in New Zealand has also expanded quickly due to new orchards being planted. The New Zealand industry has also entered the Californian market where it competes directly with Chilean fruit. Both the cost of production and shipment of fruit to the USA market are higher for the New Zealanders than for their Chilean counterparts so it is unlikely that they will survive as well as the Chilean industry if prices fall due to supply exceeding demand. If this scenario develops it is likely that the New Zealand industry will seek to place more fruit in Australia thereby competing directly with local production. There is an increasing supply of summer fruit from Western Australia also due to increased plantings and effective marketing strategies and close cooperation between two countries will be required to maintain margins and develop the market in an orderly and profitable

Fig. 2: Huerto California nursery, Quillota. 'Hass' avocado trees immediately prior to field planting have been sprayed with white wash to protect against sun damage

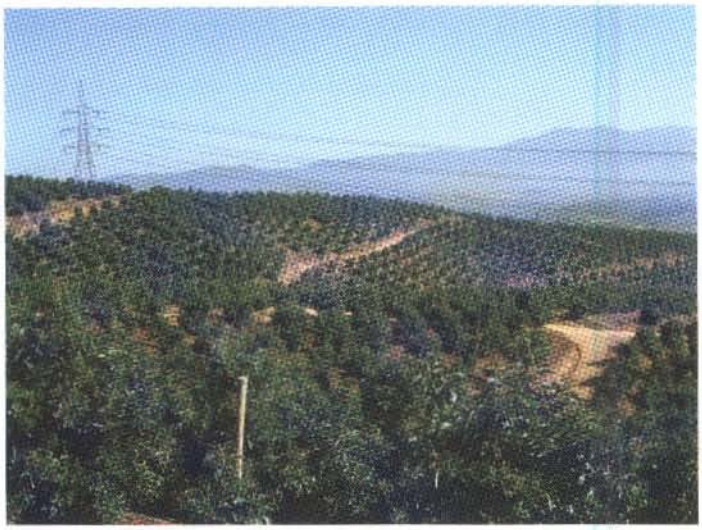


Fig. 3: A new hillside 'Hass' orchard near Quillota in the Aconcagua river valley.

Fig. 4: Phytophthora root rot which started at the top of the slope and worked its way down the hillside. 'Hass' trees are grafted to seedling 'Mexicola' rootstocks which respond poorly to phosphonate treatment.

manner. However, there is one school of thought that suggests that the USA market (outside California) has huge growth potential and that Chilean, Mexican and New Zealand fruit will assist in stabilising supply thereby assisting with the development of this market – something that the Californian industry has been unable to achieve due to their–"off/on year" cycles. While this is an optimistic view there is little doubt that there is room for more fruit in the US market although hiccups along the way can be expected and these may ripple across into the Australian domestic market.

PRODUCTION REGIONS

Avocados have been grown in Chile since the mid-1800's with the initial seeds thought to have come from Peru. Roger Magdhal first brought the 'Hass' avocado to Chile in 1935, three years after it was patented in California. The expansion of Chilean avocado plantings began in areas where good soils, favourable climate and quality water were abundant. Today many new plantings are on marginal soils, often on hillsides, with poor water quality of limited availability and the potential for occasional freezes. Prior to the initiation of exports to the US the avocado varietal composition in Chile was diverse, with 'Hass', 'Fuerte', 'Negra de La Cruz', and 'Bacon' the dominant varieties grown. Today, 75% of the avocado trees in Chile are 'Hass'. 'Edranol', 'Bacon' and 'Zutano' are used as pollinisers while 'Negra de La Cruz' which is a popular, late season Chilean selection is grown for local consumption.

ANVAS Accredited Nurseries

ANVAS accredited trees can be purchased from the following nurseries:

Anderson's Nursery
Graham and Viviene Anderson
Duranbah Road, Duranbah NSW
Phone: 02 6677 7229

Batson's Nursery
Merv and Pat Batson
Schulz Road, Woombye Qld
Phone: 07 5442 1657

Birdwood Nursery
Peter and Sandra Young
71 – 83 Blackall Range Rd, Nambour Qld
Phone: 07 5442 1611

Rainforest Nursery
Ron and Joan Knowlton
25 Reynolds Street, Mareeba Qld
Phone: 07 4092 1018

There are three major avocado growing regions in Chile, which are presented in order from north to south.

1. The valleys of the Petorca and La Ligua rivers

This region is the area with the most significant new plantings and represents 35% of the total 'Hass' plantings in Chile. 'Hass' is the main variety grown in this region. 'Edranol' is the main pollinisers variety and to a lesser extent 'Zutano' and 'Bacon' are also used. These river valleys which cross Chile from the Andes to the Pacific ocean have varying climatic conditions which are a function of their proximity to the coast. The areas of La Ligua and Longotoma, which have the greatest marine influence, have a dry cloudy summer with an average relative humidity around 70% and average temperatures of 16°C. In the inland valleys, where the marine influence is reduced, the average temperature is about 23°C, and the average relative humidity is 45%. Average annual rainfall is 150-200 mm for the region.

Irrigation water comes from two rivers that flow above ground only intermittently. Water availability is a limiting factor since the mountains supplying these valleys are not as extensive and are not as high as other ranges that provide water for agriculture in Chile. Therefore 95% of the orchards are irrigated using either shallow or deep wells. Almost all growers irrigate via pressurised irrigation with a preference for micro-sprinklers. Water quality is good, with electrical conductivity (EC) of 0.4 decisiemens/meter (dS/m) (Colorado River water, in contrast, is 0.9 – 1.0 dS/m) with a pH slightly above neutral (7.2-7.5). Even though soil quality and climatic conditions can be outstanding for growing avocados, these areas are probably near their maximum potential for planting. In the event of drought in Chile these valleys are likely to be the most affected since the water supply will deplete quickly.

There are 2 dominant soil types:

1. Light alluvial sandy alkaline soils (pH greater than 8) which are deep, poor in organic matter content and contain large quantities of rocks. The rocks help drainage and help maintain high soil temperatures.
2. Marine deposits are the dominant soils of the hillsides. They are not uniform, but are generally poor, shallow, alkaline and often affected by high levels of carbonates. They are clay soils with low organic matter content. Generally, orchards on hillsides are planted on artificial mounds usually running up and down the hill and in a north-south direction when possible.

2. The Aconcagua Valley

The Aconcagua River provides good quality irrigation water (EC 0.7 dS/m) with low sodium and chloride, to this traditional centre of avocado and citrus growing. Like the Petorca and La Ligua valleys, the Aconcagua valley represents 35% of the Chilean 'Hass' plantings. Some of the well-known localities for avocado growing in Chile are Panquehue, Llay-Llay, Hijuelas, La Cruz and Quillota. Many of Chile's nurseries are located in this zone; including the Magdahl family's renowned Huerto California Nursery (Fig. 2). This region has also experienced a large expansion of new plantings, mainly on hillsides since the flat land was already planted to avocado and other crops (Fig. 3).

Most of the old irrigation systems (flood or furrow) have been converted to pressurised systems, with micro-sprinklers as the preferred emitter. The valley floor consists of deep sedimentary soils of alluvial origin. Soil texture is light clay with clay substrate deeper in the profile. There are gravel/stones within the soil which has moderate permeability and organic matter content of 1–1.25%. Hillside soils are granitic in origin, are poor, with mild to heavy clay, and have an organic matter content of 0.5-0.75%. Average summer relative humidity is 55-60% and average annual rainfall is 423 mm. Average annual temperatures are 15.5°C with the maximum temperature around 27°C and minimum around 5.5°C.

3. The Maipo, Mapocho and Cachapoal river valleys

This region is extensive and includes the Metropolitan region of Chile's capital city Santiago, and the area south of Santiago. It represents approximately 15% of the total Chilean 'Hass'

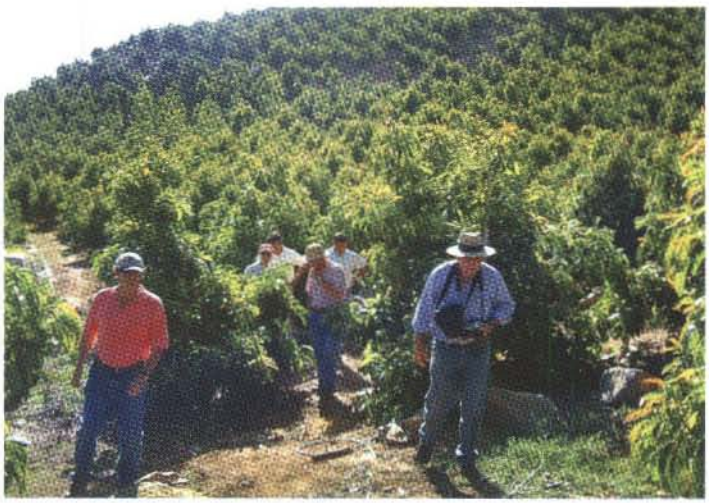


Fig. 5 High density 'Hass' at Llay Llay. The trees are planted 3 x 3 m on seedling 'Mexicola' rootstock.

Fig. 6: Large new plantings of 'Hass' are occurring on the shallow soils of the sides of the river valleys. Extensive mounding is carried out to improve soil depth and drainage.

plantings. Well-known localities are Mallarauco, Naltagua and Melipilla by the Maipo and Mapocho rivers and the localities of Peumo/Las Cabras by the Cachapoal River. New plantings in this zone are also extensive but more limited due to lower average temperatures and the high potential for freeze. As in California, growers minimise their risk by planting on hillsides where cold air can flow to lower elevations. This area has dry summers with warm temperatures (35°C maximum) and cold (as low as -5°C), wet winters with annual rainfall averaging 725-775 mm. Water quality of the Maipo and Mapocho rivers is poor. The water is hard, alkaline, with a pH near 8 and EC greater than 1.2 dS/m. There are many orchards, especially in the vicinity of Mallarauco, with severe tip-burn and poor production due to excessive chloride in the irrigation water. The region of the Cachapoal River is less affected by salinity (water EC is 0.6 dS/m). There is abundant water and drought rarely occurs. Many growers in this region still irrigate by flood irrigation although plantings, especially on hillsides, use pressurised systems. The soils are generally deep, with light to moderate clay with about 1.5% organic matter content. Hillside soils are variable in quality, thin, poor, and shallow, with moderate to heavy clay content. Average summer relative humidity for both valleys is 76-77%. Average annual temperatures are 14°C. This region was severely affected by a freeze in June, 2002 when air temperatures plummeted to -5°C resulting in total defoliation of large trees and damage to fruit and limbs.

4. Other regions

In the last few years, there have been limited new plantings in additional locations such as the interior portions of the three regions discussed above as well as the Ovalle and La Serena valleys, which are located 150 to 200 miles north of Santiago. These new and limited production zones, where citrus and table grapes have traditionally been grown, have higher temperatures and fruit is harvested 1-2 months earlier than the in coastal areas. In La Serena there are dramatic temperature and humidity differences between the coastal area and the not too distant interior valleys. All these marginal areas represent about 10% of the total 'Hass' plantings in Chile.

PESTS AND DISEASES

Chile is blessed with having only a few pests and diseases. Red Spider mite (*Oligonychus yothersi*) is controlled by application of oil or wettable sulphur. Miticides are used only during severe infestations. Thrips (*Heliothrips haemorrhoidalis*) are left alone and are only controlled during severe infestations by mineral oils and Chlorpyrifos. A characteristic of the avocado production in Chile, which unfortunately was lost in California due to the introduction of the Persea mite (*Oligonychus perseae*), and the avocado thrips (*Scirtothrips persea*), is the limited use of chemical pesticides. Most of the products used are oils, soaps and sulphur. Growers often leave control of possible pests to natural predators and IPM strategies. Although Chile is geographically isolated, there have been several occurrences of Mediterranean fruit fly over the years. The source of the fruit fly infestation is thought to be either Argentina or Peru. These infestations forced fruit to be quarantined in a manner similar to the event that took place in Ventura, CA in 1997-1998.

The occurrence of root rot (*Phytophthora cinnamomi*) is currently limited and is much less severe than in California or Australia. Some suggest that the lower occurrence of root rot is due to the fungicidal effect of high copper content in the soils, and to a limited extent in the irrigation water. However, the arid climate together with a relatively young industry is more likely the reason for the current status. There is little doubt that where conditions are marginal for production and the disease is introduced its effects are just as devastating as anywhere else in the world where the crop is grown (Fig. 4). About 95% of the Chilean trees are grafted to seedling 'Mexicola' rootstock that is notoriously sensitive to Phytophthora root rot. The disease invades both the primary and secondary root systems and invariably there are poor responses to phosphonate fungicides as there is little healthy root structure left to enable root regeneration by the time symptoms are evident.

There is little to no rain during the harvesting months in Chile and postharvest decays are substantially lower when compared to growing areas with high rainfall such as Australia, New Zealand and South Africa.

CULTURAL PRACTICES

The following discussion represents the majority of the relatively young Chilean avocado orchards. Most of the trees in Chile are grown either on seedling 'Mexicola' rootstock or, more recently, in areas of poor water quality, on 'Nabal', which is thought to be salt tolerant. In the last few years, in response to pollination studies conducted by students at the Catholic University of Valparaiso, the variety 'Edranol' has become the preferred 'B' type pollinisers variety. The Chilean advisors recommend 11% of the total planting to be planted to pollinisers. What is unusual about 'Edranol' is that, although a well-liked fruit, it produces very little if any crop but consistently flowers profusely in Chile and is planted strictly for pollination purposes. There is a lesson to be learned by California avocado growers who have been struggling with which "B-type" flower variety to plant. The Chilean argument is that 'Edranol' is such a good pollinisers that the increased production of the surrounding 'Hass' trees more than compensates for the 'Edranol's' lack of productivity. In California, the search for replacement to the traditional pollinisers varieties by 'Hass'-like varieties is somewhat misdirected. The foremost purpose of a pollinisers variety is to do the best job providing abundant quality pollen, and 'Zutano' and to a lesser extent 'Bacon' are well suited to do the job! To assist in pollination, honey bees are introduced to the orchards at the recommended rate of 10 beehives/ha. A third of the colonies are brought in prior to or at the initiation of bloom and the rest during peak bloom. Recently, a service providing bumblebees for pollination was introduced in Chile, but the cost-benefit remains questionable.

Planting, canopy management and production costs

Land prices vary depending on the location and on the potential for future residential or commercial development. In well-suited avocado areas, land prices can range from $US7000 to $US30 000/ha. Land on hillsides where generally mostly avocados are grown, can fetch $US1000 to $US4500/ha, depending on water

availability and pumping requirements. An irrigation system with micro-sprinklers costs between $US3000 and $US5000/ha. Nursery grown trees on seedling rootstocks cost about $US4 each. The irrigation system and trees normally constitute 50-70% of the total cost of planting a new orchard. By the fourth year when commercial harvest commences, a grower with a 60-ha orchard will have invested around $US10 000/ha.

The normal planting density for 'Hass' is 6 x 6 m with an additional tree on the diagonal, which is later removed. Other plantings are at 3 x 6 m. Some progressive growers have planted a ultra-high density of 3 x 3 m (about 1100 trees/ha) (Fig. 5) and girdle 1-2 branches in the second year to encourage early fruiting. Due to mild temperatures and appropriate fertilisation regime, trees don't grow as fast as in California and such densities can be maintained for a few years especially when careful irrigation and well monitored and balanced fertiliser regimes are practiced. Current hillside plantings are mostly done on mounds to improve soil depth. These are 6 m apart, approximately 1.8 m wide at the base, sloped to a height of 1.2-1.5 m and are about 600 mm wide at the top (Fig. 6). The trees are planted either 4 or 6 m apart along the mounds. The mounds are usually run down the hillside for better water and air drainage.

Pressure-compensating micro-sprinklers are used to ensure a high level of distribution uniformity for these unique systems.

The production costs per ha in Chile are between $US1200 and $US2000 per year. This includes harvest, pruning, and all other direct costs. Two important factors affecting production costs are the size of the orchard and the slope of the terrain. Labour accounts for 50-60% of the costs, and fertilisers and energy, mainly for pumping water, account for 10% each. Picking is carried out by local farm labour hired by the grower. The cost of harvest is about $US0.20/kg. The minimum wage in Chile including associated costs and benefits (oncosts) is $US6 per day for farm labour. Chilean growing conditions are less stressful to the 'Hass' avocado than the conditions in most production areas of California. In general, good quality mature orchards produce an average of 11-13.5 tonnes/ha/year. There are orchards, in areas with ideal climatic conditions during flowering and fruit set, with sustained average production exceeding 22 tonnes/ha.

Tree pruning and canopy management: This is a new concept with which Chilean growers are attempting to come to terms with. One advantage they have over California growers is the availability of plant growth regulators (PGRs) such as Sunny®, Cultar® and NAA®, which have proven to be extremely effective in Chile and elsewhere (Australia, Israel, South Africa) in improving productivity and the control of canopy size and shape. These materials are very expensive and are not used routinely in Chile. The CAC Production Research Committee is currently funding Dr Carol Lovatt to establish efficacy data on new PGRs such as Apogee®, a likely candidate to be permitted for use on avocados (note: Apogee® research on avocados has also recently started in Australia).

Irrigation: Because of the Mediterranean climate and the lack of adequate rainfall between August and May, irrigation is essential. Many of the older commercial orchards have converted from canal irrigation to pressurised systems. Modern irrigation is managed mainly through two systems: evaporation pans (or computerised weather stations that indicate evapotranspiration) and tensiometers. Tensiometers are used to control and monitor this water use and to indicate the irrigation needs during winter. Ideally, growers try to use both systems. The Chilean grower prefers to vary the irrigation frequency and keep the duration of the irrigation event constant. It is common, when micro-sprinklers are used, to irrigate every 5-12 days during the dry summer. Drip irrigation is sometimes used during the first year after planting to provide better control of the amount of water and fertiliser each tree receives and for more efficient weed control. Normally by the second year the drip system is converted to micro-sprinklers. There are some plantings that use drip irrigation, based on the recommendation of foreign consultants (mainly from Israel), but prolonged use of drip irrigation is not common. The use of micro-jets, which have a more limited and focused throw, has increased due to higher density planting and the use of mounds when planting on hillsides. Currently, new research is being conducted utilising pulse irrigation systems, which provide several pulses of irrigation per day. Water requirements are monitored by dendrometers that measure the diurnal fluctuation of the girth of the trunk, limbs and leaves.

One important difference between avocado production expenses of California and Chile is the cost of irrigation water. In the Quillota area (Aconcagua basin) for example, water cost is not higher than $US125/ha/year. Water availability and water

quality are much more important to the Chilean avocado grower. In California, although water quality has been an important issue, the cost of the irrigation water is the most critical. In areas with salinity problems the irrigation volumes are increased by 20-30% to provide leaching and to prevent the accumulation of salts in the soil. Soil variability and the availability of reliable weather data are important issues for growers, especially when marginal soils and poor quality water are used. Francisco Gardiazabal, a highly respected researcher/consultant in Chile, has been conducting a study to establish new crop coefficients (Kc) for use on avocado in Chile. Table 1 lists the currently used crop coefficients (as compared to those we use in California) and his proposed new values.

***Fertilisation*:** Fertiliser application is primarily limited to nitrogen (N) and potassium (K), although minor amounts of boron and zinc are also applied. The general rate of application is 110-195 kg of elemental N/ha. The use of K is controversial. Some advisors, influenced by Spanish researchers, do not recommend the addition of any K, while other consultants recommend 39-60 kg of elemental K/ha in the form of potassium nitrate (this is considered excessive by Californian and Australian standards and is not supported by Chilean research results). Zinc, in the form of zinc sulphate, is applied at the rate of 20-24 kg/ha and boron in the form of boric acid is applied at the rate of 39-78 kg/ha. Often, especially in alkaline soils, the total application of these micronutrients is buried in shallow holes at the four corners of the tree or in a band along the drip line. Most Chilean avocado growers have leaf analyses performed annually, while soils are analysed less frequently.

***Organic production*:** Organic production has been slow to take hold and is constrained by certain limitations. Even though the pest pressure in avocado orchards in Chile is low and the use of pesticides is limited, the main limiting factor is the availability of a good and reliable source of organic nitrogen. The cost of organic fertilisers, which are always in high demand for use in avocado orchards and in other crops, in addition to the transportation and handling costs of large volumes of manures and other bulk organic products, limit the adoption of organic farming.

***The Chilean educational system*:** The Chilean educational system is superb, producing many professionals with an uncanny determination to work hard, learn, and excel. The Catholic University of Valparaiso is where the majority of the subtropical fruit research is conducted. Under the watchful eyes of Francisco Gardiazabal, their major professor, students are required to produce after graduating from college a significant, albeit one year in length, research project, and a final report in order to receive their degree in Agronomy. The experiments are well designed and executed, and include a comprehensive literature review of the subject and rigorous statistical analysis.

In the last 10 years the research, which is very pragmatic in nature, has been concentrated on subjects such as avocado phenology under Chilean conditions, nutrition and fertilisation, irrigation, pruning, tree manipulation with growth regulators and girdling, the use of honey bees and other insects, fruit set and the selection and use of pollinisers, and the evaluations of new varieties from local and international sources. This practical approach to research is enhanced by the participation of technical people and advisors who are close to the grower community and to the industry. The research activities are not funded by the industry and financial support is available mainly through the initiative and vision of individuals within the industry. An unfortunate problem with the research performed in Chile is that the results are not published in any national journal and are difficult to access. These valuable studies are only available in the library of the universities where the research was conducted. This author (Reuben Hofshi) has requested those

Table 1: A comparison of crop coefficient (Kc) values used in Chile and California.

Month		Current crop coefficient (Kc) values		Proposed Kc values for
Chile	**California**	**Chile**	**California**	**Chile**
January	July	0.72	0.65	0.72 – 0.75
February	August	0.65	0.65	0.72 – 0.75
March	September	0.58	0.60	0.72 – 0.75
April	October	0.58	0.55	0.72
May	November	0.58	0.55	0.72
June	December	0.52	0.50	0.72
July	January	0.52	0.40	0.72
August	February	0.52	0.50	0.72
September	March	0.58	0.55	0.72
October	April	0.58	0.55	0.72
November	May	0.65	0.60	0.72 – 0.75
December	June	0.72	0.65	0.72 – 0.75

with access to these works to post summaries in Spanish or English on an accessible web page (now at www.avocadosource.com). Some representative summaries of the research these young agronomists conducted will be presented in future issues of AvoResearch.

***Consulting*:** In Chile, a system of technical consulting and advising has been established as part of the duties of the field personnel of the fruit exporting companies. The growers have accepted this service as an integral and important part of the service the exporting companies provide. These technical consultants are mostly agronomists who have specialised as field representatives and who also provide technical assistance for each type of exported fruit. This system is beneficial to the growers and also helps the exporters predict and control the volume, size, and quality of fruit they ship. In addition, and often in place of company agronomists, many large growers use independent consultants/farm advisors, to help them with the technical aspects of their orchards.

These consultants are highly trained, well travelled, and have intimate knowledge of international avocado research and cultural practices. Some growers who employ private consultants believe that it is difficult for the field representatives, although well trained, to be up to-date in the technical management aspects of their orchards. The crop is valuable and an educated opinion from a different perspective is good insurance.

There is no extension service or government sponsored farm advisor service in Chile. In recent years international consultants have begun advising and setting up experimental plots in Chile. These arrangements are expensive and are often limited to only those growers associated with certain exporting companies. Sharing of experiences and specific information dissemination is more difficult under these circumstances. The basic text in Chile is a book titled 'Cultivo del Palto' (Cultivating the Avocado), by F. Gardiazabal and G. Rosenberg, 1990. This book even today, is a fine compilation of information gathered from around the world but with a Chilean perspective.

Growers under the umbrella of the Comité de la Palta are provided with one important meeting per year in which political, strategic, and technical issues are discussed. This meeting attracts from 800-1000 people representing all aspects of the avocado industry. There are also seminars from time to time run by various organisations, mainly concentrating on the technical aspects of growing avocados. Otherwise, there are very few organised industry-wide meetings such as those held in California. Some exporting companies have held growers meetings inviting foreign experts for well-attended seminars and others have taken their growers to visit other avocado industries in different countries. A large number of Chilean growers attend international avocado events, such as the World Avocado Congress. The Chilean industry is for the most part, open and transparent, a trait learned from the openness and generosity of other industries such as Australia, Israel, South Africa, Spain and the US.

***Quality assurance and food safety*:** Walking into a modern avocado pack house in Chile is an experience in sanitary discipline we should all learn from. Most growers and exporters in Chile are getting involved in a program developed by the Chilean Export Association (ASOEX) known as "BPA" (Buenas Prácticas Agrícolas), which means "Best Agricultural Practices". The program's objectives are to assure sanitary quality of the fruit, environmental conservation, product-traceability, and safety for both field and pack-house personnel. Additionally, most of the pack-houses have international inspectors to certify quality assurance practices. USDA-APHIS inspects the Chilean avocados before embarkation and issues a phytosanitary certificate.

Upon arrival at destinations in the US, USDA will again inspect the fruit. The inspectors use the Florida Avocado Standards (a federal standard) to ascertain that the fruit meets minimum quality standards. CDFA, during the early part of the export season, will test fruit arriving in California to insure that the fruit meets California's minimum maturity standards although measuring dry matter content of the fruit 2-3 weeks after harvest is questionable. Implementing a standardised testing protocol that is easy to use, similar to the one being developed currently in California, could entice the Chilean industry to officially test fruit destined for export to the US prior to shipment. The most popular food safety program is called HACCP (Hazard Analysis Critical Control Point), which is an internationally recognised food safety methodology that provides the framework for hazard identification and control. Some progressive companies have implemented this program and are contemplating the implementation of an ISO (International Organisation for Standardisation) protocol. ISO sets out the methods that can be implemented in an organisation to assure that the customers' requirements are fully met. The organisation's requirements will be met both internally and externally and at an optimum cost, resulting in efficient utilisation of the resources available including material, people, and technology. The Chilean avocado industry is export oriented and is quick to implement requirements and standards requested by importers, especially those with strict standards such as Europe and Japan. Soon the California avocado industry will be called upon to do the same and the sooner we begin working down this track as an industry the better it will be for all of us. Various pack houses in California have been experimenting with different quality assurance programs. Initial steps were recently taken by CAC when it created a new Quality Task Force chaired by Roger Essick. The mission of this taskforce is to examine all aspects of fruit quality and fruit safety from the tree to the consumer.

CONCLUSION

One can only be amazed at the progress achieved by the Chilean avocado industry in the last 10 years with respect to their modernisation, innovation, and rapid adaptability to new techniques. They are not frightened to import and pay for new technology and expertise developed in other countries and work at adapting it for local conditions. Everyone participates in the changes that benefit the industry as a whole although the industry is fragmented. The Chilean growers are capitalistic and are as secretive as any California/Australian grower, but they have a common denominator - they recognise and continually work on improving the industry in all its aspects for the benefit and profitability of the industry as a whole.

The Role of Rootstocks, Nutrition and Antifungal Compounds in Resistance of Avocado to Anthracnose

By Dr. Sonia Willingham (QHI, Indooroopilly DPI)

In this article on the rootstock research conducted by the Fruit Pathology team at Indooroopilly (Dr. Lindy Coates, Ken Pegg, Jay Anderson, Tony Cooke, Jan Dean, Fiona Giblin) during projects AV97001 and AV01004 has been summarised to date.

Natural Disease Resistance...

Plants naturally have a range of highly effective defence mechanisms to protect themselves from attack by pests and pathogens. These defences can be physical and biochemical barriers to infection and may be preformed or inducible.

In avocado, specific preformed antifungal compounds called dienes have been identified. These antifungal dienes are usually concentrated in the outer layers of the fruit, and are in highest concentration in the skin and thus act in the first line of defence. However, because dienes are quite toxic, they naturally decline once the fruit reaches a certain stage of maturity and starts to ripen.

This decline in antifungal concentrations has been found to co-incide with an increase in the fruits susceptibility to disease. Once the antifungal compounds have declined past a certain concentration, quiescent infections such as anthracnose, resume development and disease symptoms appear.

Plant resistance depends on a number of factors such as:

1) **plant part or tissue**;
2) **plant age** – plants usually become more susceptible with age, although the reverse can also be true, for example young citrus fruitlets are most susceptible to black spot (*Guignardia citricarpa*) during the first 5 weeks after petal fall;
3) **environmental factors** – for example temperature, light and moisture; and
4) **cultural factors** – for example plant nutrition and rootstock.

Plant Nutrition and Disease...

The effects of plant nutrition on disease susceptibility has been well documented for many years now. Each essential nutrient, and one non-essential nutrient (Si), has been shown to influence disease severity or incidence. However, the effects of each nutrient on disease susceptibility can be quite variable and a particular nutrient may decrease the severity of one disease but increase others.

Different mineral nutrients can affect disease susceptibility in a number of ways. Nitrogen (N) and manganese (Mn) can directly affect the production of defence compounds produced by the plant. Nitrogen can directly affect the production of defence compounds (and thus disease susceptibility) by influencing the rate of metabolism in the plant. Excessive use of N fertilisers has been found to decrease the production of defence compounds by pushing more energy towards primary metabolism (eg. growth) and away secondary metabolism, which includes the production of defence compounds.

Many of the enzymes involved in the production of defence compounds in the plant require Mn, so anything that affects the availability of Mn can indirectly affect the production of defence compounds. One factor that has been shown to decrease the availability of Mn in the soil solution is the excessive use of inorganic N fertilisers and their nitrification. Thus, N can impact on defence compound production in two different ways.

Calcium (Ca) is another very important nutrient for disease resistance. High concentrations of Ca have been shown to reduce disease in some fruits by strengthening and thickening the fruit cell walls and therefore restricting access to the cell walls and middle lamella by fungal enzymes. Silicon has also been shown to enhance resistance by strengthening cell walls. Also, by increasing Ca or Si concentrations and strengthening fruit cell walls, we may be able to prevent tissue maceration and therefore delay the 'attack' signal to the fungus.

Rootstock and Disease...

Rootstock is another cultural factor that has been found to be important for disease resistance in a number of crops. In our avocado research we've found that rootstock can have a very significant impact on fruit susceptibility to postharvest anthracnose. Research generated from our previous project AV97001 discovered that when we have 'Hass', which is of Guatemalan origin is grafted to 'Velvick' rootstock, which is also of Guatemalan origin, we have low levels of anthracnose compared with 'Hass' grafted to a Mexican race rootstock such as 'Duke 6'.

In our first study in 1999, we looked at a block of young trees, around $3^1/_2$ years old grafted to different rootstocks and planted in adjacent rows in the same block of the orchard at Duranbah, northern NSW. 'Hass' fruits on the 'Velvick' rootstock took slightly longer to ripen, had less severe and lower incidences of anthracnose and more marketable fruit than 'Hass' on 'Duke 6' (Table 1).

We then repeated this study on an older block of trees (ca. 8 years old) in the same orchard. Again we found 'Hass' fruits on 'Velvick' rootstock had less severe and lower incidences of anthracnose and more marketable fruit than 'Hass' on the Mexican 'Duke 6' rootstock (Table 1).

These differences in anthracnose susceptibility were related to differences in concentrations of antifungal dienes in the leaves and mineral nutrients in the leaves and fruits from trees grafted to different rootstocks. Leaf diene concentrations were up to 1.5 times higher in 'Hass' trees on the 'Velvick' than the 'Duke 6' rootstock (Table 2). In ungrafted nursery stock trees, diene concentrations were around 10 times higher in 'Velvick' than 'Duke 6' leaves (Table 2).

The Mexican 'Duke 6' rootstock was also accumulating more N than the Guatemalan 'Velvick' rootstock which resulted in an imbalance of the N/Ca ratio that is well known to be detrimental for sound fruit quality and disease resistance (Table 3). A significant correlation between anthracnose severity and skin N/Ca ratio was also evident (Figure 1).

This strong nitrogen effect resulted in our research team conducting a N fertiliser study on this block of trees. In the 1999/2000 and then again in the 2000/01 season, three N fertiliser regimes were imposed across both rootstocks. Our three treatments were 1) control - standard grower rate (13.3% NH_4-N per tree per month), 2) nil N – no fertiliser and 3) high N - double the standard rate (26.6% NH_4-N per tree per month). Monthly fertiliser applications commenced at flowering and continued until fruit harvest.

The N fertiliser effect was not evident in the trees until the second season of the experiment. In 2001, there was significantly less severe and a lower incidence of anthracnose in fruits from the low N trees compared with the control and high N trees (Figure 2). This corresponded with a significantly lower concentration of N in the skin of fruits from the nil N trees (Figure 3).

In both seasons we were once again seeing a very strong rootstock effect with 'Hass' on 'Velvick' with significantly less anthracnose and more marketable fruit than 'Duke 6' (Table 4). Fruits from the 'Velvick' rootstock also had significantly lower concentrations of N and K and a higher concentration of Ca compared with 'Duke 6' (Table 5). This resulted in a more favourable N/Ca ratio and a positive correlation between the N/Ca ratio and anthracnose was again evident (Figure 4).

Currently, we have expanded our N fertiliser studies by looking at the effects of N source, nitrate vs ammonium, on anthracnose susceptibility across the two rootstocks. The previous N rate experiments used an ammonium-N based fertiliser. In this experiment two similar rates of a nitrate-N based fertiliser were applied to give five treatments across the two rootstocks namely, 1) nil N'– no fertiliser applied, 2) control - standard rate (13.3% NH_4-N per tree per month), 3) high ammonium - double rate (26.6% NH_4-N per tree per month), 4) control nitrate –standard rate (13.3% NO_3-N per tree per month and 5) high nitrate – double rate (26.6% NO_3-N per tree per month). Monthly fertiliser applications commenced at flowering and continued until fruit harvest.

The first season of this study was completed in 2002, but a nitrogen fertiliser effect on anthracnose has not been detected yet. There were however, some very consistent trends showing up across both rootstocks. Nitrogen source rather than rate may be having a larger effect on disease (Figure 5). The nitrate rates, on average, tended to have more anthracnose than the ammonium rates. There also seemed to be larger differences in disease levels between the ammonium rates than the nitrate rates.

For the ammonium treatments, there was a consistent trend for anthracnose to be increased when the rate was doubled, but a trend for anthracnose to be slightly reduced when nitrate rates were doubled (Figure 5).

Another interesting trend, that was quite consistent, was that there seemed to be larger treatment differences in anthracnose between fruits on the 'Duke 6' rootstock than the 'Velvick' rootstock (Figure 6). As is evident in Figure 6, there was still a strong rootstock effect on anthracnose susceptibility with 'Velvick' having less severe and a lower incidence of anthracnose and a higher percentage of marketable fruit than 'Duke 6' (Table 6).

All of the treatments had significantly higher concentrations of N in the skin tissue than the nil N treatment (Figure 7). There were however, no significant differences between the fertiliser sources or rates, although there was a slight trend evident for the nitrate to have higher N concentrations, which supports the trends in the disease data.

Last season an experiment to compare the disease susceptibility of 'Hass' fruits from three other Guatemalan race rootstocks with a Mexican race rootstock was also conducted. The three Guatemalan rootstocks were 1) 'A8' and 2) 'A10' – Anderson's 8 and 10 which were seedling selections made in the 1930's from a tree at the Plant Introduction Centre (now Tropical Fruit World) at Duranbah and 3) 'Nabal'– a parent of Reed. The Mexican rootstock was 'P1', which was brought over in 1984 from the Californian breeding program. Similar to the other rootstock studies, these trees were planted in adjacent rows in the same block of the orchard at Graham Anderson's property at Duranbah.

'Hass' fruits from the Guatemalan rootstocks 'A8' and 'A10' had significantly less severe anthracnose than fruits from the 'P1' Mexican rootstock trees (Table 7). Fruits from 'Nabal', the other Guatemalan rootstock had disease levels only slightly and not significantly lower than the Mexican rootstock. The 'P1' Mexican rootstock had a lighter crop load than the Guatemalans but had similar sized fruit (Table 7).

The Guatemalan 'A10' rootstock also had a significantly lower concentration of N and all three Guatemalan rootstocks had lower and thus more favourable N/Ca ratios than the 'P1' rootstock (Table 8). The 'A8' and 'A10' rootstocks also had higher or more favourable Ca+Mg/K ratios than the Mexican rootstocks (Table 8).

Conclusion...

To conclude, our studies over the past four seasons have shown that rootstock can have a significant impact on postharvest anthracnose susceptibility by influencing the accumulation of mineral nutrients and antifungal diene compounds in the scion tissue. We have also observed that N applications can increase fruit susceptibility to anthracnose.

Preliminary results have also indicated that nitrate-N may increase anthracnose compared with ammonium-N based fertilisers, especially on the Mexican 'Duke 6' rootstock.

By August this year we will have completed our second season of the N source fertiliser study and hopefully we will confirm the trends observed last season on anthracnose and nutrient concentrations. As part of our continuing rootstock studies we will also be evaluating the effect of N fertiliser source on diene accumulation in the fruit skin tissue across the two rootstocks.

For further information, please contact Dr. Sonia Willingham on sonia.willingham@dpi.qld.gov.au

ACKNOWLEDGEMENTS:

The team wish to thank Graham Anderson and Harold Taylor, Duranbah. The research was funded by the AAGF, HAL, CRC Tropical Plant Protection and DPI.

Table 1: The effect of rootstock on shelf life, anthracnose and fruit marketability of 'Hass' fruits harvested from young (3 years old) and older (8 years old) trees on 'Velvick' and 'Duke 6' rootstocks. For a fruit to be considered marketable it had to have 5% or less anthracnose severity and no stem-end rot.

Rootstock	Shelf life (days)	Anthracnose (%) severity	Anthracnose (%) incidence	Marketable fruit (%)
Young trees				
'Velvick'	7.0a	7.7b	61.9b	66.1a
'Duke 6'	6.7b	41.8a	93.2a	13.6
Older trees				
'Velvick'	9.1a	15.6b	50.0b	64.5a
'Duke 6'	8.9a	39.5a	77.0a	33.6b

Table 2. The effect of rootstock on antifungal dienes in 'Hass' avocado leaves from young (3 years old), older (8 years old) and ungrafted nursery stock trees on 'Velvick' and 'Duke 6' rootstocks.

Rootstock	Diene (mg/g FW leaf)
Young trees	
'Velvick'	2.45a
'Duke 6'	1.74b
Older trees	
'Velvick'	3.30a
'Duke 6'	2.57b
Nursery trees	
'Velvick'	1.01a
'Duke 6'	0.08b

Table 3. The effect of rootstock on nitrogen concentration and N/Ca ratio of 'Hass' leaves from young (3 years old) trees on 'Velvick' and 'Duke 6' rootstocks.

Rootstock	N (% DW)	N/Ca ratio
'Velvick'	2.3b	0.9b
'Duke 6'	2.5a	1.1a

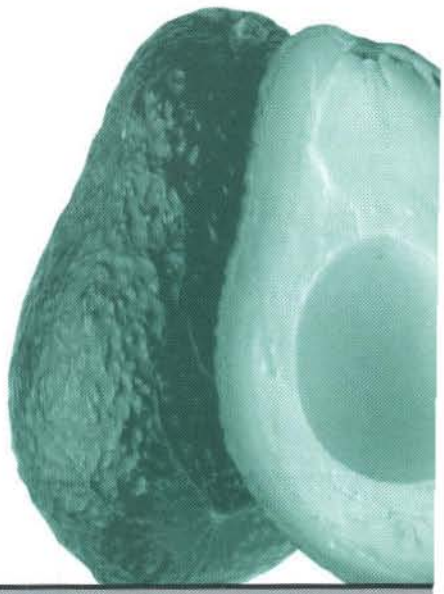


Table 4: The effect of rootstock on shelf life, anthracnose and fruit marketability of 'Hass' avocado fruits from the nitrogen rate fertiliser experiment (2001). For a fruit to be considered marketable it had to have 5% or less anthracnose severity and no stem-end rot.

Rootstock	Shelf life (days)	Anthracnose (%) severity	Anthracnose (%) incidence	Marketable fruit (%)
'Velvick'	10.4a	10.5b	41.7b	76.7a
'Duke 6'	10.1a	28.9a	66.0a	50.7b

Table 5: The effect of rootstock on fruit skin mineral concentrations (% DW) of 'Hass' avocado fruits from the nitrogen rate fertiliser experiment (2001).

Rootstock	N	Ca	Mg	K
'Velvick'	0.90b	0.054a	0.083a	1.3b
'Duke 6'	1.03a	0.045b	0.082a	1.6a

Table 6: The effect of rootstock on shelf life, anthracnose and fruit marketability of 'Hass' avocado fruits from the nitrogen source fertiliser experiment (2002). For a fruit to be considered marketable it had to have 5% or less anthracnose severity and no stem-end rot.

Rootstock	Shelf life (days)	Anthracnose (%) severity	Anthracnose (%) incidence	Marketable fruit (%)
'Velvick'	8.2a	14.7b	38.3b	70.1a
'Duke 6'	8.2a	23.4a	51.1a	55.4b

Table 7: The effect of rootstock (Guatemalan: A8; A10; Nabal versus Mexican: P1) on anthracnose susceptibility and crop load of 'Hass' avocado fruits (2002).

Rootstock	Anthracnose severity (%)	Fruit number	Yield (kg/tree)	Fruit size (g)
'A8'	53.4b	90a	19.7a	221a
'A10'	57.5b	83a	17.8a	214a
'Nabal'	64.4ab	76a	17.1a	228a
'P1'	78.0a	51b	11.5b	227a

Table 8: The effect of rootstock (Guatemalan: A8; A10; Nabal versus Mexican: P1) on fruit skin mineral concentrations of 'Hass' avocado fruits (2002).

Rootstock	N (% DW)	N/Ca ratio	Ca+Mg/K ratio
'A8'	1.19ab	26.9b	0.080a
'A10'	1.08b	23.9b	0.077a
'Nabal'	1.22a	28.4b	0.070ab
'P1'	1.23a	35.0a	0.059b

Figure 1: Correlation between skin N/Ca ratio and anthracnose severity (%) of 'Hass' avocado fruits from 'Velvick' and 'Duke 6' rootstocks.

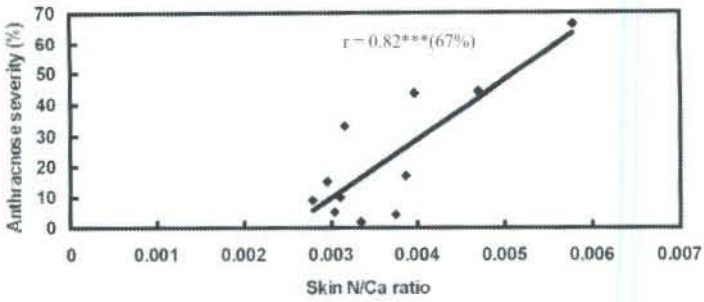


Figure 2: Effects of nitrogen fertiliser on anthracnose in 'Hass' avocado on 'Velvick' and 'Duke 6' rootstocks.

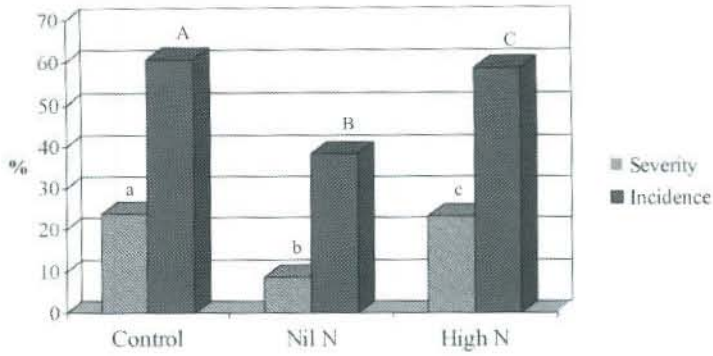


Figure 3: Effects of nitrogen fertiliser on the concentration of nitrogen (N) in the skin of 'Hass' avocado fruits.

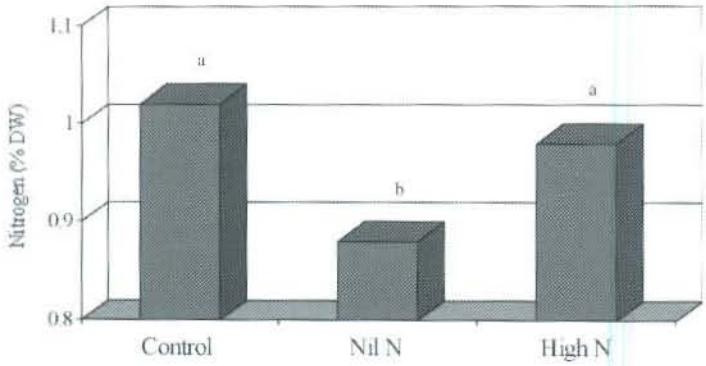


Figure 4: Correlation between skin N/Ca ratio and anthracnose severity (%) of 'Hass' avocado fruits from 'Velvick' and 'Duke 6' rootstocks that had been treated with different nitrogen fertiliser regimes.

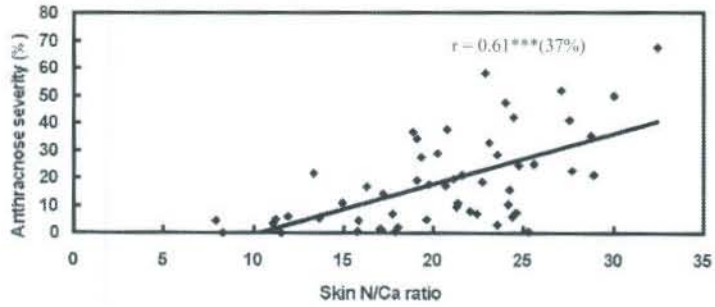


Figure 5: Effects of nitrogen fertiliser source (ammonium, NH_4 versus nitrate, NO_3) on anthracnose in 'Hass' avocado on 'Velvick' and 'Duke 6' rootstocks.

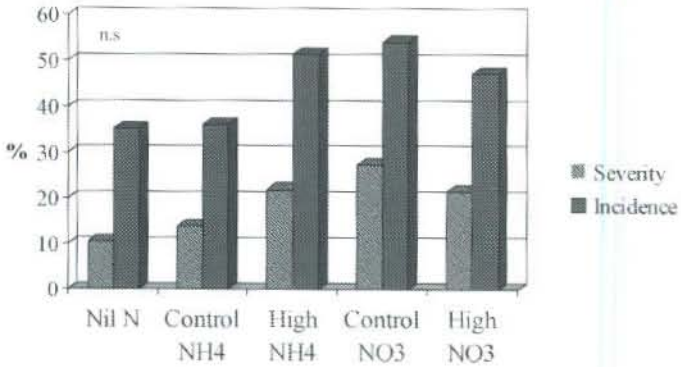
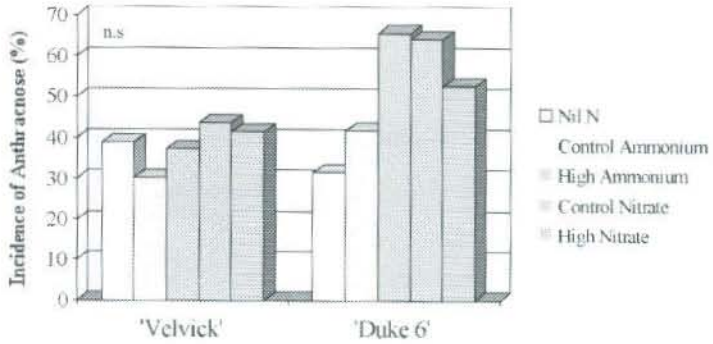


Figure 6: Effects of nitrogen fertiliser source (ammonium, NH_4 versus nitrate, NO_3) on the incidence of anthracnose in 'Hass' avocado on 'Velvick' and 'Duke 6' rootstocks.



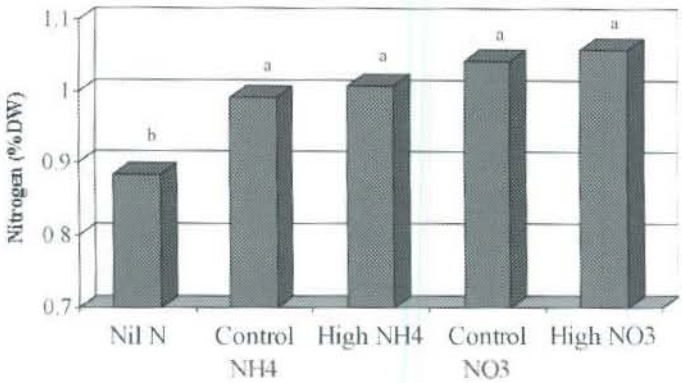


Figure 7: Effects of nitrogen fertiliser source (ammonium, NH_4 versus nitrate, NO_3) on the concentration of nitrogen in the skin of 'Hass' avocado fruits.

Tour to the World Avocado Congress also studies South African and Spanish industries

A tour to the Fifth World Avocado Congress in Spain next October will also offer a valuable opportunity to study the production and packing aspects of the industry in South Africa and Spain. Specifically the tour will study clonal propagation, canopy management, irrigation techniques, and post-harvest management in both countries. As well as providing information of relevance to Australian growers, the tour will provide good opportunities for networking and joint ventures with northern hemisphere producers.

Passengers on the tour would be away from Australia for 19 days, and the tour is attractively priced at $8745.00 per person, twin share.

The tour has been submitted to Horticulture Australia Limited for funding approval, and if successful will allow eligible delegates to receive a 45% subsidy of their costs.

Full details of the itinerary or readers interested in joining the tour are invited to register their interest with:

AgTour Australia Pty Ltd,

Freecall: 1300 301 128

Email: enquiry@agtour.com.au

The official publication of the Australian Avocado Growers' Federation and published in conjunction with Horticulture Australia Ltd.

Produced by: Marketing Line Consultancy
PO Box 58, Sydney Markets NSW 2129

Printed by: Glovers Printing Works Pty Ltd, Bundaberg Qld 4670

Talking Avocados