Final Report

Achieving more consistent yields of quality fruit in the Australian Avocado industry

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Delivery partner:

Department of Agriculture and Fisheries

Project code:

AV14000

Project:

Achieving more consistent yields of quality fruit in the Australian Avocado industry AV14000

Content

Summary

Irregular bearing was identified as a major issue in the Australian avocado industry. An opportunity existed to provide Australian avocado growers with the knowledge required to implement practices that would lead to a more consistent supply of good quality avocado fruit from year to year.

The target audience was Australian avocado producers, many of whom were new to growing avocados. Consultants, advisers and re-sellers were also encouraged to participate so the information could be leveraged to growers.

There were five main activities:

(a) Engage Australia's commercial avocado growers in a series of regional farm workshops where they would learn about practices that would lead to more consistent yields of high quality fruit.

(b) Encourage growers to become more observant in their orchards during the flowering, fruitset and fruit shedding time and therefore be able to implement practices to optimise fruitset and retention.

(c) Encourage growers to make use of the 'Growing' section of the industry's on-line 'Best Practice Resource' (BPR) to get the most up-to-date information on growing avocados. Part of the strategy was to add new information such as reports and videos on a regular basis. The BPR is intended as a 'one-stop-shop' for the Australian avocado industry for information covering all aspects of the industry including comprehensive advice on growing the crop.

(d) Update avocado plant nutrition guidelines after a survey of practices and trends, a review of same by a panel of experts and a literature review of avocado plant research.

(e) Attend the World Avocado Congress IX in Peru in 2015 to network and find out about the latest research and also visit leading orchards in Peru and Chile on the same trip to learn about the latest developments in orchard practices. Co-organising the grower study tour in Chile attended by 12 Australian participants. Extend the information and applicable production practices to the Australian industry.

Key outputs

Forty two workshops were held across all eight major avocado production regions of Australia. 27 of these were organised directly by this project whilst the other 15 were joint (Qualicado) events with Avocados Australia Ltd. Six regions received two workshops per year whilst the two smallest production regions received one per year. Copies of all the presentations at these workshops plus specially prepared comprehensive illustrated minutes from each of the 27 workshops organised by this project were uploaded to the Best Practice Resource so that growers could access the information at any time.

Members of the project team and 28 growers participated in the collection of observations on flowering and fruitset mainly during the 2015 and 2016 flowering seasons on 28 orchards across the country whilst data loggers were used at these sites to record temperature and humidity. The data was analysed and the results presented to growers at the workshops to educate growers about this complex but critical stage of fruit production in order to help them implement practices to improve fruitset and retention. 16 presentations and reports were produced from this exercise and all are available on the BPR.

Three new YouTube videos were produced, shown at grower workshops and made available through the Best Practice Resource. These videos are:

- "Getting boron right in avocados" https://www.youtube.com/watch?v=RPXuGB8Oq1Q

- "How to plant an avocado tree" https://www.youtube.com/watch?v=SDGW1jmhxws

- "Mulching avocados" https://youtu.be/fYYZuNjnvbk

A boron rate worksheet was developed in conjunction with the boron video to allow growers and advisors to calculate customised rates of boron for each orchard situation.

The project team also produced an 'Avo Alert' list for each of the 8 main production regions for each month of the year. An 'Avo Alert' consists of a list of reminders about orchard practices that fall due in that month in that region. Avocados Australia Ltd staff enhance these lists by including live links which take the user to the relevant section of the BPR, and they distribute the 'Avo Alerts' to all known commercial avocado growers.

A review of the recommended avocado plant nutritional practices was conducted and the guidelines in the BPR

updated. This involved a survey of current nutritional practices across the industry, a meeting of experts to discuss practices and trends, a literature search and a re-write of the nutrition guidelines in the BPR.

A comprehensive illustrated report and presentation were produced in 2015 from information gathered during visits to avocado orchards in Peru and Chile whilst in the region attending the World Avocado Congress. The presentation was shown to growers at a workshop in each region and was uploaded together with the report to the BPR.

Key outcomes

Australian avocado growers are now better informed and able to take steps to improve yields and fruit quality and to reduce the amount of irregular and alternate bearing.

Total attendance at the 42 workshop events was 2,613, this is an average of 62 people per event or 496 per round which is comfortably more than 60% of the estimated 682 growers in Australia. Survey respondents each attended an average of 4.3 workshops of the average 5.25 events available to them in each region.

An electronic project evaluation survey was conducted at the end of the project which attracted 106 individual responses. The key outcomes were as follows:

- 89% of respondents said that they had made changes to their businesses as a result of attending the grower workshops.

- 91% of survey respondents said that they now had a better understanding of the flowering and fruitset process and 52% claimed that they had reduced the amount of irregular and alternate bearing on their orchards as a result of the project.

- The number of growers who registered for access to the BPR rose from 266 at the start of the project to 683 by the end. This represents an increase of 156% and therefore accounts for the majority of the estimated 682 commercial growers in Australia.

- Growers were asked to estimate the financial benefit of the project to their businesses. For the 100 respondents who attempted to answer this question the value reached $7.1 m. Since there are an estimated 682 commercial growers in Australia it is reasonable to assume that the overall benefit was several times this figure. In addition many of the benefits will be ongoing. The total cost of the project was $1.3m so the cost benefit appears very favourable.

- Survey respondents scored different aspects of the project as follows:

  - Usefulness of workshops 84/100

  - Improving communication across the industry and sharing information 86/100

  - Usefulness of 'Avo Alerts' 76/100

  - Usefulness of information in the Best Practice Resource 79/100

  - Usefulness of videos 72/100 (and 83% stated they like to see more produced)

Recommendations for future and practical application to industry

All activities in the project were very popular especially the grower workshops and many comments were received that the workshops, 'Avo Alerts', videos and maintenance of the Best Practice Resource should be continued.

Keywords

Avocado extension; irregular bearing; field days; avocado flowering; avocado fruitset; on-line resource; video;

Introduction

Inconsistent yields from year to year create issues throughout the value chain of the Australian avocado industry. They lead to management difficulties such as staffing, workloads and cash flow for growers, packers and distributors. They also create difficulties in developing and maintaining market share due to unreliability of supply.

One of the causes of inconsistent supply is 'irregular bearing' and this occurs when there is adequate flowering but conditions such as adverse weather, inadequate moisture, *Phytophthora* root rot, nutrient deficiencies and poor pollinator activity also affect the tree at flowering or during the periods of natural fruitlet shedding. The result is poor fruitset or heavy shedding of partially grown fruit.

Other reasons for inconsistent avocado supply include 'alternate bearing' and simply inadequate adoption of good orchard husbandry practices across a wide range of management areas.

The project set out to equip growers with the knowledge needed to reduce the incidence of irregular bearing. The strategy was not only to present and make the information available but also to provide the means for growers to network and learn from each other. The project also aimed to improve productivity and fruit quality across the industry.

This project followed AV10002 (November 2010 till December 2013) "Avocado best management practices and Internet based information delivery" which focussed on consolidating and making available up-to-date growing information through various information resources including 'The avocado problem solver field guide' and crop production guidelines in the 'Growing' section of the industry on-line Best Practice Resource.

AV10002 was preceded by AV06003 (December 2006 till May 2010) "Study groups to achieve globally competitive avocados" which (like AV14000) delivered 42 grower workshops to the major production regions of Australia. These were so popular that after a break to consolidate information resources (AV10002) the workshops were reinstated in AV14000.

This project aimed to address the following priorities in the avocado Strategic Investment Plan:

- Promote uptake of established on-farm good practice tailored to variety/region
- Identify and use proven technologies and automation that reduces costs and improves marketable yields
- Review and prioritise the main constraints (e.g. irregular bearing, pest and disease, rootstock selection, nutrition, irrigation management) to increasing farm productivity and address those with the greatest national impact

Methodology

A team approach was used with extension staff located in North Queensland, Central Queensland, South Eastern Queensland and Western Australia. The target audience was Australian avocado growers and those that advise them which include advisors, consultants and re-sellers. The team liaised closely with other avocado research and development staff (e.g. plant pathologists and entomologists) working in avocado to deliver effective presentations the regional grower workshops and provide proven scientific information required to keep the material in the Best Practice Resource up to date.

A factor that had to be taken into account was the large number of new growers entering the industry that were starting from a very low knowledge base for the crop (widely acknowledged as being a difficult crop to grow) and in many case with no background in agriculture. Over the life of the project the estimated number of commercial growers rose by 21%, from 564 to 682.

Regional grower workshops

Regional avocado grower study groups were resumed (after the successful series conducted in AV06003) to deliver regular workshops in the following eight districts:

- North Queensland (6 workshops)
- Central Queensland (6 workshops)
- Sunshine Coast (3 workshops)
- South Queensland (6 workshops)
- Northern NSW/Mt Tamborine (3 workshops)
- Central NSW (6 workshops)
- Tristate (6 workshops)
- Western Australia (6 workshops)

A total of 42 workshops were presented, 27 of these were organised directly by the project team whilst 15 were conducted jointly Avocados Australia Ltd as part of the 'Qualicado' series.

The workshops were all held on avocado orchards, generally focused on one or two main topics (chosen by the growers themselves at the previous workshop) that had relevance to irregular bearing and fruit quality. They usually included one or two expert guest speakers and always included a structured farm walk. Sufficient time was allocated in the programme to allow networking to occur.

Each workshop organised by the project (27 of the 42) was followed up by detailed, illustrated and grower-friendly minutes prepared by the project team. Considerable time was spent preparing these minutes to ensure they were easy to read, clearly explained what was presented and were well illustrated. In addition they also recorded names of attendees and a summary of the feedback sheets so they provide a useful and valuable reference to growers, re-sellers, consultants and team members alike. These 27 sets of minutes and the presentations from all 42 events were made available on the Best Practice Resource (BPR). These served to reinforce the lessons delivered and also ensured that growers unable to make it to the workshop benefitted from the information and discussion.

An attempt was made to make greater use of the experience and knowledge of growers by formally including them in some of the presentations as well as encouraging them to contribute to discussion as time permitted.

Priority was given to those topics known to be associated with irregular bearing, productivity and fruit quality. In addition, other topics that effect productivity and fruit quality were included in the mix.

Detail about each workshop including venue, presentations and attendance can be found in Appendix I.

Flowering, fruitset and fruit retention

In the regions that have historically suffered the most from irregular bearing, growers were encouraged to participate in an exercise to gather information on flowering times, opening times for male and female flower stages, fruitset and fruit retention for both commercial variety(s) and potential polliniser varieties. Data loggers were installed on participating orchards and growers were supplied with recording forms and instructions on how

to collect the information. Major weather events were also recorded.

After each season the information was gathered from the growers, analysed and an attempt made to explain the relative success or failure of the fruitset at each site. The results were then presented and discussed at subsequent workshops in the region where the information had been collected. As for all other presentations this information is also available on the BPR. The presentations given to growers at the workshops helped them understand the complex flowering, pollination, fertilization, fruitset and fruit retention process of avocado, the importance of the prevailing conditions during this time and what they could do to improve the chances of fruit set and retention and thus minimise irregular bearing.

In the Atherton Tablelands and Central Queensland regions, where observations were collected by team members, comprehensive reports were produced which are also available on the BPR.

Other information resources

Three new YouTube videos were produced on important topics that were appropriate for this method of delivery.

- ▪ "Getting boron right in avocados" https://www.youtube.com/watch?v=RPXuGB8Oq1Q

- ▪ "How to plant an avocado tree" https://www.youtube.com/watch?v=SDGW1jmhxws

- ▪ "Mulching avocados" https://youtu.be/fYYZuNjnvbk

A boron rate worksheet was developed in conjunction with the boron video to allow growers and advisors to calculate customised rates of boron for each orchard situation.

A new initiative, the 'Avo Alerts', were commenced in 2016. These are designed to give growers timely monthly reminders of important orchard tasks that are due in that month. They are produced by the project team then Avocados Australia Ltd staff enhance these lists by including live links (which take the user to the relevant section of the BPR) and then distribute the 'Avo Alerts' to all known commercial avocado growers. Eight sets are produced each month to cover the different production regions and the two main varieties (Hass and Shepard).

New information uploaded to the Best Practice Resource included:

- • The three videos listed above

- • Comprehensive minutes from the 27 grower workshops organised by this project.

- • Copies of all 114 different presentations made at the 42 grower workshops

- • The reports written by team members on the flowering and fruitset studies – North Queensland and Central Queensland) and copies of the presentations on this topic from all the regions studied

- • The reports prepared on the visits to orchards in Peru and Chile in 2015

- • The new guidelines on avocado plant nutrition generated by this project

World Avocado Congress 2015 and production practices in Peru and Chile

The project leader attended the World Avocado Congress IX in 2015 which was held in Lima, Peru, took part in the four day pre-congress tour of new orchards in the north of the country and co-organised a two day tour of orchards in Chile for 12 Australian growers and researchers on the return journey which included the ultra-high density orchards in the Llay Llay district near Santiago. The intention was to gather information on the latest research, new production technology and to network with researchers, advisors and producers. Comprehensive reports and presentations were prepared and delivered to Australian growers via the workshop series and the BPR.

Outputs

- Regular workshops (42 in total) for each of the 8 major avocado production region in Australia covering key topics identified as having an influence on irregular bearing, productivity and fruit quality. Please refer to Appendix I for more detail. The six largest producing regions had 6 workshops each in total whilst the two smallest regions received 3 workshops each in total over the three year life of the project.

- 114 separate MS PowerPoint talks were prepared and presented at the growers workshops and are all available on the BPR, 60 of these were prepared and presented by project team members and 54 by guest speakers (listed in Appendix I)

- Each workshop organised by the project (27 of the 42) was followed up by detailed, illustrated and grower-friendly minutes. Copies of these minutes are available on the Best Practice Resource (BPR). These serve to reinforce the lessons delivered and act as a useful and permanent reference. They also ensure that growers unable to make it to the workshop on the day are able to benefit from the information presented and discussed in the shed and during the farm walk.

- Observations on flowering, pollination, fruitset and fruit retention in areas affected by irregular bearing were made at 28 orchards in 2015, 20 orchards in 2016 and 4 orchards in 2017. This data, along with temperature and humidity data collected by automatic data loggers, was analysed and the information presented to growers via 16 presentations at workshops and reports which are also available in the BPR. A separate presentation was also made to members of the Atherton Tablelands Avocado Growers Association on 27 January 2016 on the information gathered in North Queensland.

- Three new YouTube videos were produced on important topics that were appropriate for this method of delivery.
    - "Getting boron right in avocados" https://www.youtube.com/watch?v=RPXuGB8Oq1Q
    - "How to plant an avocado tree" https://www.youtube.com/watch?v=SDGW1jmhxws
    - "Mulching avocados" https://youtu.be/fYYZuNjnvbk

- A boron rate worksheet was developed in conjunction with the boron video to allow growers and advisors to calculate customised rates of boron for each orchard situation.

- Monthly 'Avo Alerts' (lists of orchard tasks due each month) for two varieties and all 8 major production regions for the past 16 months (thus 128 separate 'Avo Alerts' in total to date)

- Comprehensive illustrated report on avocado orchard visits in Peru 2015

- Comprehensive illustrated report on avocado orchard visits in Chile 2015

- Survey of Australian avocado fertiliser practices

- New avocado plant nutrition guidelines

- Articles (7) in the avocado industry magazine "Talking Avocados":
    - Achieving more consistent yields of quality fruit in the Australian avocado industry – research project overview – Autumn 2015
    - Visits to avocado orchards in Peru during the World Avocado Congress in September 2015 – Spring 2015
    - Visits to avocado orchards in Chile during the World Avocado Congress in September 2015 – Summer 2016
    - Understanding irregular bearing better – flowering observations during 2015 – Summer 2017
    - Avocado study group workshops – Autumn 2017
    - Look out for the citrus blossom bug! – Winter 2017
    - Northern avocado flower trends – Spring 2017

Outcomes

The project aimed to address the following priorities in the avocado Strategic Investment Plan:

- Promote uptake of established on-farm good practice tailored to variety/region

- Identify and use proven technologies and automation that reduces costs and improves marketable yields

- Review and prioritise the main constraints (e.g. irregular bearing, pest and disease, rootstock selection, nutrition, irrigation management) to increasing farm productivity and address those with the greatest national impact

The aim of the project was to "provide Australian growers with the knowledge required to implement practices that will lead to more consistent high yields of good quality fruit".

The stated outcomes in the project proposal were to:

- Produce higher and more consistent yields of good quality fruit

- Improve fruit size and quality

- Minimise irregular bearing

- Reduce the chances of alternate bearing developing and minimise the severity when it does occur

The strategies used to achieve this aim included the on-farm workshops, encouraging growers to use the 'Growing' section (generated in the project AV10002) of the on-line Best Practice Resource and generating more resources for it including videos, producing the monthly 'Avo Alert' orchard task reminders, engaging growers in an exercise to gain a better understanding of the flowering and fruitset process in order to improve management decisions for this critical stage, updating the avocado plant nutrition guidelines and informing growers about the latest international research and advanced orchard practices.

The stated outcomes are difficult to measure due to differences between seasons but the evaluation survey at the end of the project revealed the following information which provides a measure of the extent to which the outcomes and aims were achieved. (The survey was sent to approximately 600 growers and 108 responses were received).

Table 1. Outcome-related data from the project records and final survey

Measure	Result
Total attendance at the 42 workshop events	2,613 (62 per event & 496 per round)
Growers who made changes to their business as a result of the workshops	89%
Estimated value of the project to the 108 survey respondents	$7.1 m
Growers that gained a better understanding of the avocado flowering & fruitset process	91%
Growers that reduced the level of irregular & alternate bearing on their orchards	51%
Usefulness of information in 'Growing' section of BPR	79/100
Usefulness of workshops	84/100
Extent to which the workshops improved communication & sharing of information	86/100

Comments from growers in the final survey that reinforce the outcome related data above:

- "The Queensland presenters have had a significant impact in our area (WA)".
- "The project is well worth continuing and is needed to keep the industry improving".
- "Essential for connecting growers with researchers".
- "The work that these extension people do in this industry is vital and has been lost by many other crops".
- "This area of industry is extremely important for all sectors of the industry to keep it successful".

Table 2. Areas of management that growers made changes to as a result of the project

Management practice	Survey respondents who made changes to this area of management
Nutrition	61%
Phytophthora root rot	60%
Canopy management	60%
Irrigation	54%
Under tree mulching	45%
Soil health	43%
Pollination, pollinisers, pollination, fruitset &/or fruit retention	35%
Composting	30%
Insect pest management	27%
Using phenology to determine timing of management practices	23%
Managing in extreme weather	21%
Irregular and alternate bearing	20%
Varieties & rootstocks	19%
Plant Growth Regulators	18%
Pesticides	17%
Diseases other than root rot	15%
Planting density	14%
Planting a tree correctly	12%
Postharvest	7%
Remote sensing	7%
Brown root rot *(Phellinus noxius)*	5%
Black root rot *(Calonectria ilicicola)*	4%
Export readiness	2%

More evidence of the outcomes is presented in the next section (Monitoring and Evaluation).

Monitoring and evaluation

Four main approaches were used to monitor and evaluate the project:

- Evaluation sheets at the end of each workshop organised by AV14000
- A mid-term review which included an electronic survey of growers
- An electronic evaluation survey of growers at the end of the project
- Data on users of the Best Practice Resource

Individual event evaluation

Total attendance at the 42 workshop events was 2,613, this is an average of 62 per event or 496 per round which is comfortably more than 60% of the estimated 682 growers in Australia in December 2017 (564 growers at the start of the project in 2014). Respondents to the electronic survey at the end of the project each attended an average of 4.3 workshops of the 5.25 events available in each region (six of the eight regions had 6 workshops in total whilst the two smallest producing regions had three).

At the end of each of the 27 workshops organised directly by AV14000 attendees were asked to complete a single page evaluation sheet about the day. An average of 82% of the attendees who completed the evaluation sheets stated that they intended making changes to their orchard practices as a result of having attended the events. More detailed breakdown is available in Appendix I. This result is comparable to the data from the electronic end-of-project evaluation survey in which 89% of respondents claimed to have made changes as a result of attending the workshops.

The summary of the evaluation sheets for each event are included in the minutes of each of the 27 events organised directly by AV14000.

Evaluation survey at completion of the project

An electronic evaluation survey (using Survey Monkey) consisting of 25 questions was put together at the end of the project and sent out via email by Avocados Australia Ltd to all know growers. Two subsequent reminders were sent out to growers on the AV14000 project database. Only 108 people (about 13% of all growers) completed the survey which was less than hoped for but because the survey was done over the festive season this is probably not unexpected. Attitudes of respondents was relatively consistent so it is reasonable to assume that the feedback would be quite representative of the majority of respondents.

The following information shows where the respondents were based and their role in the industry.

Number of respondents by region:

- WA   25
- North Queensland   18
- Tristate   18
- South Queensland   12
- NNSW/Tamborine   11
- Central NSW   9
- Central Queensland   8
- Sunshine Coast   6

Occupation of respondents:

- Grower   92
- Consultant/agronomist   11
- Scientist   2
- Re-seller   2
- Nursery   1

The stated measurable goals of the project

- 60% of all commercial avocado growers in Australia participate in some way in the project
- 50% increase in number of growers registered for the Best Practice Resource (BPR) over the life of the project
- 50% of all growers implement changes on their farms as a result of participating in this project

All these goals appear to have been comfortably achieved as outlined in the evidence below.

Estimated number of growers participating in the project

The target was to achieve 60% of commercial growers participating in some way. The number of growers attending the workshops and the number of growers registered to use the Best Practice Resource is used as a guide for participation rates. The data in Table 3 below can be used as a measure, it lists the number of growers that attended the last round of project workshops (numbers built up during the life of the project) in each region as compared with the estimated number of growers in each region. Sometimes more than one member of a business attended a workshop (hence numbers reaching over 100% at times) but this list has excluded non-growers such as consultants and resellers that attended and therefore underestimates the reach of the benefits.

Table 3. Estimated number of growers in Australia and those attending the last round of grower workshops

Region	Estimated total number of commercial avocado growers in Australia in 2016/17*	Number of growers (and as an approximate % of total growers in each region) attending the final workshop in each region
NQ	91	81 (89%)
CQ	55	60 (109%)
SC	47	18 (38%)
SQ	67	95 (142%)
NNSW/Tamb.	79	38 (48%)
CNSW	94	45 (48%)
TRISTATE	84	67 (80%)
WA	165	95 (58%)
TOTAL	**682**	**499 (73%)**

* Data supplied by Avocados Australia Ltd

Grower workshops

Total attendance at the 42 workshop events was 2,613, this is an average of 62 people per event or an average of 496 per round which is comfortably more than 60% of the estimated 682 growers in Australia.

The electronic project evaluation survey conducted at the end of the project attracted 106 respondents. The key outcomes relating to the workshops are provided below.

- Respondents attended an average of 4.3 workshops of the average number of 5.25 events available to them in each region.
- 89% of respondents said that they had made changes to their businesses as a result of attending the grower workshops.
- Growers gave a score of 84/100 to the overall usefulness of the workshops, and the following scores for their components of the day:
  - 83/100 for the presentations
  - 83/100 for the networking

- 86/100 for improving communication across the industry and sharing information, and
- 85/100 for the farm walks

Please also refer to Table 2. in the 'Outcome' section above which lists the areas of management that growers made changes to as a result of the project

Additional comments in the survey relating to the workshops included the following.

- "The coverage of topics and the speakers this year have been excellent at the field days. Such an amazing amount of information is exchanged, both with the speakers and with the interaction between growers sharing experiences".
- "Remove repetitive presentations and stimulate more grower communication".

In terms of the minutes produced and availability of the minutes and the presentations on the BPR after the event, 18% did not know they were available on the BPR, 55% knew that they were available but hadn't accessed them and 32% knew about them and had accessed them. Comments by those who had accessed them included the following.

- "Minutes are a great reminder of topics discussed"
- "Refer back to regularly"
- "Very useful as a refresh and very interesting to read notes from other regions"
- "I find they provide a very useful reference"
- "Great resource"

Best Practice Resource (BPR)

Table 4. Numbers of growers and those registered for the Best Practice Resource (BPR) at the start and end of the project

Region	Estimated total number of commercial avocado growers in Australia in 2014/15	Number of growers registered for the BPR in Nov 2014	Estimated total number of commercial avocado growers in Australia in 2016/17	Number of growers registered for the BPR in Dec 2017*
NQ	78	25 (32%)	91	94 (103%)
CQ	45	34 (76%)	55	73 (133%)
SC	45	20 (44%)	47	33 (70%)
SQ	59	26 (44%)	67	62 (93%)
NNSW/Tamb.	74	17 (23%)	79	68 (86%)
CNSW	82	41 (50%)	94	75 (80%)
TRISTATE	64	53 (83%)	84	100 (119%)
WA	117	50 (43%)	165	171 (104%)
'National'				7
TOTAL	**564**	**266 (47%)**	**682**	**683 (100%)**

Note: more than one person can be registered per business

The analytical information presented in Table 4. was supplied by Avocados Australia Ltd and shows that the number of growers registered for the BPR by the end of 2017 grew by 156% over the life of the project comfortably exceeding the 50% increase project target for BPR users and the 60% target for project participation.

In the project evaluation survey respondents gave a score of 79/100 to the usefulness of the information in the BPR.

As a snap shot, the most popular pages in the BPR during the 30 days leading up to 20th December 2017, in order of popularity, were:

1. Crop cycle calendars
2. Diseases
3. Nutrition
4. Canopy management
5. Irrigation
6. Packhouse
7. Site selection
8. Mulching

Flowering, pollination, fruitset and fruit retention

Members of the project team and 28 growers participated in the collection of observations on flowering and fruitset mainly during the 2015 and 2016 flowering seasons on 28 orchards whilst data loggers were used at these sites to record temperature and humidity. The data was analysed and the results presented to growers at the workshops to educate growers about this complex but critical stage of fruit production in order to help growers implement practices to improve fruitset and retention. 17 presentations and reports were produced from this exercise and all are available on the BPR.

91% of respondents to the final electronic survey said they had a better understanding of the flowering and fruitset process as a result of the project and 51% said that they had reduced the level of irregular and alternate bearing.

Given the complexity of the flowering process, the variability between one season and another this and the difficulty in achieving some control over the process (which was mentioned by several of the respondents) this is a good result.

'Avo Alerts'

Production of these monthly orchard task reminder lists were not included in the project proposal but appeared to be a good way of achieving better orchard management given the importance of correct timing for management practices and the tendency for some important tasks to be forgotten in the busy schedule of running a business.

Survey respondents scored the usefulness of this initiative as 76/100 and many favourable comments were given including the following.

- "They are a handy reminder when you are busy and forget things or put them off for a later date"

- "Good innovation"

- " A very timely reminder and checklist"

- "Use every month"

- "Extremely useful, excellent area specific information without the need for me to research. Has greatly improved particularly my fertiliser program"

Videos

In the evaluation survey growers gave a score of 72/100 for the usefulness of the videos produced. It should be pointed out that only the first two videos (boron and tree planting) had been released at the time of the survey, the video on mulching was released after the survey was issued. Growers were asked for ideas for future videos and the most popular requests were as follows:

- Canopy management   29 requests
- Tree injection and root rot management   12
- Nutrition   6
- Grafting   6
- Sampling (leaf, soil, roots)   5

Root rot poster

A poster called "Manage Phytophthora root rot" was produced and dispatched to all commercial growers at the end of the previous project but it was too soon to evaluate. Given that high demand necessitated a second print run of posters and that these were distributed during AV14000 it was decided to seek feedback on its usefulness in this project's evaluation. Respondents rated the usefulness of this poster at 73/100 and 65% of growers wanted more posters to be produced. The most popular suggestions for future posters were as follows.

- Nutrition including boron   14
- Canopy management   10
- Phenology   4

Estimated financial value of the project to individual growers

Growers were asked in the evaluation survey to try and put a dollar value on the benefit of the project to their business. The survey presented categories to choose from ranging from $0 – 1,000 to over $1 million. Using the mid-point of each category and $1.25m for the 'over $1m' category an estimated total benefit for the 100 growers who attempted this question added up to $7.1m million. Since there are an estimated 682 commercial growers in Australia it is reasonable to assume that the overall benefit was several times this figure. In addition many of the benefits will be ongoing. The total cost of the project was $1.3m so the cost benefit appears very favourable.

Growers were also asked to try and identify where the financial benefits had come from. The main areas identified were as follows:

- Better irrigation   31
- Better management of root rot   25
- Improved plant nutrition   22
- Better canopy management   11
- Application of a range of practices   9
- Better yields   7
- Improved disease control other than root rot   5
- Better timing of practices   3
- Use of mulching   3
- Reduction of irregular bearing   3
- Reduced input costs   3
- Better management of soil   3

Updated plant nutrition guidelines

It is too early to evaluate these.

Attendance at World Avocado Congress IX in Peru in 2015 and study of orchard practices on leading orchards in Peru and Chile

The project leader undertook this trip and co-organised the study tour of orchards in Chile following the congress. The study tour attracted 12 Australian participants. The associated comprehensive 53 and 34 page illustrated reports that were written that detailed the orchard visits in Peru and Chile respectively and the presentation to each of the eight regional workshops were well received as reflected in the workshop evaluation sheets. The information and contacts for the ultra-high density plantings in Chile have also been useful to researchers in the Small Tree High Productivity Initiative project.

Recommendations

The feedback from this project indicates that growers were very happy with the activities and would like to see the workshops, videos, posters, updating of material in the BPR and the 'Avo Alerts' continued.

Having established or confirmed the basic information on flowering times of the mainstream varieties and some pollinisers, the flower-stage opening patterns and the conditions conducive to fruitset it is probably unnecessary to repeat this exercise in an extension project but research into how carbohydrate levels affect fruitset and the effect of humidity on pollen viability would be worthwhile. Some of this may be addressed in AV16005.

There have been some suggestions that there should be two different levels of workshops or presentations, one (e.g. masterclasses) for the more advanced growers and the other for new and relatively inexperienced growers aimed at addressing the basic needs for avocado production. The criticism of this approach is that some of the networking opportunities and learning by new growers from experienced growers would be lost.

There is a need to allocate time to updating some sections of the Best Practice Resource where new information and developments have taken place (e.g. spotting bug control, pollination, canopy management and rootstocks) and perhaps make enhancements to how information is presented.

Refereed scientific publications

None to report.

Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report.

Acknowledgements

The following people all contributed significantly to making the various parts of the project work and we extend our gratitude and thanks to them.

The staff who were part of the project team for all or part of the project were:

North Queensland - Geoff Dickinson, Ingrid Jenkins, Pat O'Farrell and Kaila Ridgway

Central Queensland - Helen Hofman

South East Queensland - Bridie Carr, Debbie Maxfield, Shane Mulo, Simon Newett (project leader), Peter Rigden and Liz Singh

Western Australia - Dudley Mitchell

The many guest speakers from the Queensland Department of Agriculture and Fisheries, NSW Department of Primary Industries, the WA Department of Primary Industries and Regional Development, the Universities of Queensland and New England, CSIRO, New Zealand Plant and Food, independent consultants, and representatives from various companies.

All the growers who hosted workshops. They went to a lot of trouble to provide and prepare suitable venues, show us their operations and share information about them. Without them the workshops would not have been possible.

The helpful and supportive staff at Avocados Australia Ltd for their close collaboration and assistance with many aspects of the project including co-organising some of the workshops, sending out invitations, survey and Avo Alerts and providing the platform of the Best Practice Resource and ensuring that the material generated by the project was smoothly uploaded to it.

To the directors of Avocados Australia Ltd for their support of the workshops and providing the industry updates at each of these events.

Appendices

Appendix I: Details about the 42 grower workshops

Appendix II: Results of the final evaluation survey

Appendix III: Avocado plant nutrition review

Appendix I. Details about the 42 grower workshops

	Activity	Region	Orchard where held	Date	Attended	% intending to make changes	Topics and presentations by AV14000
1	Qualicado field day NQ	Mareeba, Qld	Ravanello	4 Dec '14	90	Not available	• Pre & Post-Harvest Nutrition – Simon Newett, DAF, Nambour • R U real about Root Rot? – Simon Newett
2	Qualicado field day SEQ	Nambour, Qld	Jeffers	13 Feb '15	33	Not available	• Avocado irrigation principles – Simon Newett
3	Qualicado field day NNSW	Alstonville, NSW	Silver	26 Mar '15	43	Not available	• Nutrition for healthy avocados, good yields & high quality – Simon Newett
4	Study group field day CQ	Bundaberg, Qld	Bundaberg Research Facility	1 Apr '15	43	64%	• Small tree – high productivity initiative – John Wilkie, DAF • Precision agriculture, options for orchardists – Ian Layden, DAF • Update on Phellinus noxius R & D – David Armour, UQ
5	Qualicado field day SQ	Gatton, Qld	Krenske	7 May '15	48	Not available	• Registered pesticides for Australian avocados – Simon Newett
6	Qualicado field day CNSW	Comboyne, NSW	Burch	4 Jun '15	48	Not available	• Pollination and fruitset – Simon Newett
7	Qualicado field day WA	Pemberton, WA	AVONOVA	25 Jun '15	72	Not available	• Why is irrigation so important in avocados – Simon Newett • Pollination and fruitset – Simon Newett
8	Qualicado field day CQ	Childers, Qld	Philpott	6 Aug '15	50	Not available	• Avocado nutrition – Simon Newett • Registered avocado pesticides – Simon Newett
9	Study group field day NQ	Mareeba, Qld	Battistin	15 Oct '15	73	57%	• Pollination & fruitset – Simon Newett • Progress report on pollination studies – Pat O'Farrell, DAF • Small Tree High Productivity Initiative – Peter Rigden, DAF • Fruitspotting bug lures – Ian Newton, DAF • Ambrosia beetles – Ian Newton • Best Practice Resource, Problem Solver Guide & Root rot poster – Peter Rigden • Avocados in Peru & Chile – Simon Newett

10	Study group field day Tristate	Robinvale, Victoria	MacIntosh	25 Nov '15	43	85%	- Pollination & fruitset – Simon Newett - A new perspective on avocado insect pollinators – Brad Howlett, NZ Plant & Food - Small Tree High Productivity Initiative – Peter Rigden - Update on rootstocks – Simon Newett - Best Practice Resource, Problem Solver Guide, Root rot poster – Peter Rigden - Avocados in Peru & Chile – Simon Newett
11	Study group field day Central NSW	Stuarts Point, NSW	Heather & Tolson	3 Dec '15	29	93%	- Use of plant growth regulants – Simon Newett - A new perspective on avocado insect pollinators – David Pattemore, NZ Plant & Food - Small Tree High Productivity Initiative – Peter Rigden - Mulch & nutrition – Simon Newett - Best Practice Resource, Problem Solver Guide, Root rot poster – Peter Rigden - Avocados in Peru & Chile – Simon Newett
12	Study group field day South Queensland	Ravensbourne, Qld	Boardman	9 Dec '15	46	86%	- Avocado nutrition – Lisa Martin, Ripe Horticulture - Small Tree High Productivity Initiative – Peter Rigden - Fruitspotting bug lures – Ian Newton - Best Practice Resource, Problem Solver Guide, Root rot poster – Peter Rigden - Overview of ICA 30 hard green protocol – Bruce Birtwell, DAF - Avocados in Peru & Chile – Simon Newett
13	Study group field day Western Australia	Manjimup, WA	Mitchell Ipsen	17 Mar '16	64	74%	- Avocado flowering and fruitset in WA 2015 – Simon Newett & Dudley Mitchell - IPM and the Six Spotted Mite – Lachlan Chilman, Biological Services - Small tree high productivity initiative – Peter Rigden, DAF - Avocados in Peru & Chile – Simon Newett
14	Study group field day Tristate	Renmark, SA	Costa Exchange and David Howie	14 Apr '16	37	100%	- Principles of canopy management – Peter Rigden - Use of PGRs – Simon Newett - Canopy management debate – all - Observations from the 2015 flowering and fruitset season – Simon Newett
15	Study group field day Central Queensland	Childers, Qld	Simpson Farms	21 Apr '16	39	96%	Observations from the 2015 flowering and fruitset season – Helen Hofman, DAF

							• Spotting bug pheromone trap – Ian Newton • Update on small tree high productivity initiative – Peter Rigden • Avocados in Peru & Chile – Simon Newett
16	Qualicado field day Sunshine Coast, Qld	Bellthorpe, Qld	Neil & Joss Donovan	28 Apr '16	40	Not available	• Production management: Phytophthora root rot re-visited – Simon Newett • Production management: Pollination – Simon Newett • Avocados in Peru & Chile – Simon Newett
17	Qualicado field day Tamborine/NNSW	Mt Tamborine, Qld	John & Lindy Williams	5 May '16	80	Not available	• Avocado nutrition – Simon Newett • Avocados in Peru & Chile – Simon Newett
18	Qualicado field day Central NSW	Comboyne, NSW	Kevin Debrecency	26 May '16	70	Not available	• Managing disease for productivity & quality – Simon Newett • Avocado nutrition – Simon Newett
19	Qualicado field day South Queensland	Kumbia, Qld	Dennis & Lorraine Dugdell	9 June '16	64	Not available	• Observations from the 2015 flowering and fruitset season – Simon Newett
20	Qualicado field day WA	Manjimup, WA	Joe Bendotti & family	23 June '16	80	Not available	• Managing for productivity and quality - Simon Newett
21	Qualicado field day NQ	Mareeba, NQ	Colin Foyster,	14 July '16	100	Not available	• Current management issues – spotting bug and irrigation Simon Newett
22	Qualicado field day, Tristate	Trentham Cliffs, Victoria	Marr family	28 July '16	75	Not available	• Managing for productivity and quality in Tristate - Simon Newett •
23	Qualicado field day, CQ	Bundaberg, CQ	DAF Bundaberg Research Facility	11 August '16	80	Not available	• Managing for maximum productivity and quality - Simon Newett
24	Study group field day, NQ	Kairi, NQ	Peter & Chelley Howe	6 October '16	100	90%	• National & NQ irregular bearing project update – Simon Newett & Pat O'Farrell • Bee psychology - Wim de Jong • Maluma Hass – Henk Van Niekerk • Converting from mini sprinkler to drip - Henk Van Niekerk • STHPI update – Peter Rigden • Electrical safety – Jason Beasley
25	Study group field day, CNSW	Peats Ridge, NSW	Sparacino family orchard	3 November 2016	41	90%	• Disease control in avocado – Liz Dann • Update on the Small Tree High productivity Initiative – Simon Newett • Flowering, pollination and fruitset update – Simon Newett

							• Insect pest management in CNSW – Craig Maddox
26	Study group field day, SQ	Hampton, Qld	Robyn Lubach	1 December 2016	56	62%	• Insect pest management including spotting bug – Craig Maddox • Update on the Small Tree High productivity Initiative – Peter Rigden • Canopy management – Simon Newett & Peter Rigden • Nutrient replacement – Simon Newett
27	Study group field day, WA	Manjimup, WA	Winfield family orchard	16 March 2017	63	72%	• Update on management of six spotted mite and greenhouse thrips – Stewart Learmonth & Lachlan Chilman • What happens to your fruit after it leaves the farm - different perspectives from Dudley Mitchell & Jennie Franceschi • Last year's yield results from the 'Small tree high productivity initiative' – Peter Rigden • Mulching and mulch material – Simon Newett • Introduction to the new Best Practice Resource
28	Study group field day, Tristate	Waikerie, South Australia	Boehm and Thiel family orchards	30 March 2017	41	67%	• Technical and practical aspects of irrigation and fertigation – Trevor Sluggett • Last year's yield results from the 'Small tree high productivity initiative' – Peter Rigden • Observations from the 2016 flowering and fruitset season – Simon Newett • Latest results from the Tristate rootstock trial – Liz Dann (presented by Simon Newett) • Introduction to the new Best Practice Resource
29	Study group field day, Sunshine Coast	Gunalda, near Gympie, SEQ	Gary Cox's orchard at Scotchy Pocket	4 May 2017	32	95%	• Update on fruitspotting bug management including new insecticides – Simon Newett • New Hass-type varieties – Denis Roe • Last year's yield results from the 'Small tree high productivity initiative' – Peter Rigden • Principles of canopy management – Simon Newett • 'The Great Canopy Management Debate' • Showed new project video 'How to plant an avocado tree' • Introduction to the new Best Practice Resource

30	Study group field day, NNSW/Tamborine	Wollongbar & Alstonville, NNSW	Wollongbar Research Station and Centre for Tropical Horticulture, Alstonville	18 May 2017	47	89%	• Avocado insect pest management including latest developments with fruitspotting bug, and the trap hedge monitoring system – Craig Maddox & Ruth Huwer • The 'Small Tree High Productivity Initiative' including the planting systems trial - background and results to date – Peter Rigden • Principles of canopy management – Simon Newett • 'The Great Canopy Management Debate' • Showed new project video 'How to plant an avocado tree' • Introduction to the new Best Practice Resource
31	Study group field day, CNSW	Comboyne, CNSW	Chris Nelson's orchard	1 June 2017	68	91%	• Growing quality avocado – it doesn't just happen (special focus on root rot management and root phosphonate testing) – Graeme Thomas • Update and video on Small Tree High Productivity Initiative – Peter Rigden • Developments in canopy management practices – Chris Searle • Using Plant Growth Regulants (PGRs) – Chris Searle • Showed new project video 'How to plant an avocado tree' • Introduction to the new Best Practice Resource
32	Study group field day, South Qld	Esk, SEQ	Rob Bowie's orchard	15 June 2017	44	69%	• Learning to evaluate pollination in your orchard – Brad Howlett • Export readiness – Noel Ainsworth & John Tyas • All about mulch – Simon Newett • Show new video on Small Tree High Productivity Initiative • Preparing the ground for planting and new video "How to plant an avocado tree" – Peter Rigden • Introduction to the new Best Practice Resource
33	Study group field day, WA	Pemberton, WA	Lisa Roche's orchard	20 June 2017	75	70%	• The latest information on disease management – Liz Dann • Black root rot – Louisa Parkinson • Ambrosia/pinhole borer beetles – are they a threat? – Kaila Ridgway • Observations during the 2016 flowering season in Western Australia – Simon Newett & Dudley Mitchell • Different nutrient levels for WA conditions – Dudley Mitchell

						• Recent developments in canopy management techniques in the Bundaberg/Childers region • New YouTube video "How to plant an avocado tree" • The potential of UAVs (drones) in avocado orchards – Jon Smith
34	Study group field day/bus tour, WA	Carabooda and Gingin, WA	AVOWEST, The Avocado Grove & Green Pear orchards	22 June 2017	34	81%	• Tours of orchards and a nursery: • AVOWEST orchard at Carabooda • The Avocado Grove orchard and nursery at Carabooda • Green Pear Avocado orchard at Gingin
35	Study group field day, NQ	Dimbulah near Mareeba	DBC Farming	13 July 2017	134	68%	• Science & research of the banana spotting bug lure trap – Ian Newton • Practical aspects of spotting bug management – Leonie Wittenberg • Purchase and use of the lure trap – Jason Vella • Progress with registration of new insecticides Transform® (Dow Agrisciences), and Trivor® (Adama) – Ken Springall • Update on the Maluma variety – Henk Van Niekerk • Local fruit quality enquiries and diagnosis – Peter Trevorrow & Kathy Grice • Ambrosia beetle update – Kaila Ridgway • Mechanical selective limb removal • Work Place Health & Safety information on chainsaws – Adam Spinelli • Correct use of Altacor® (chlorantraniliprole) – Kent Bell • Preparing the ground for planting and new video "How to plant an avocado tree" • Introduction to the new Best Practice Resource • Review of the 2016 flowering and fruitset season in FNQ – Pat O'Farrell
36	Study group field day, Tristate – South Australia	Renmark, SA	Nick Hobb's orchard	26 July 2017	30	76%	• Managing frosts on avocado orchards – Lisa Martin • Outline of the new irregular bearing project – Harley Smith • Managing heat waves on avocado orchards – Lisa Martin • New YouTube video "How to plant an avocado tree" • Management of Phytophthora root rot – Simon Newett
37	Study group field day, Tristate –Vic	Nangiloc, Vic	Goldup family orchards	27 July 2017	51	78%	• Managing frosts on avocado orchards – Lisa Martin

						• Outline of the new irregular bearing project – Harley Smith • Managing heat waves on avocado orchards – Lisa Martin • New YouTube video "How to plant an avocado tree" • Management of Phytophthora root rot – Simon Newett
38	Study group field day, Central Qld	Bundaberg, Qld	DAF Bundaberg Research Facility	17 August 2017	81	77%	• 2016 flowering season assessment – observations on a commercial orchard and in the planting systems trial at Bundaberg Research Facility – Helen Hofman • Avocado cool chain best practice – Jenny Ekman & Adam Goldwater • Show project boron video and explain boron rate worksheet – Simon Newett • New YouTube video "How to plant an avocado tree" • Nutrition session • Small Tree High Productivity Initiative (STHPI) video • Update on the planting systems trial (2017 yields) and rootstock trial – Helen Hofman • Genetic induction of flowering in avocado – Francois Barber
39	Study group field day, NQ	Atherton, NQ	Tinaroo Falls Orchard, Kochi Bros	12 October 2017	113	65%	• Learning to evaluate pollination in your orchard – Brad Howlett • Organic practices including compost – Denis Roe • Avocado disease control update – Liz Dann • Update of Small Tree High Productivity Initiative including 2nd year's yields – Peter Rigden • Use of Plant Growth Regulants & discussion – Simon Newett
40	Study group field day, CNSW	Stuarts Point, CNSW	Roger Cotterell's orchard	2 November 2017	65	74%	• Avocado disease control update – Liz Dann • The avocado industry in New Zealand and the NZ R&D programme – Marisa Till • Remote sensing in avocados – Andrew Robson • Update of Small Tree High Productivity Initiative including 2nd year's yields – Peter Rigden
41	Study group field day, Central Qld	Childers, CQ	Simpson Farms and De Paoli's orchard	16 November 2017	89	100%	• Avocado disease control update – Liz Dann • Remote sensing in avocados – Jasmine Muir • Canopy management

42	Study group field day, SQ	Blackbutt, SQ	Terry Clark's orchard and Beutel family's orchard	7 December 2017	102	62%	• Nutrition practices and trends emerging from the recent industry survey – Simon Newett presented by peter Rigden • Different types of irrigation – Jamie Zapp • 2017 Results for the Small Tree High Productivity Initiative research – Peter Rigden • Canopy management
	TOTAL 42				**2,613**	**Average 82%**	

618 attendees in 2015, 12 events (51.5 attendees per workshop).

926 attendees in 2016, 14 events (66 attendees per workshop).

1,069 attendees in 2017, 16 events (67 attendees per workshop).

Appendix II: Results of the final evaluation survey

Appendix II: Results of the final evaluation survey

Q1 Your involvement in the industry?

Answered: 108   Skipped: 0
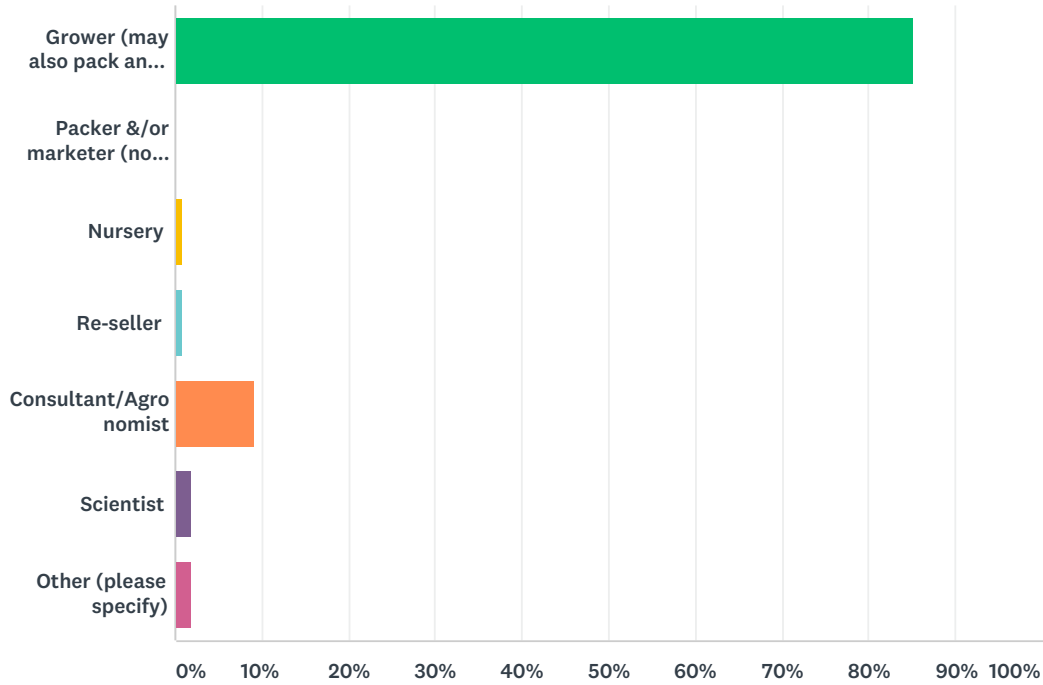
ANSWER CHOICES	RESPONSES	
Grower (may also pack and market)	85.19%	92
Packer &/or marketer (not grower)	0.00%	0
Nursery	0.93%	1
Re-seller	0.93%	1
Consultant/Agronomist	9.26%	10
Scientist	1.85%	2
Other (please specify)	1.85%	2
TOTAL		108

#	OTHER (PLEASE SPECIFY)	DATE
1	team member	1/3/2018 8:49 AM
2	Supplier of fertiliser and phosphorous acid	1/2/2018 10:46 AM

Q2 Region of main operation?

Answered: 107   Skipped: 1
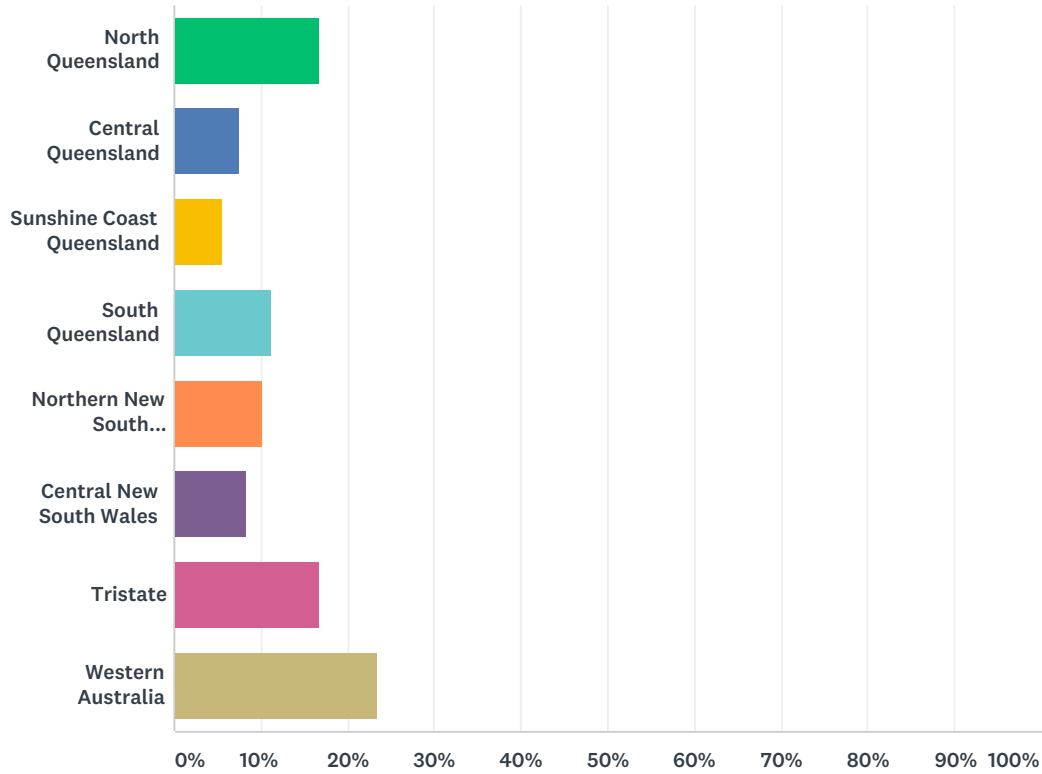
ANSWER CHOICES	RESPONSES	
North Queensland	16.82%	18
Central Queensland	7.48%	8
Sunshine Coast Queensland	5.61%	6
South Queensland	11.21%	12
Northern New South Wales/Tamborine Mountain	10.28%	11
Central New South Wales	8.41%	9
Tristate	16.82%	18
Western Australia	23.36%	25
TOTAL		107

Q3 The project has organised or contributed to 42 avocado grower workshops in the 8 regional production areas (the study group workshop events and the Qualicado events), over the past three years. Please indicate approximately how many of these events you have attended.

Answered: 108　　Skipped: 0
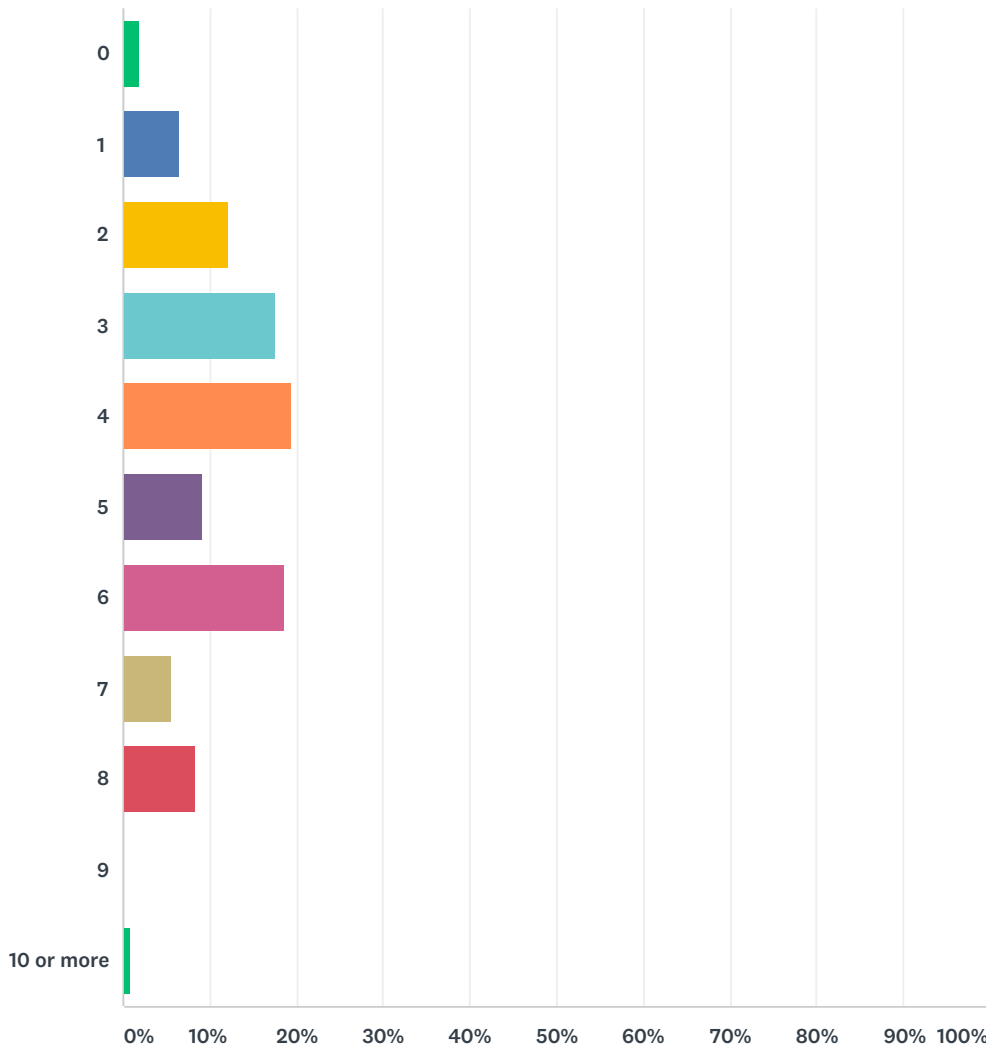
ANSWER CHOICES	RESPONSES	
0	1.85%	2
1	6.48%	7
2	12.04%	13
3	17.59%	19
4	19.44%	21
5	9.26%	10
6	18.52%	20

7	5.56%	6
8	8.33%	9
9	0.00%	0
10 or more	0.93%	1
TOTAL		108

7	5.56%	6

Q4 On a scale of 0 to 100 (where 0 is not useful, and 100 is extremely useful) please give a general rating of how useful you have found the workshops that you have attended?

Answered: 107   Skipped: 1
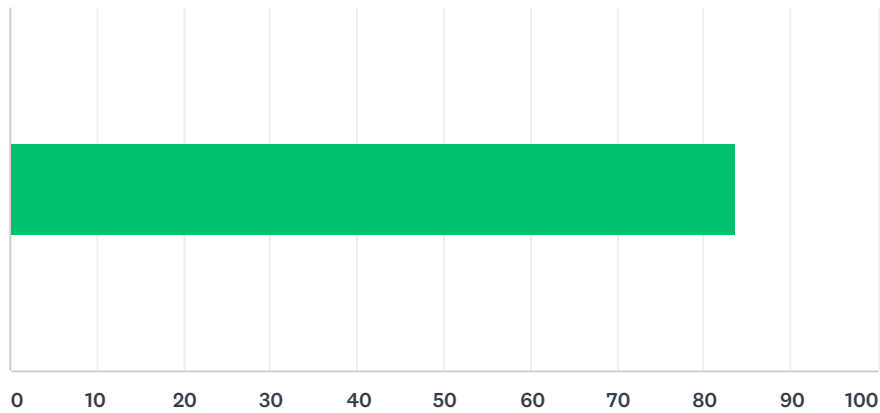
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	84	8,952	107
Total Respondents: 107			

#		DATE
1	85	1/10/2018 7:19 AM
2	100	1/9/2018 3:47 PM
3	73	1/9/2018 1:52 PM
4	80	1/9/2018 12:04 PM
5	76	1/9/2018 11:19 AM
6	66	1/9/2018 9:52 AM
7	80	1/9/2018 6:51 AM
8	80	1/8/2018 8:47 PM
9	75	1/8/2018 7:43 PM
10	56	1/8/2018 6:45 PM
11	87	1/8/2018 6:39 PM
12	83	1/8/2018 5:39 PM
13	70	1/8/2018 2:25 PM
14	100	1/8/2018 1:20 PM
15	59	1/8/2018 1:08 PM
16	100	1/8/2018 12:23 PM
17	75	1/8/2018 12:21 PM
18	94	1/8/2018 10:48 AM
19	80	1/8/2018 10:30 AM
20	90	1/8/2018 9:59 AM

21	90	1/8/2018 9:57 AM
22	100	1/8/2018 9:43 AM
23	86	1/8/2018 9:37 AM
24	75	1/8/2018 9:37 AM
25	100	1/5/2018 8:35 AM
26	92	1/4/2018 5:33 PM
27	95	1/4/2018 9:58 AM
28	65	1/4/2018 9:44 AM
29	80	1/4/2018 9:05 AM
30	66	1/4/2018 8:46 AM
31	88	1/3/2018 11:22 PM
32	82	1/3/2018 6:56 PM
33	90	1/3/2018 4:14 PM
34	80	1/3/2018 2:47 PM
35	99	1/3/2018 2:47 PM
36	90	1/3/2018 12:40 PM
37	79	1/3/2018 11:29 AM
38	50	1/3/2018 11:26 AM
39	89	1/3/2018 10:05 AM
40	100	1/3/2018 8:49 AM
41	90	1/3/2018 8:44 AM
42	95	1/3/2018 8:27 AM
43	75	1/3/2018 6:10 AM
44	90	1/2/2018 9:35 PM
45	75	1/2/2018 8:13 PM
46	90	1/2/2018 6:10 PM
47	90	1/2/2018 6:00 PM
48	56	1/2/2018 5:40 PM
49	90	1/2/2018 5:23 PM
50	100	1/2/2018 5:17 PM
51	90	1/2/2018 5:06 PM
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56	100	1/2/2018 2:04 PM
57	94	1/2/2018 1:58 PM
58	65	1/2/2018 1:15 PM
59	100	1/2/2018 12:32 PM
60	81	1/2/2018 12:28 PM
61	9	1/2/2018 11:44 AM

62	100	1/2/2018 11:38 AM
63	75	1/2/2018 11:26 AM
64	99	1/2/2018 10:56 AM
65	87	1/2/2018 10:55 AM
66	80	1/2/2018 10:48 AM
67	70	1/2/2018 10:46 AM
68	81	1/2/2018 10:42 AM
69	80	1/2/2018 10:41 AM
70	75	1/2/2018 10:41 AM
71	90	1/2/2018 10:37 AM
72	75	1/2/2018 10:30 AM
73	70	1/2/2018 10:20 AM
74	70	1/2/2018 10:19 AM
75	90	12/29/2017 11:21 AM
76	90	12/26/2017 6:56 PM
77	95	12/26/2017 4:10 PM
78	100	12/26/2017 9:12 AM
79	100	12/26/2017 6:07 AM
80	50	12/23/2017 3:37 PM
81	74	12/23/2017 9:42 AM
82	95	12/23/2017 3:12 AM
83	100	12/22/2017 3:15 PM
84	100	12/22/2017 2:40 PM
85	100	12/22/2017 12:31 PM
86	100	12/22/2017 10:58 AM
87	86	12/22/2017 10:05 AM
88	100	12/22/2017 9:50 AM
89	89	12/22/2017 7:43 AM
90	0	12/22/2017 7:12 AM
91	99	12/22/2017 6:04 AM
92	78	12/22/2017 5:49 AM
93	100	12/21/2017 11:34 PM
94	75	12/21/2017 10:08 PM
95	90	12/21/2017 8:39 PM
96	100	12/21/2017 8:32 PM
97	96	12/21/2017 8:12 PM
98	77	12/21/2017 7:54 PM
99	99	12/21/2017 7:50 PM
100	52	12/21/2017 7:43 PM
101	99	12/21/2017 6:43 PM
102	100	12/21/2017 6:31 PM

103	95	12/21/2017 6:13 PM
104	100	12/21/2017 5:44 PM
105	75	12/21/2017 5:44 PM
106	74	12/21/2017 5:11 PM
107	75	12/21/2017 4:47 PM

Q5 Please rate the following aspects of the workshops..Presentations/talks

Answered: 107　　Skipped: 1
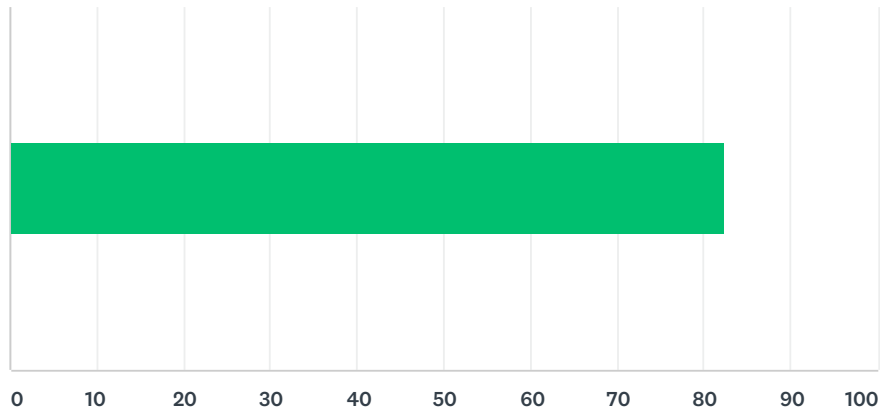
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	83	8,829	107
Total Respondents: 107			

#		DATE
1	80	1/10/2018 7:19 AM
2	68	1/9/2018 3:47 PM
3	58	1/9/2018 1:52 PM
4	89	1/9/2018 12:04 PM
5	50	1/9/2018 11:19 AM
6	87	1/9/2018 9:52 AM
7	80	1/9/2018 6:51 AM
8	80	1/8/2018 8:47 PM
9	82	1/8/2018 7:43 PM
10	59	1/8/2018 6:45 PM
11	100	1/8/2018 6:39 PM
12	89	1/8/2018 5:39 PM
13	70	1/8/2018 2:25 PM
14	100	1/8/2018 1:20 PM
15	60	1/8/2018 1:08 PM
16	83	1/8/2018 12:23 PM
17	80	1/8/2018 12:21 PM
18	96	1/8/2018 10:48 AM
19	80	1/8/2018 10:30 AM
20	90	1/8/2018 9:59 AM
21	90	1/8/2018 9:57 AM

22	100	1/8/2018 9:43 AM
23	72	1/8/2018 9:37 AM
24	80	1/8/2018 9:37 AM
25	100	1/5/2018 8:35 AM
26	93	1/4/2018 5:33 PM
27	95	1/4/2018 9:58 AM
28	75	1/4/2018 9:44 AM
29	80	1/4/2018 9:05 AM
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31	88	1/3/2018 11:22 PM
32	82	1/3/2018 6:56 PM
33	99	1/3/2018 4:14 PM
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35	99	1/3/2018 2:47 PM
36	90	1/3/2018 12:40 PM
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40	80	1/3/2018 8:49 AM
41	85	1/3/2018 8:44 AM
42	100	1/3/2018 8:27 AM
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44	90	1/2/2018 9:35 PM
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58	60	1/2/2018 1:15 PM
59	100	1/2/2018 12:32 PM
60	85	1/2/2018 12:28 PM
61	10	1/2/2018 11:44 AM
62	92	1/2/2018 11:38 AM

63	75	1/2/2018 11:26 AM
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65	82	1/2/2018 10:55 AM
66	80	1/2/2018 10:48 AM
67	75	1/2/2018 10:46 AM
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102	100	12/21/2017 6:31 PM
103	95	12/21/2017 6:13 PM

104	99		12/21/2017 5:44 PM
105	70	12 / 65	12/21/2017 5:44 PM
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Q6 Interaction/networking with others

Answered: 107   Skipped: 1
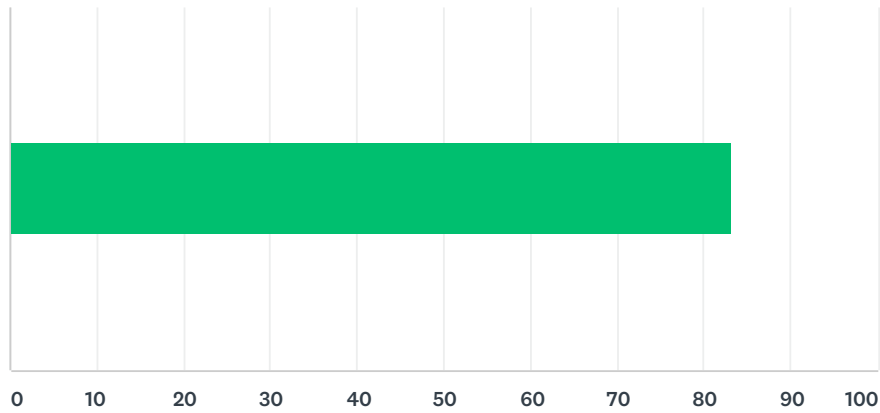
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
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Total Respondents: 107			

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9	80	1/8/2018 7:43 PM
10	92	1/8/2018 6:45 PM
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21	90	1/8/2018 9:57 AM
22	100	1/8/2018 9:43 AM

23	93	1/8/2018 9:37 AM
24	60	1/8/2018 9:37 AM
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32	82	1/3/2018 6:56 PM
33	98	1/3/2018 4:14 PM
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35	99	1/3/2018 2:47 PM
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40	100	1/3/2018 8:49 AM
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55	70	1/2/2018 2:06 PM
56	100	1/2/2018 2:04 PM
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60	90	1/2/2018 12:28 PM
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64	94	1/2/2018 10:56 AM
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98	80	12/21/2017 7:54 PM
99	96	12/21/2017 7:50 PM
100	78	12/21/2017 7:43 PM
101	94	12/21/2017 6:43 PM
102	60	12/21/2017 6:31 PM
103	100	12/21/2017 6:13 PM
104	81	12/21/2017 5:44 PM

105	79		12/21/2017 5:44 PM
106	79	16 / 65	12/21/2017 5:11 PM
107	89		12/21/2017 4:47 PM

Q7 Farm walks

Answered: 107   Skipped: 1
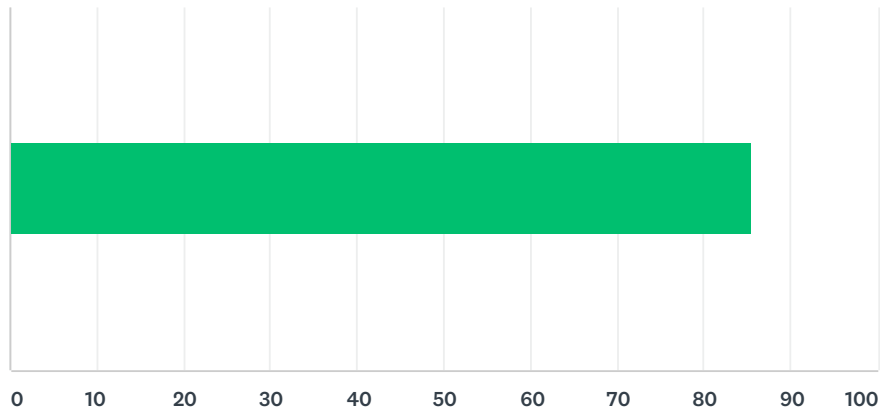
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
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Total Respondents: 107			

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5	85	1/9/2018 11:19 AM
6	97	1/9/2018 9:52 AM
7	70	1/9/2018 6:51 AM
8	80	1/8/2018 8:47 PM
9	85	1/8/2018 7:43 PM
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14	100	1/8/2018 1:20 PM
15	80	1/8/2018 1:08 PM
16	100	1/8/2018 12:23 PM
17	80	1/8/2018 12:21 PM
18	100	1/8/2018 10:48 AM
19	100	1/8/2018 10:30 AM
20	100	1/8/2018 9:59 AM
21	80	1/8/2018 9:57 AM
22	100	1/8/2018 9:43 AM

23	92	1/8/2018 9:37 AM
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25	100	1/5/2018 8:35 AM
26	100	1/4/2018 5:33 PM
27	100	1/4/2018 9:58 AM
28	40	1/4/2018 9:44 AM
29	80	1/4/2018 9:05 AM
30	71	1/4/2018 8:46 AM
31	74	1/3/2018 11:22 PM
32	90	1/3/2018 6:56 PM
33	97	1/3/2018 4:14 PM
34	95	1/3/2018 2:47 PM
35	99	1/3/2018 2:47 PM
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43	92	1/3/2018 6:10 AM
44	95	1/2/2018 9:35 PM
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46	99	1/2/2018 6:10 PM
47	85	1/2/2018 6:00 PM
48	85	1/2/2018 5:40 PM
49	100	1/2/2018 5:23 PM
50	100	1/2/2018 5:17 PM
51	100	1/2/2018 5:06 PM
52	76	1/2/2018 3:46 PM
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54	93	1/2/2018 2:14 PM
55	75	1/2/2018 2:06 PM
56	100	1/2/2018 2:04 PM
57	93	1/2/2018 1:58 PM
58	75	1/2/2018 1:15 PM
59	100	1/2/2018 12:32 PM
60	90	1/2/2018 12:28 PM
61	10	1/2/2018 11:44 AM
62	100	1/2/2018 11:38 AM
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| 64	91	1/2/2018 10:56 AM
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66	85	1/2/2018 10:48 AM
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83	100	12/22/2017 3:15 PM
84	100	12/22/2017 2:40 PM
85	100	12/22/2017 12:31 PM
86	100	12/22/2017 10:58 AM
87	91	12/22/2017 10:05 AM
88	95	12/22/2017 9:50 AM
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93	98	12/21/2017 11:34 PM
94	80	12/21/2017 10:08 PM
95	87	12/21/2017 8:39 PM
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97	100	12/21/2017 8:12 PM
98	67	12/21/2017 7:54 PM
99	100	12/21/2017 7:50 PM
100	95	12/21/2017 7:43 PM
101	79	12/21/2017 6:43 PM
102	100	12/21/2017 6:31 PM
103	95	12/21/2017 6:13 PM
104	98	12/21/2017 5:44 PM

105	75		12/21/2017 5:44 PM
106	70		12/21/2017 5:11 PM
107	80		12/21/2017 4:47 PM

Q8 Did you know that the minutes and presentations for each event can be accessed on the Best Practice Resource?

Answered: 105   Skipped: 3
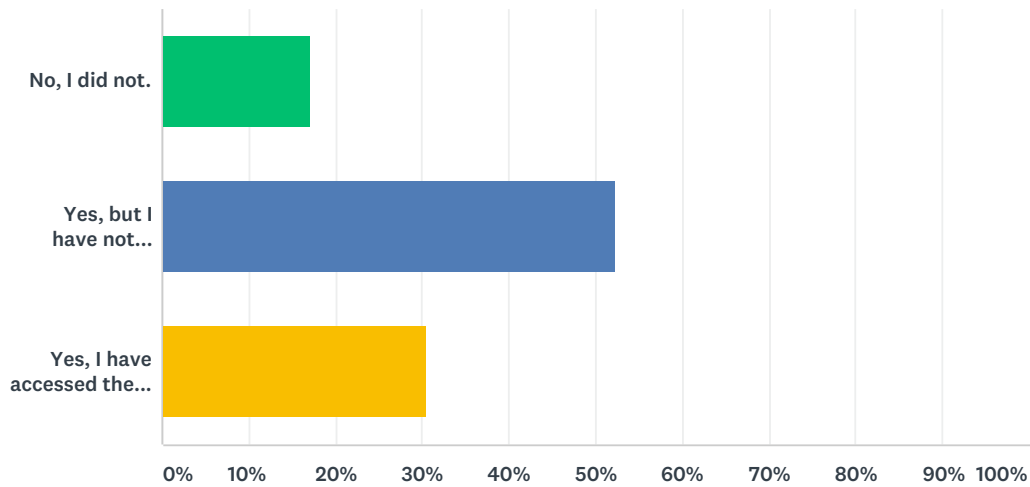
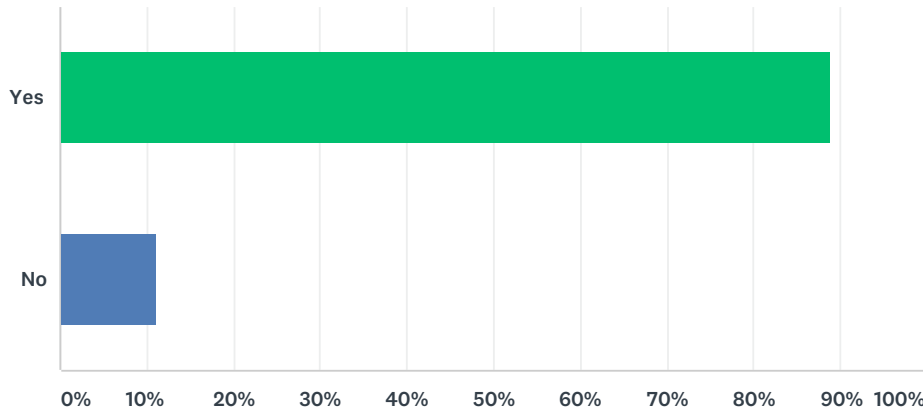| ANSWER CHOICES	RESPONSES	
No, I did not.	17.14%	18
Yes, but I have not accessed them	52.38%	55
Yes, I have accessed them. Please let us know if you have you found these useful?	30.48%	32
TOTAL		105

#	YES, I HAVE ACCESSED THEM. PLEASE LET US KNOW IF YOU HAVE YOU FOUND THESE USEFUL?	DATE
1	Helpful that they are there if one wishes to access	1/9/2018 1:52 PM
2	Refer back regularly	1/8/2018 5:39 PM
3	Yes	1/8/2018 12:21 PM
4	very useful,as a refresh for those attended and also very interesting to read notes from other regions.	1/8/2018 10:30 AM
5	Yes	1/8/2018 9:59 AM
6	N/A	1/8/2018 9:57 AM
7	Many of the minutes are useful to review what was discussed	1/8/2018 9:37 AM
8	Good to verify any problems	1/5/2018 8:35 AM
9	very usefull	1/4/2018 5:33 PM
10	had to verify talks given	1/4/2018 9:05 AM
11	Very good reminders	1/3/2018 2:47 PM
12	Yes. I find the workshop records provide a very useful reference	1/3/2018 12:40 PM
13	Yes	1/3/2018 11:26 AM
14	very useful to refer back to.	1/3/2018 8:44 AM
15	very useful	1/3/2018 6:10 AM

16	very useful	1/2/2018 6:10 PM
17	I generally take notes as well so they fill in the gaps	1/2/2018 5:23 PM
18	Yes, useful reminder of what was discussed	1/2/2018 12:28 PM
19	Mostly	1/2/2018 10:56 AM
20	Yes they are useful	1/2/2018 10:41 AM
21	yes	12/26/2017 4:10 PM
22	minutes are a great reminder of topics discussed	12/26/2017 6:07 AM
23	somewhat	12/23/2017 3:12 AM
24	It saves me from having to write heaps of notes on the day	12/22/2017 2:40 PM
25	yes	12/22/2017 12:31 PM
26	Yes it helps knowing they will be put up on the BPR site as then you can concentrate on the speaker and know that you can refer to the minutes at a later date. BPR is a great facility and has so much information available, use it constantly and refer new growers to joining up.	12/22/2017 10:58 AM
27	Yes... great resource.	12/22/2017 9:50 AM
28	useful	12/22/2017 7:12 AM
29	Useful	12/21/2017 6:43 PM
30	Yes very useful to refresh my memory	12/21/2017 6:31 PM
31	useful yes	12/21/2017 6:13 PM
32	To refresh information from workshops .	12/21/2017 5:44 PM

Q9 Have you made changes (large or small) to your business as a result of these workshops?
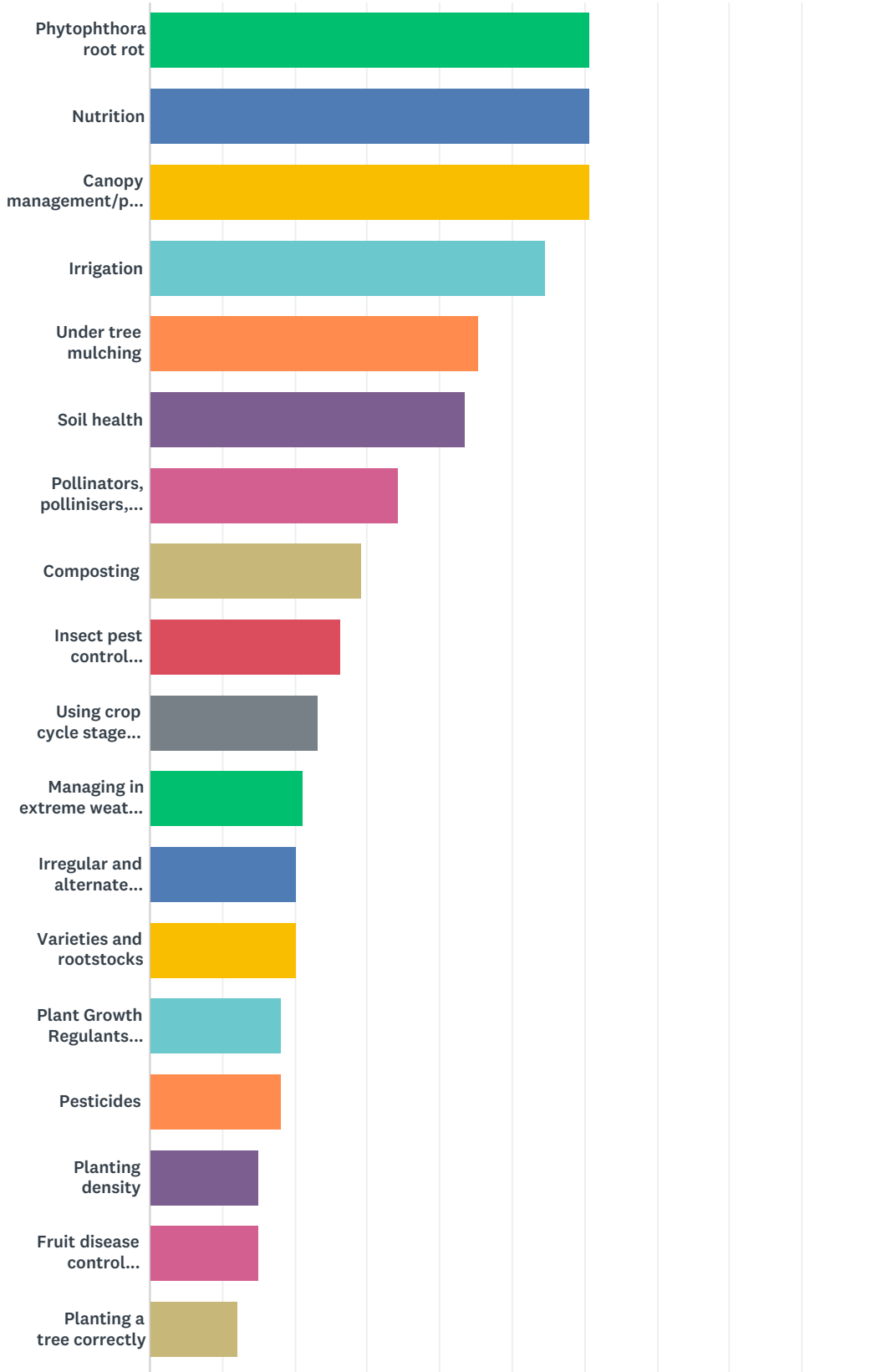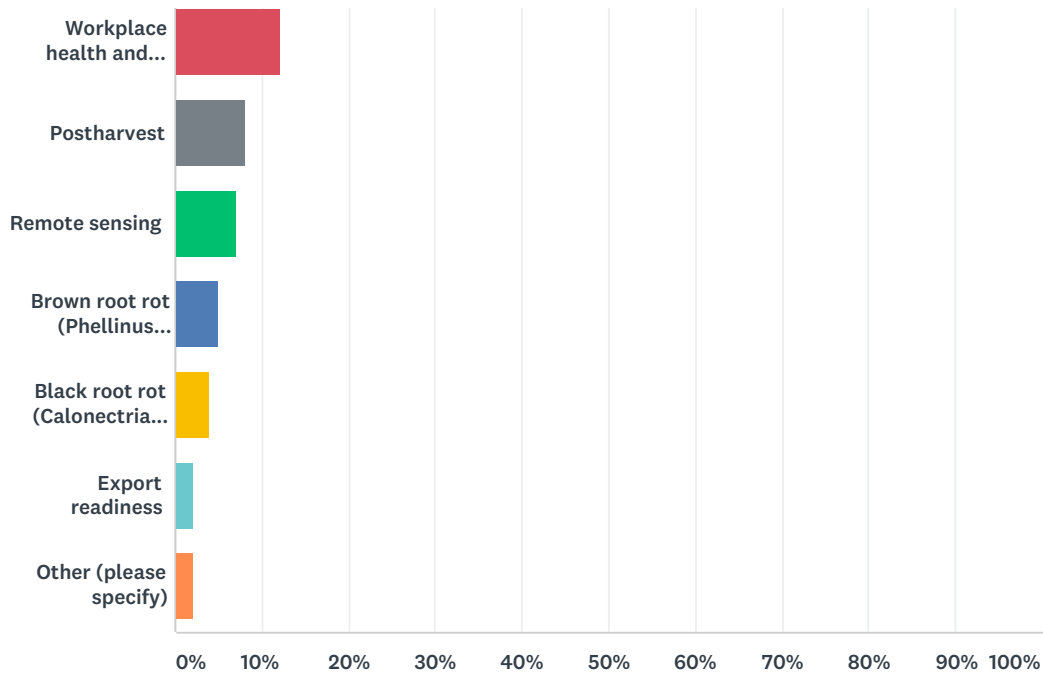
Answered: 108   Skipped: 0

ANSWER CHOICES	RESPONSES	
Yes	88.89%	96
No	11.11%	12
TOTAL		108

Q10 If yes, please tick what area(s) of management you have made changes to

Answered: 99   Skipped: 9

ANSWER CHOICES	RESPONSES	
Phytophthora root rot	60.61%	60
Nutrition	60.61%	60
Canopy management/pruning	60.61%	60
Irrigation	54.55%	54
Under tree mulching	45.45%	45
Soil health	43.43%	43
Pollinators, pollinisers, pollination, fruit set and/or fruit retention	34.34%	34
Composting	29.29%	29
Insect pest control including spotting bug, Ambrosia beetle/pinhole borer, SSM etc	26.26%	26
Using crop cycle stage (phenology) to determine timing of management practices	23.23%	23
Managing in extreme weather (heat waves, frosts, drought and floods)	21.21%	21
Irregular and alternate bearing	20.20%	20
Varieties and rootstocks	20.20%	20
Plant Growth Regulants (PGRs)	18.18%	18
Pesticides	18.18%	18
Planting density	15.15%	15
Fruit disease control (anthracnose)	15.15%	15
Planting a tree correctly	12.12%	12
Workplace health and safety	12.12%	12
Postharvest	8.08%	8

Remote sensing	7.07%	7
Brown root rot (Phellinus noxius)	5.05%	5
Black root rot (Calonectria ilicicola)	4.04%	4
Export readiness	2.02%	2
Other (please specify)	2.02%	2
Total Respondents: 99		

#	OTHER (PLEASE SPECIFY)	DATE
1	aaaa	1/2/2018 10:41 AM
2	All aspects have been interesting and the ones marked are ones that we have done further research on after listening to the speakers and learning at the field days and from information on the BPR website.	12/22/2017 10:58 AM

Q11 How useful do you think the workshops have been to improving communication and sharing information?

Answered: 106   Skipped: 2
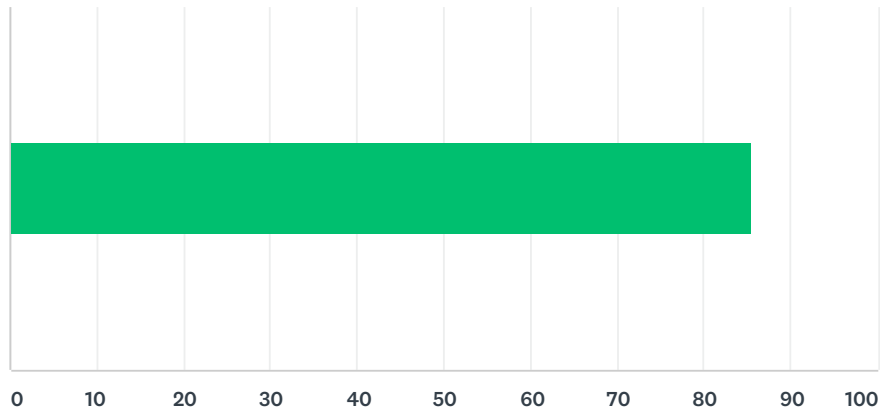
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
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Total Respondents: 106			

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5	75	1/9/2018 11:19 AM
6	85	1/9/2018 9:52 AM
7	75	1/9/2018 6:51 AM
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14	100	1/8/2018 1:20 PM
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16	100	1/8/2018 12:23 PM
17	60	1/8/2018 12:21 PM
18	95	1/8/2018 10:48 AM
19	100	1/8/2018 10:30 AM
20	100	1/8/2018 9:59 AM
21	90	1/8/2018 9:57 AM

22	100	1/8/2018 9:43 AM
23	90	1/8/2018 9:37 AM
24	60	1/8/2018 9:37 AM
25	100	1/5/2018 8:35 AM
26	92	1/4/2018 5:33 PM
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41	97	1/3/2018 8:44 AM
42	100	1/3/2018 8:27 AM
43	86	1/3/2018 6:10 AM
44	90	1/2/2018 9:35 PM
45	86	1/2/2018 8:13 PM
46	80	1/2/2018 6:10 PM
47	95	1/2/2018 6:00 PM
48	68	1/2/2018 5:40 PM
49	90	1/2/2018 5:23 PM
50	100	1/2/2018 5:17 PM
51	90	1/2/2018 5:06 PM
52	80	1/2/2018 3:46 PM
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55	85	1/2/2018 2:06 PM
56	100	1/2/2018 2:04 PM
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62	100	1/2/2018 11:38 AM

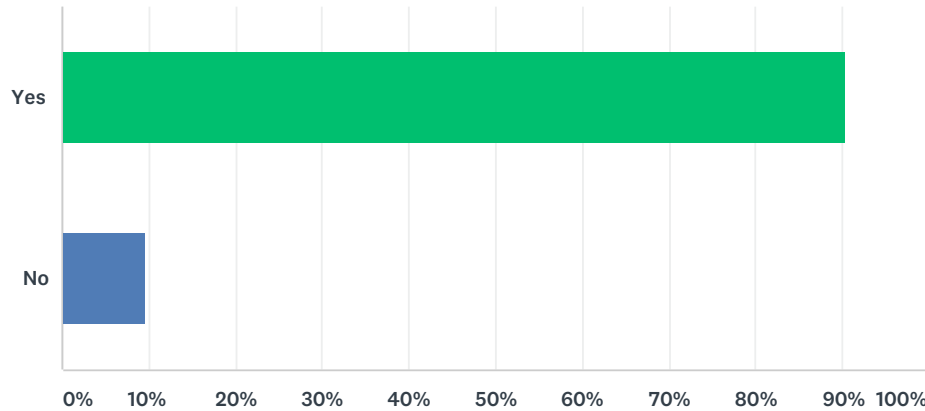| 63	75	1/2/2018 11:26 AM
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71	80	1/2/2018 10:30 AM
72	90	1/2/2018 10:20 AM
73	75	1/2/2018 10:19 AM
74	80	12/29/2017 11:21 AM
75	50	12/26/2017 6:56 PM
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77	100	12/26/2017 9:12 AM
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79	50	12/23/2017 3:37 PM
80	74	12/23/2017 9:42 AM
81	80	12/23/2017 3:12 AM
82	100	12/22/2017 3:15 PM
83	100	12/22/2017 2:40 PM
84	100	12/22/2017 12:31 PM
85	100	12/22/2017 10:58 AM
86	66	12/22/2017 10:05 AM
87	100	12/22/2017 9:50 AM
88	89	12/22/2017 7:43 AM
89	99	12/22/2017 7:12 AM
90	80	12/22/2017 6:04 AM
91	100	12/22/2017 5:49 AM
92	98	12/21/2017 11:34 PM
93	75	12/21/2017 10:08 PM
94	84	12/21/2017 8:39 PM
95	100	12/21/2017 8:32 PM
96	98	12/21/2017 8:12 PM
97	80	12/21/2017 7:54 PM
98	98	12/21/2017 7:50 PM
99	74	12/21/2017 7:43 PM
100	90	12/21/2017 6:43 PM
101	90	12/21/2017 6:31 PM
102	100	12/21/2017 6:13 PM
103	58	12/21/2017 5:44 PM

104	70	12/21/2017 5:44 PM
105	78	12/21/2017 5:11 PM
106	98	12/21/2017 4:47 PM

Q12 A number of growers and project team members recorded observations on flowering and fruitset. This information was compared against prevailing temperatures and presented at grower workshops and the reports included in the Best Practice Resource. Did you get a better understanding of the avocado flowering and fruitset process from this part of the project?

Answered: 105   Skipped: 3

ANSWER CHOICES	RESPONSES	
Yes	90.48%	95
No	9.52%	10
TOTAL		105

#	COMMENTS	DATE
1	the information is too complicated. Information given was on methodology mainly but growers are more interested in the simple explanation of how to define a flowering event so they can monitor themselves and record the information.	1/8/2018 10:30 AM
2	Such a complex process. This year we had amazing fruit set but have shed more than we would like.	1/2/2018 5:23 PM
3	very helpful	12/23/2017 3:12 AM
4	Flowering and fruitlet is more complicated for avocados then a lot of crops and so it is important to understand as much as we can by the process.	12/22/2017 10:58 AM
5	harpns stinks where was our reps all should be sacked now	12/22/2017 10:05 AM
6	Confirmed own observations	12/21/2017 7:54 PM
7	I wasn't aware this had happened	12/21/2017 4:47 PM

Q13 Do you think you have reduced the level of irregular and/or alternate bearing on your orchard as a result of what you have learned through this project?

Answered: 100   Skipped: 8
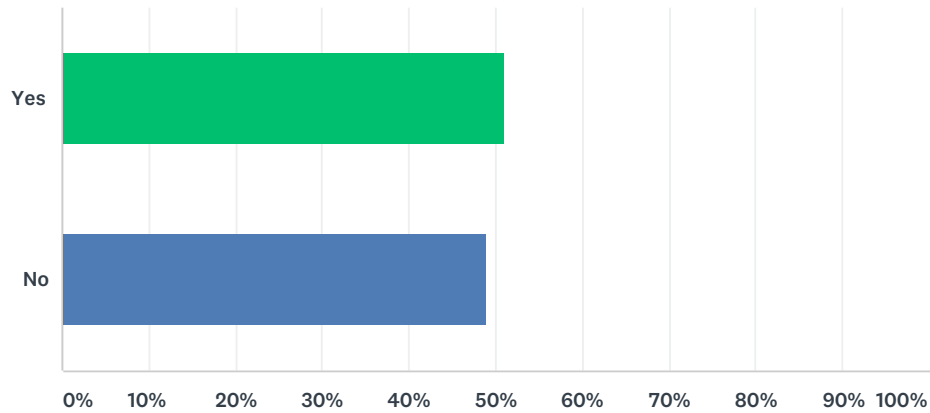
ANSWER CHOICES	RESPONSES	
Yes	51.00%	51
No	49.00%	49
TOTAL		100

| #	COMMENTS	DATE
1	Debatable - weather has a huge influence	1/9/2018 1:52 PM
2	an ongoing process	1/8/2018 1:20 PM
3	not sure. We only have vague clues as to what may be the cause. I have not heard or read of specific do's and dont's for starters. What are we sure of?	1/8/2018 10:30 AM
4	Unsure as yet	1/3/2018 11:29 AM
5	work in progress	1/3/2018 8:44 AM
6	Being a southern grower and middle to late harvester its difficult to control the alternate bearing unless the fruit has been harvested	1/3/2018 8:27 AM
7	We would like our off year to be 60-70% of the on year but we are moving in the right direction	1/2/2018 5:23 PM
8	Only Young Orchard	1/2/2018 1:58 PM
9	Too early to tell	1/2/2018 10:56 AM
10	Not yet - climatic conditions have resulted in very light crops in the Tristate in 2018	1/2/2018 10:48 AM
11	n/a	1/2/2018 10:46 AM
12	N/A	1/2/2018 10:30 AM
13	We run a different highly effective strategy	12/23/2017 3:12 AM
14	Certainly understand more about the issue	12/22/2017 10:58 AM
15	But we still have a way to go.	12/22/2017 9:50 AM
16	Not Yet	12/21/2017 11:34 PM
17	Has explained why my efforts are not all ways successfull	12/21/2017 7:54 PM

| 18 | still a young orchard though so probably not so prone to it | 12/21/2017 6:13 PM |

Q14 Eight sets of 'AvoAlerts' are issued every month as reminders about important orchard management tasks that fall due at different times of the year. They cover the major Australian production regions for 'Hass' and 'Shepard'. 'AvoAlerts' commenced in September 2016.Have you found the 'AvoAlerts' useful?

Answered: 103   Skipped: 5
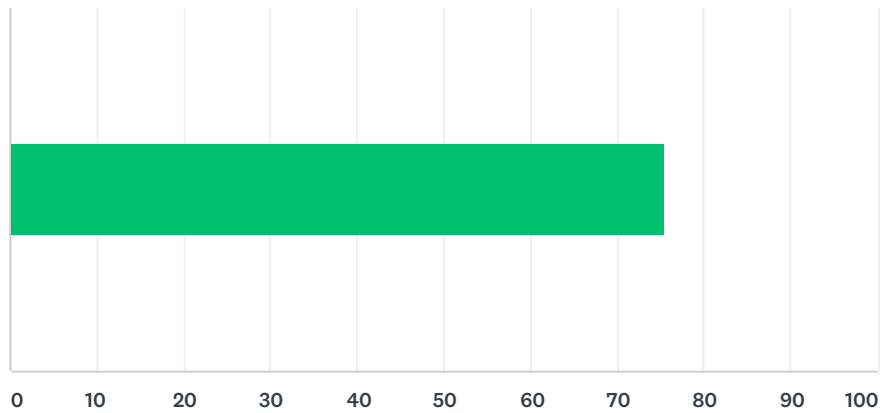
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	76	7,778	103
Total Respondents: 103			

#		DATE
1	80	1/10/2018 7:19 AM
2	88	1/9/2018 3:47 PM
3	68	1/9/2018 1:52 PM
4	80	1/9/2018 12:04 PM
5	80	1/9/2018 11:19 AM
6	89	1/9/2018 9:52 AM
7	70	1/9/2018 6:51 AM
8	50	1/8/2018 8:47 PM
9	53	1/8/2018 7:43 PM
10	58	1/8/2018 6:45 PM
11	99	1/8/2018 6:39 PM
12	100	1/8/2018 5:39 PM
13	85	1/8/2018 2:25 PM
14	100	1/8/2018 1:20 PM
15	20	1/8/2018 1:08 PM
16	100	1/8/2018 12:23 PM
17	80	1/8/2018 12:21 PM

18	70	1/8/2018 10:48 AM
19	100	1/8/2018 10:30 AM
20	75	1/8/2018 9:59 AM
21	85	1/8/2018 9:57 AM
22	100	1/8/2018 9:43 AM
23	61	1/8/2018 9:37 AM
24	80	1/8/2018 9:37 AM
25	100	1/5/2018 8:35 AM
26	90	1/4/2018 5:33 PM
27	75	1/4/2018 9:58 AM
28	2	1/4/2018 9:44 AM
29	60	1/4/2018 9:05 AM
30	69	1/4/2018 8:46 AM
31	59	1/3/2018 11:22 PM
32	99	1/3/2018 6:56 PM
33	100	1/3/2018 4:14 PM
34	90	1/3/2018 2:47 PM
35	99	1/3/2018 2:47 PM
36	95	1/3/2018 12:40 PM
37	84	1/3/2018 11:29 AM
38	70	1/3/2018 11:26 AM
39	59	1/3/2018 10:05 AM
40	75	1/3/2018 8:49 AM
41	94	1/3/2018 8:44 AM
42	49	1/3/2018 8:27 AM
43	88	1/3/2018 6:10 AM
44	90	1/2/2018 9:35 PM
45	60	1/2/2018 8:13 PM
46	51	1/2/2018 6:10 PM
47	85	1/2/2018 6:00 PM
48	0	1/2/2018 5:40 PM
49	36	1/2/2018 5:23 PM
50	100	1/2/2018 5:17 PM
51	90	1/2/2018 5:06 PM
52	70	1/2/2018 3:46 PM
53	50	1/2/2018 3:09 PM
54	73	1/2/2018 2:14 PM
55	65	1/2/2018 2:06 PM
56	100	1/2/2018 2:04 PM
57	95	1/2/2018 1:58 PM
58	100	1/2/2018 12:32 PM

59	90	1/2/2018 12:28 PM
60	5	1/2/2018 11:44 AM
61	99	1/2/2018 11:38 AM
62	50	1/2/2018 11:26 AM
63	99	1/2/2018 10:56 AM
64	89	1/2/2018 10:55 AM
65	1	1/2/2018 10:48 AM
66	94	1/2/2018 10:42 AM
67	80	1/2/2018 10:41 AM
68	5	1/2/2018 10:41 AM
69	0	1/2/2018 10:37 AM
70	60	1/2/2018 10:20 AM
71	0	1/2/2018 10:19 AM
72	90	12/29/2017 11:21 AM
73	90	12/26/2017 6:56 PM
74	95	12/26/2017 4:10 PM
75	100	12/26/2017 6:07 AM
76	88	12/23/2017 3:37 PM
77	56	12/23/2017 9:42 AM
78	100	12/23/2017 3:12 AM
79	90	12/22/2017 3:15 PM
80	100	12/22/2017 2:40 PM
81	100	12/22/2017 12:31 PM
82	90	12/22/2017 10:58 AM
83	46	12/22/2017 10:05 AM
84	75	12/22/2017 9:50 AM
85	84	12/22/2017 7:43 AM
86	99	12/22/2017 7:12 AM
87	90	12/22/2017 6:04 AM
88	52	12/22/2017 5:49 AM
89	100	12/21/2017 11:34 PM
90	80	12/21/2017 10:08 PM
91	86	12/21/2017 8:39 PM
92	92	12/21/2017 8:29 PM
93	100	12/21/2017 8:12 PM
94	87	12/21/2017 7:54 PM
95	100	12/21/2017 7:50 PM
96	99	12/21/2017 7:43 PM
97	79	12/21/2017 6:43 PM
98	100	12/21/2017 6:31 PM
99	100	12/21/2017 6:13 PM

100	50	12/21/2017 5:44 PM
101	60	12/21/2017 5:44 PM
102	85	12/21/2017 5:11 PM
103	50	12/21/2017 4:47 PM

Q15 Any comments about the 'Avo Alerts'?

Answered: 50   Skipped: 58

#	RESPONSES	DATE
1	.	1/9/2018 3:47 PM
2	SOME TIMES IMTERESTING	1/9/2018 12:04 PM
3	Timely and interesting	1/9/2018 9:52 AM
4	Use every montg	1/8/2018 5:39 PM
5	a good reminder	1/8/2018 10:30 AM
6	No	1/8/2018 9:59 AM
7	N/A	1/8/2018 9:57 AM
8	Difficult to print off at times.	1/5/2018 8:35 AM
9	incorporate other varieties	1/4/2018 5:33 PM
10	They are handy as a reminder when you're busy and forget things or put them off for a later date.	1/4/2018 9:58 AM
11	Havent used it	1/4/2018 9:44 AM
12	Only remember seeing one or two. Certainly not 8 per month?	1/3/2018 11:22 PM
13	have to align to our area	1/3/2018 6:56 PM
14	Something to look forward to to make improvements	1/3/2018 4:14 PM
15	Good innovation	1/3/2018 2:47 PM
16	Avo Alerts are a very timely reminder and checklist	1/3/2018 12:40 PM
17	useful reminders	1/3/2018 8:44 AM
18	I need to follow them more closley	1/3/2018 8:27 AM
19	Great idea	1/2/2018 9:35 PM
20	Have not accessed these. Are they on Best Practice website?	1/2/2018 6:10 PM
21	No	1/2/2018 5:40 PM
22	As a gauge off our programs	1/2/2018 2:06 PM
23	no	1/2/2018 2:04 PM
24	Have not received the Avo Alerts	1/2/2018 1:15 PM
25	no	1/2/2018 11:38 AM
26	They are a good reminder of works to be done	1/2/2018 10:56 AM
27	no	1/2/2018 10:55 AM
28	I've tried to access these via AGA but had no success	1/2/2018 10:48 AM
29	n/a	1/2/2018 10:46 AM
30	I don't receive them	1/2/2018 10:41 AM
31	Have not accessed them	1/2/2018 10:30 AM
32	NONE	1/2/2018 10:20 AM
33	I don't receive them	1/2/2018 10:19 AM
34	They are a good tool that can be expanded upon over time to provide more specific information on areas as it comes available. It is completely orchard focused so no waste of time information.	12/29/2017 11:21 AM

35	they are a handy reminder with relevant links to more information	12/26/2017 6:07 AM
36	The prompts, and memory joggers are very useful, helpful and beneficial notwithstanding the somewhat generic nature of the "alert".	12/23/2017 3:12 AM
37	They are a good reminder.	12/22/2017 2:40 PM
38	no	12/22/2017 10:05 AM
39	Good	12/22/2017 7:43 AM
40	no	12/22/2017 6:04 AM
41	useful	12/22/2017 5:49 AM
42	No other than they are very useful reminders	12/21/2017 11:34 PM
43	No	12/21/2017 8:32 PM
44	very helpful	12/21/2017 8:29 PM
45	Keep it up	12/21/2017 7:54 PM
46	extremely helpful reminders	12/21/2017 7:50 PM
47	keep them going	12/21/2017 7:43 PM
48	Extremely useful, excellent area specific information without the need for me to research. Has greatly improved particularly my fert program	12/21/2017 6:13 PM
49	haven't taken note due to major orchard pruning	12/21/2017 5:44 PM
50	no	12/21/2017 4:47 PM

Q16 This project has maintained the information in the 'Growing' section of the BPR. Although most of the information was prepared during the previous project we would like your opinion on how useful the existing information has been.

Answered: 104　　　Skipped: 4
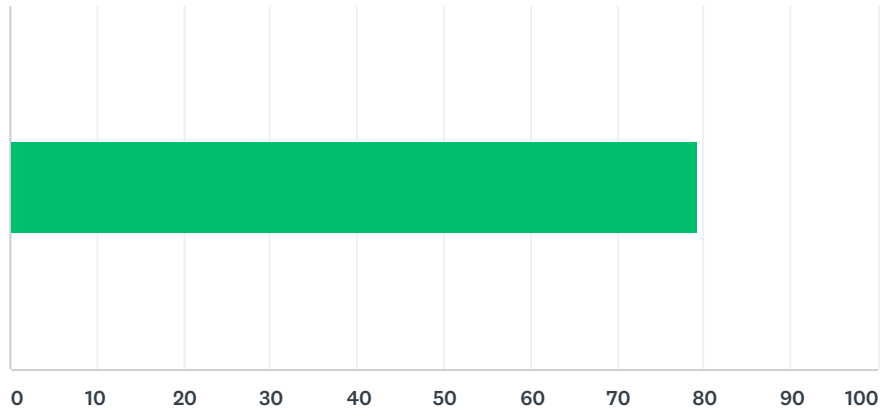
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	79	8,246	104
Total Respondents: 104			

#		DATE
1	91	1/10/2018 7:19 AM
2	100	1/9/2018 3:47 PM
3	74	1/9/2018 1:52 PM
4	83	1/9/2018 12:04 PM
5	75	1/9/2018 11:19 AM
6	58	1/9/2018 9:52 AM
7	90	1/9/2018 6:51 AM
8	50	1/8/2018 8:47 PM
9	57	1/8/2018 6:45 PM
10	98	1/8/2018 6:39 PM
11	100	1/8/2018 5:39 PM
12	79	1/8/2018 2:25 PM
13	100	1/8/2018 1:20 PM
14	42	1/8/2018 1:08 PM
15	100	1/8/2018 12:23 PM
16	75	1/8/2018 12:21 PM
17	90	1/8/2018 10:48 AM
18	100	1/8/2018 10:30 AM
19	75	1/8/2018 9:59 AM

20	85	1/8/2018 9:57 AM
21	100	1/8/2018 9:43 AM
22	71	1/8/2018 9:37 AM
23	75	1/8/2018 9:37 AM
24	100	1/5/2018 8:35 AM
25	91	1/4/2018 5:33 PM
26	50	1/4/2018 9:58 AM
27	79	1/4/2018 9:44 AM
28	80	1/4/2018 9:05 AM
29	62	1/4/2018 8:46 AM
30	68	1/3/2018 11:22 PM
31	82	1/3/2018 6:56 PM
32	97	1/3/2018 4:14 PM
33	99	1/3/2018 2:47 PM
34	85	1/3/2018 12:40 PM
35	72	1/3/2018 11:29 AM
36	70	1/3/2018 11:26 AM
37	75	1/3/2018 10:05 AM
38	100	1/3/2018 8:49 AM
39	91	1/3/2018 8:44 AM
40	50	1/3/2018 8:27 AM
41	67	1/3/2018 6:10 AM
42	90	1/2/2018 9:35 PM
43	50	1/2/2018 8:13 PM
44	68	1/2/2018 6:10 PM
45	85	1/2/2018 6:00 PM
46	49	1/2/2018 5:40 PM
47	80	1/2/2018 5:23 PM
48	100	1/2/2018 5:17 PM
49	80	1/2/2018 5:06 PM
50	42	1/2/2018 3:46 PM
51	99	1/2/2018 3:09 PM
52	35	1/2/2018 2:14 PM
53	65	1/2/2018 2:06 PM
54	99	1/2/2018 2:04 PM
55	96	1/2/2018 1:58 PM
56	46	1/2/2018 1:15 PM
57	100	1/2/2018 12:32 PM
58	95	1/2/2018 12:28 PM
59	7	1/2/2018 11:44 AM
60	82	1/2/2018 11:38 AM

61	59	1/2/2018 11:26 AM
62	97	1/2/2018 10:56 AM
63	86	1/2/2018 10:55 AM
64	80	1/2/2018 10:48 AM
65	80	1/2/2018 10:46 AM
66	91	1/2/2018 10:42 AM
67	80	1/2/2018 10:41 AM
68	75	1/2/2018 10:41 AM
69	90	1/2/2018 10:37 AM
70	80	1/2/2018 10:30 AM
71	70	1/2/2018 10:20 AM
72	85	1/2/2018 10:19 AM
73	91	12/29/2017 11:21 AM
74	70	12/26/2017 6:56 PM
75	93	12/26/2017 4:10 PM
76	100	12/26/2017 6:07 AM
77	52	12/23/2017 3:37 PM
78	66	12/23/2017 9:42 AM
79	70	12/23/2017 3:12 AM
80	100	12/22/2017 3:15 PM
81	100	12/22/2017 2:40 PM
82	100	12/22/2017 12:31 PM
83	90	12/22/2017 10:58 AM
84	57	12/22/2017 10:05 AM
85	80	12/22/2017 9:50 AM
86	97	12/22/2017 7:43 AM
87	99	12/22/2017 7:12 AM
88	70	12/22/2017 6:04 AM
89	91	12/22/2017 5:49 AM
90	90	12/21/2017 11:34 PM
91	60	12/21/2017 10:08 PM
92	88	12/21/2017 8:39 PM
93	62	12/21/2017 8:29 PM
94	98	12/21/2017 8:12 PM
95	89	12/21/2017 7:54 PM
96	100	12/21/2017 7:50 PM
97	62	12/21/2017 7:43 PM
98	85	12/21/2017 6:43 PM
99	91	12/21/2017 6:31 PM
100	90	12/21/2017 6:13 PM
101	98	12/21/2017 5:44 PM

102	61		12/21/2017 5:44 PM
103	81	43 / 65	12/21/2017 5:11 PM
104	38		12/21/2017 4:47 PM

Q17 Over the course of this project three YouTube videos have been produced, "Getting boron right in avocado", "How to plant an avocado tree" and (only just published) "Mulching avocados".How useful have you found the boron and tree planting videos for yourself and your staff?

Answered: 99   Skipped: 9
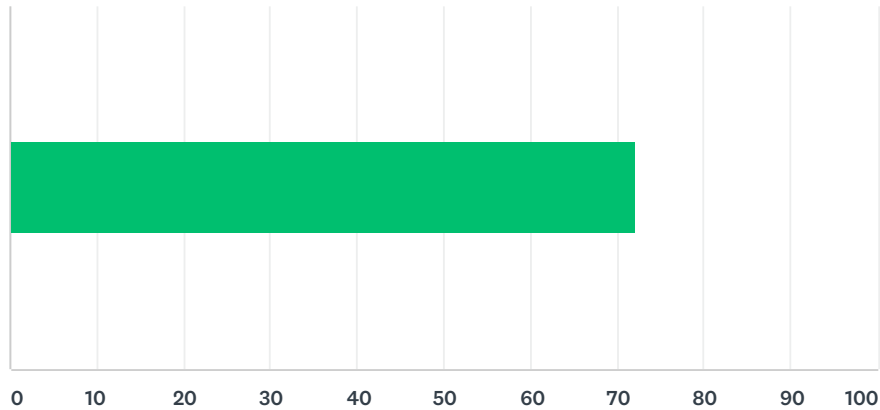
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	72	7,140	99
Total Respondents: 99			

#		DATE
1	84	1/10/2018 7:19 AM
2	100	1/9/2018 3:47 PM
3	23	1/9/2018 1:52 PM
4	80	1/9/2018 12:04 PM
5	65	1/9/2018 11:19 AM
6	82	1/9/2018 9:52 AM
7	80	1/9/2018 6:51 AM
8	50	1/8/2018 8:47 PM
9	45	1/8/2018 7:43 PM
10	57	1/8/2018 6:45 PM
11	98	1/8/2018 6:39 PM
12	100	1/8/2018 5:39 PM
13	74	1/8/2018 2:25 PM
14	0	1/8/2018 1:20 PM
15	70	1/8/2018 12:23 PM
16	0	1/8/2018 12:21 PM
17	80	1/8/2018 10:30 AM
18	75	1/8/2018 9:59 AM
19	70	1/8/2018 9:57 AM

20	100	1/8/2018 9:43 AM
21	55	1/8/2018 9:37 AM
22	65	1/8/2018 9:37 AM
23	100	1/5/2018 8:35 AM
24	97	1/4/2018 5:33 PM
25	51	1/4/2018 9:58 AM
26	91	1/4/2018 9:44 AM
27	75	1/4/2018 9:05 AM
28	53	1/4/2018 8:46 AM
29	66	1/3/2018 11:22 PM
30	82	1/3/2018 6:56 PM
31	99	1/3/2018 4:14 PM
32	100	1/3/2018 2:47 PM
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39	50	1/3/2018 8:27 AM
40	74	1/3/2018 6:10 AM
41	95	1/2/2018 9:35 PM
42	50	1/2/2018 8:13 PM
43	87	1/2/2018 6:10 PM
44	95	1/2/2018 6:00 PM
45	35	1/2/2018 5:40 PM
46	54	1/2/2018 5:23 PM
47	79	1/2/2018 5:17 PM
48	80	1/2/2018 5:06 PM
49	30	1/2/2018 3:46 PM
50	83	1/2/2018 3:09 PM
51	28	1/2/2018 2:14 PM
52	70	1/2/2018 2:06 PM
53	93	1/2/2018 2:04 PM
54	93	1/2/2018 1:58 PM
55	100	1/2/2018 12:32 PM
56	85	1/2/2018 12:28 PM
57	6	1/2/2018 11:44 AM
58	100	1/2/2018 11:38 AM
59	51	1/2/2018 11:26 AM
60	49	1/2/2018 10:56 AM

61	79	1/2/2018 10:55 AM
62	80	1/2/2018 10:48 AM
63	63	1/2/2018 10:42 AM
64	92	1/2/2018 10:41 AM
65	61	1/2/2018 10:41 AM
66	90	1/2/2018 10:37 AM
67	80	1/2/2018 10:30 AM
68	70	1/2/2018 10:20 AM
69	100	1/2/2018 10:19 AM
70	75	12/29/2017 11:21 AM
71	96	12/26/2017 4:10 PM
72	100	12/26/2017 6:07 AM
73	56	12/23/2017 3:37 PM
74	4	12/23/2017 9:42 AM
75	70	12/23/2017 3:12 AM
76	83	12/22/2017 3:15 PM
77	79	12/22/2017 2:40 PM
78	70	12/22/2017 12:31 PM
79	100	12/22/2017 10:58 AM
80	85	12/22/2017 10:05 AM
81	80	12/22/2017 9:50 AM
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83	99	12/22/2017 7:12 AM
84	60	12/22/2017 6:04 AM
85	39	12/22/2017 5:49 AM
86	91	12/21/2017 11:34 PM
87	50	12/21/2017 10:08 PM
88	78	12/21/2017 8:39 PM
89	57	12/21/2017 8:29 PM
90	98	12/21/2017 8:12 PM
91	84	12/21/2017 7:50 PM
92	26	12/21/2017 7:43 PM
93	74	12/21/2017 6:43 PM
94	100	12/21/2017 6:31 PM
95	85	12/21/2017 6:13 PM
96	100	12/21/2017 5:44 PM
97	62	12/21/2017 5:44 PM
98	62	12/21/2017 5:11 PM
99	50	12/21/2017 4:47 PM

Q18 Would you like to see more videos made?

Answered: 96   Skipped: 12
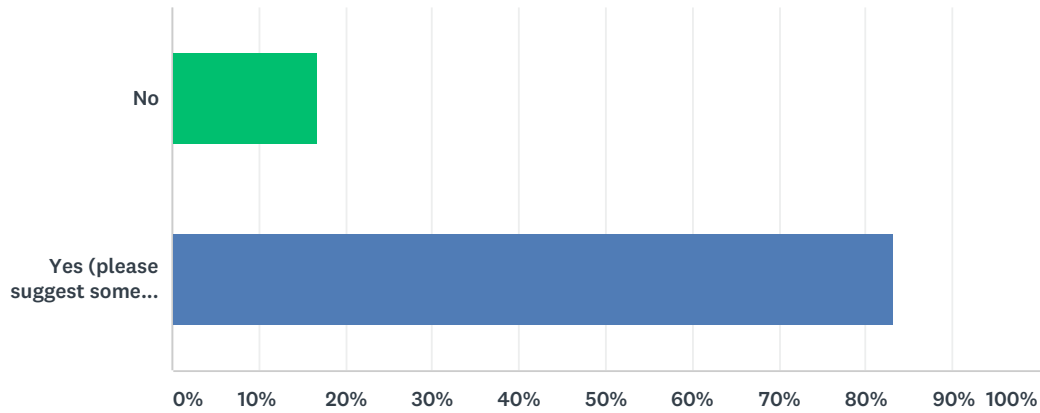
ANSWER CHOICES	RESPONSES	
No	16.67%	16
Yes (please suggest some topics)	83.33%	80
TOTAL		96

#	YES (PLEASE SUGGEST SOME TOPICS)	DATE
1	Packing avos. How to take root samples	1/9/2018 3:47 PM
2	TREE INJECTING	1/9/2018 12:04 PM
3	Tree density	1/9/2018 9:52 AM
4	canopy management	1/8/2018 7:43 PM
5	A stronger basis for natural nutrition and methods of soil nutrients/health	1/8/2018 6:39 PM
6	Spraying	1/8/2018 5:39 PM
7	Pruning	1/8/2018 2:25 PM
8	consistent cropping on select area over # of years	1/8/2018 1:20 PM
9	We did not know the videos existed	1/8/2018 12:21 PM
10	nothing specific at the moment	1/8/2018 10:30 AM
11	Testing Fertigation applications within a block	1/8/2018 9:59 AM
12	pruning methods	1/8/2018 9:43 AM
13	pruning	1/5/2018 8:35 AM
14	irragation monitoring, drainage, over head heat water	1/4/2018 5:33 PM
15	injecting the trees...the best position in the branch and how to mix the phos acid. eg rates and procedure	1/4/2018 9:58 AM
16	Spray application and water rates for spraying	1/4/2018 9:44 AM
17	canopy management and pruning.	1/4/2018 8:46 AM
18	leaf & root sampling, injecting	1/3/2018 11:22 PM
19	growing subjects	1/3/2018 6:56 PM
20	The best way to maintain syringes for injection.	1/3/2018 4:14 PM

21	Tree nutrition	1/3/2018 2:47 PM
22	Canopy management, mulching and various phytophthera controls such as foliar spray v injection v butt drench.	1/3/2018 12:40 PM
23	Canopy Management	1/3/2018 11:29 AM
24	Pruning	1/3/2018 11:26 AM
25	how to pick and handle fruit	1/3/2018 10:05 AM
26	how composting and soil health works in avocados	1/3/2018 8:49 AM
27	pruning	1/3/2018 8:44 AM
28	Microbes in the soil, importance of healthy soils	1/3/2018 8:27 AM
29	limb removal selection and execution	1/2/2018 9:35 PM
30	Pruning	1/2/2018 8:13 PM
31	videos showing trace element/nutrient issues.	1/2/2018 6:10 PM
32	Yes on anything that can help	1/2/2018 6:00 PM
33	pruning - canopy managment	1/2/2018 5:23 PM
34	Q	1/2/2018 5:17 PM
35	consistent cropping	1/2/2018 3:46 PM
36	Pruning	1/2/2018 3:09 PM
37	Injection	1/2/2018 2:14 PM
38	Pruning	1/2/2018 2:06 PM
39	Every aspect of growing a crop. A video will be etched into our brain better than words	1/2/2018 1:58 PM
40	Root rot management	1/2/2018 12:32 PM
41	Post harvest processes	1/2/2018 12:28 PM
42	Canopy managment	1/2/2018 11:44 AM
43	Flowering and fruit development	1/2/2018 11:38 AM
44	Na	1/2/2018 11:26 AM
45	Pruning and Managinf high density planting. Grafting	1/2/2018 10:56 AM
46	work place health and safety	1/2/2018 10:55 AM
47	Canopy management; Phytophthora control	1/2/2018 10:48 AM
48	Crop manipulation incl. pruning & use of PGRs	1/2/2018 10:46 AM
49	canopy management	1/2/2018 10:42 AM
50	Root rot.	1/2/2018 10:41 AM
51	Canopy management, checking sprinklers	1/2/2018 10:41 AM
52	All different topics.	1/2/2018 10:37 AM
53	different priority issues for growers	1/2/2018 10:30 AM
54	Pollination, Variety choice to location/zone	1/2/2018 10:20 AM
55	as much as passable	1/2/2018 10:19 AM
56	Irrigation/water management in avocados, Process for problem solving and treating sick trees/areas of orchard, Soil/leaf sampling, PGR analysis and use	12/29/2017 11:21 AM
57	pruning	12/26/2017 4:10 PM
58	canopy management - selective limb removal	12/26/2017 6:07 AM
59	Root management	12/23/2017 3:37 PM

60	disease identification (leaf identification) and managment practices (such as Phytophora)	12/23/2017 3:12 AM
61	Grafting	12/22/2017 2:40 PM
62	tree grafting	12/22/2017 12:31 PM
63	There are always new growers joining the industry and we refer recommend they join AA and use the BPR as it has a lot of information especially useful to existing growers as well as new growers. Maybe one on pruning young trees would be good.	12/22/2017 10:58 AM
64	Canopy management options and canopy pruning techniques	12/22/2017 9:50 AM
65	Pollination	12/22/2017 7:43 AM
66	orchard establishment to pre harvest	12/22/2017 7:12 AM
67	canopy management	12/22/2017 5:49 AM
68	Pruning young trees	12/21/2017 11:34 PM
69	Grafting Trees	12/21/2017 8:39 PM
70	gathering samples (roots and leaf) for testing of phytophera	12/21/2017 8:29 PM
71	nutrition	12/21/2017 8:12 PM
72	Staff training/induction, root sampling, leaf sampling,maturity testing	12/21/2017 7:54 PM
73	insects and pollination	12/21/2017 7:50 PM
74	Video showing range of each nutritional deficiency. I know photos exist, but sometimes looking at 10-15 examples of a particular deficiency	12/21/2017 6:43 PM
75	Canopy management	12/21/2017 6:31 PM
76	Grafting (both seedlings and large trees)	12/21/2017 6:13 PM
77	pruning	12/21/2017 5:44 PM
78	tree stage for phosphonate application .	12/21/2017 5:44 PM
79	I dont know	12/21/2017 5:11 PM
80	grafting an avocado tree and timing of budwood harvest	12/21/2017 4:47 PM

Q19 An important part of evaluating a project is to try and put a dollar figure on how valuable the project has been to your business. Please consider the estimated short and long term benefits of decisions you have made as a result of information gathered from the project (e.g. disease and insect control, irrigation etc). Please estimate what the financial value this has been to your operation.

Answered: 101   Skipped: 7
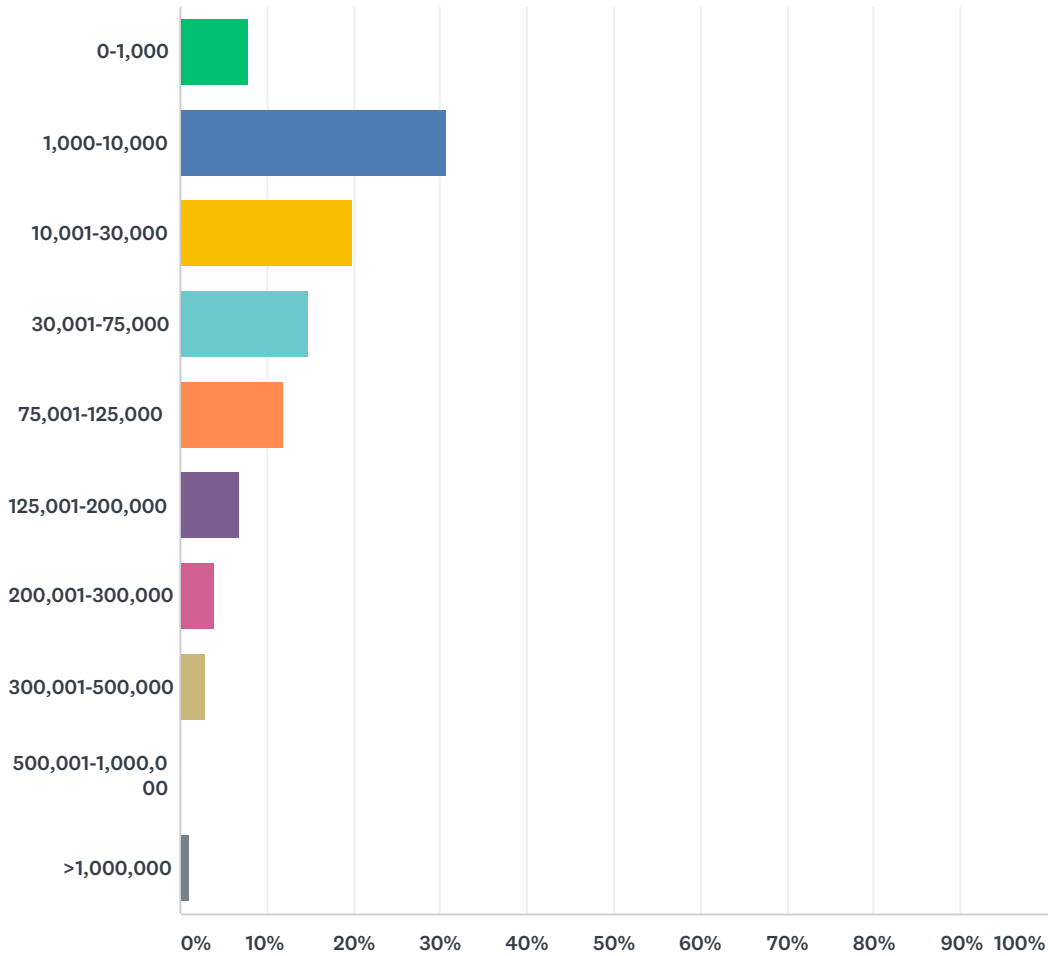
ANSWER CHOICES	RESPONSES	
0-1,000	7.92%	8
1,000-10,000	30.69%	31
10,001-30,000	19.80%	20
30,001-75,000	14.85%	15
75,001-125,000	11.88%	12
125,001-200,000	6.93%	7
200,001-300,000	3.96%	4

300,001-500,000	2.97%	3
500,001-1,000,000	0.00%	0
>1,000,000	0.99%	1
TOTAL		101

Q20 Please comment where the main financial benefits have occurred (e.g. better irrigation, better control of root rot etc).

Answered: 83   Skipped: 25

#	RESPONSES	DATE
1	Better root rot control, better general tree health	1/10/2018 7:19 AM
2	irrigation nutrition root rot	1/9/2018 3:47 PM
3	A;; OF THE ABOVE	1/9/2018 12:04 PM
4	Better control of root rot	1/9/2018 11:19 AM
5	Better understanding of tree health	1/9/2018 9:52 AM
6	root rot irrigation with niutrition	1/9/2018 6:51 AM
7	canopy management	1/8/2018 7:43 PM
8	irrigation management, plant and soil health	1/8/2018 6:39 PM
9	Better irrigation and nutrition	1/8/2018 5:39 PM
10	canopy management	1/8/2018 1:20 PM
11	Irrigation	1/8/2018 12:23 PM
12	Nutrition and Phytophthora	1/8/2018 12:21 PM
13	root rot	1/8/2018 10:48 AM
14	better control of root rot better timing of irrigation identifing control of pepper spot understanding nutrition, timing and the different forms of soluble nutrients	1/8/2018 10:30 AM
15	More efficient methods of doing farming operations	1/8/2018 9:59 AM
16	N/A	1/8/2018 9:57 AM
17	better fruit set irrigation pruning	1/8/2018 9:43 AM
18	Better pruning and reduction in biannual bearing	1/8/2018 9:37 AM
19	monthly outline of orchard requirements via avo alerts	1/5/2018 8:35 AM
20	fertilizer management, irrigation heat water	1/4/2018 5:33 PM
21	a combination of a lot of things has helped overall	1/4/2018 9:58 AM
22	Pruning management	1/4/2018 9:44 AM
23	better canopy management and mulching value	1/4/2018 8:46 AM
24	more frequent fertilising	1/3/2018 11:22 PM
25	a better understanding on how to do things	1/3/2018 6:56 PM
26	Knowing the correct times of year to fertilize, inject , mulch etc.	1/3/2018 4:14 PM
27	Improved nutrition	1/3/2018 2:47 PM
28	reducing input costs for electricity, fertiliser and more efficient water usage.	1/3/2018 12:40 PM
29	Higher yield, better irrigation	1/3/2018 11:29 AM
30	irrigation and mulch	1/3/2018 11:26 AM
31	higher yield due to irrigation, disease control and nutrition	1/3/2018 10:05 AM
32	input saving and efficacy. Fruit quality.	1/3/2018 8:49 AM
33	better control of root rot & better nutrition	1/3/2018 8:44 AM

34	understanding flowering	1/3/2018 8:27 AM
35	Better irrigation, better nutrition, better understanding of phytophthora root rot treatment.	1/2/2018 9:35 PM
36	Root rot control	1/2/2018 8:13 PM
37	Better control of irrigation, biennial bearing and root rot	1/2/2018 6:10 PM
38	Watering savings, on power and water usage	1/2/2018 6:00 PM
39	Irregular bearing. More consistent cropping	1/2/2018 5:40 PM
40	improved knowledge of crop cycle, phytophera and irrigation	1/2/2018 5:23 PM
41	Better production better quality of fruit	1/2/2018 5:17 PM
42	canopy management	1/2/2018 3:46 PM
43	no comment	1/2/2018 2:04 PM
44	Root rot control	1/2/2018 1:58 PM
45	Better control of root rot, better irrigation	1/2/2018 12:28 PM
46	Irrigation,nutrition,soil managment	1/2/2018 11:44 AM
47	Pesticide/fungacide useage and effectiveness, nutrition	1/2/2018 11:38 AM
48	Areas highlighted in q10.	1/2/2018 11:26 AM
49	Generally all contributes to benefits, some like Water management can return a more quantifiable result.	1/2/2018 10:56 AM
50	Better irrigation, nutrition, pruning	1/2/2018 10:48 AM
51	We are suppliers and thus the advantage to us is gain in sales. The workshops have allowed some networking although often growers prefer to chat on farm. Some technical aspects of workshops have improved our understanding of how are products can be used in practice.	1/2/2018 10:46 AM
52	Boron application	1/2/2018 10:41 AM
53	Better understanding all aspects of the avocado tree, hopefully making a improvement in tree health and cropping.	1/2/2018 10:37 AM
54	N/A	1/2/2018 10:30 AM
55	Irrigation & Tree stress period in phenology	1/2/2018 10:20 AM
56	I'm a re-seller	1/2/2018 10:19 AM
57	better irrigation better understanding of canopy management	12/29/2017 11:21 AM
58	higher production less diseases	12/26/2017 4:10 PM
59	increased yields through better irrigation and fertilizer application	12/26/2017 6:07 AM
60	better irrigation better control of fungus	12/23/2017 9:42 AM
61	General Overall Practice	12/23/2017 3:12 AM
62	Having a better handle on our nutrition and our timing overall has been our main financial benefit.	12/22/2017 3:15 PM
63	Better irrigation and root rot control.	12/22/2017 2:40 PM
64	better control of spotting bug, irrigation	12/22/2017 12:31 PM
65	For us this is a great meeting place to chat our customers about any concerns or issues and also meet new growers. The interaction between growers and scientific groups is a wonderful place to keep up with trends whether local or international and hear about their research projects and the outcomes of this work. The work that these extension people do in this industry is vital and has been lost by many other crops such as apples etc and the growers then do not have anyone to turn to for advice. This area of the industry is extremely important for all sectors of the industry to keep it successful.	12/22/2017 10:58 AM
66	net working	12/22/2017 10:05 AM
67	Better control of PC Better nutrition management	12/22/2017 9:50 AM

68	Irrigation	12/22/2017 7:43 AM
69	root rot	12/22/2017 6:04 AM
70	better irrigation	12/22/2017 5:49 AM
71	Better understanding of managing our trees through their growing cycle	12/21/2017 11:34 PM
72	hard to quantify	12/21/2017 10:08 PM
73	Both of these	12/21/2017 8:32 PM
74	Disease and flower/ pollination	12/21/2017 8:12 PM
75	Root rot, canopy management	12/21/2017 7:54 PM
76	better control of dieback	12/21/2017 7:50 PM
77	root rot control	12/21/2017 7:43 PM
78	I believe the key to everything is in the soil. If you can get this right life is a breeze	12/21/2017 6:43 PM
79	Root management	12/21/2017 6:31 PM
80	better irrigation, fertigation and management of extreme weather events	12/21/2017 6:13 PM
81	irrigation and fertilizers	12/21/2017 5:44 PM
82	Fruit harvested .	12/21/2017 5:11 PM
83	better timing of canopy mgt.	12/21/2017 4:47 PM

Q21 The 'Manage Phytophthora Root Rot' poster was developed and distributed at the end of the previous project, but it was too early to evaluate its usefulness then. How useful have you found this poster?

Answered: 101   Skipped: 7
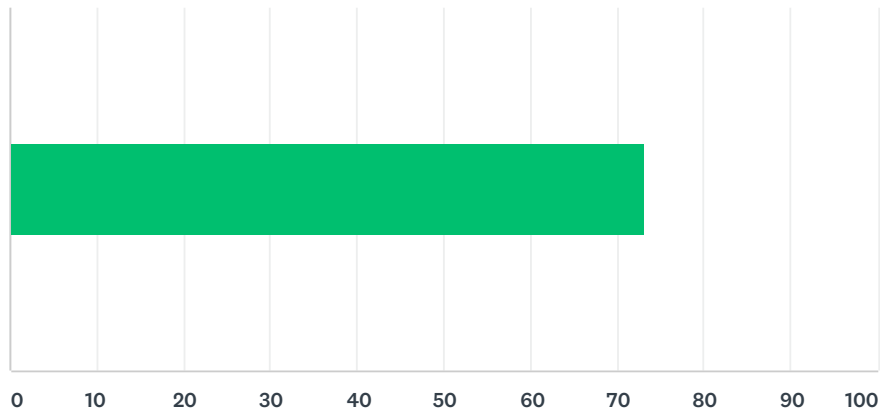
ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	73	7,396	101
Total Respondents: 101			

#		DATE
1	80	1/10/2018 7:19 AM
2	100	1/9/2018 3:47 PM
3	80	1/9/2018 12:04 PM
4	65	1/9/2018 11:19 AM
5	89	1/9/2018 9:52 AM
6	75	1/9/2018 6:51 AM
7	60	1/8/2018 8:47 PM
8	76	1/8/2018 7:43 PM
9	59	1/8/2018 6:45 PM
10	98	1/8/2018 6:39 PM
11	100	1/8/2018 5:39 PM
12	0	1/8/2018 1:20 PM
13	75	1/8/2018 1:08 PM
14	86	1/8/2018 12:23 PM
15	100	1/8/2018 10:30 AM
16	90	1/8/2018 9:59 AM
17	90	1/8/2018 9:57 AM
18	50	1/8/2018 9:43 AM
19	86	1/8/2018 9:37 AM
20	50	1/8/2018 9:37 AM

21	65	1/5/2018 8:35 AM
22	77	1/4/2018 5:33 PM
23	87	1/4/2018 9:58 AM
24	88	1/4/2018 9:44 AM
25	80	1/4/2018 9:05 AM
26	72	1/4/2018 8:46 AM
27	17	1/3/2018 11:22 PM
28	82	1/3/2018 6:56 PM
29	100	1/3/2018 4:14 PM
30	60	1/3/2018 2:47 PM
31	99	1/3/2018 2:47 PM
32	98	1/3/2018 12:40 PM
33	52	1/3/2018 11:29 AM
34	50	1/3/2018 11:26 AM
35	60	1/3/2018 10:05 AM
36	75	1/3/2018 8:49 AM
37	95	1/3/2018 8:44 AM
38	5	1/3/2018 8:27 AM
39	86	1/3/2018 6:10 AM
40	100	1/2/2018 9:35 PM
41	75	1/2/2018 8:13 PM
42	7	1/2/2018 6:10 PM
43	90	1/2/2018 6:00 PM
44	3	1/2/2018 5:40 PM
45	90	1/2/2018 5:23 PM
46	100	1/2/2018 5:17 PM
47	70	1/2/2018 5:06 PM
48	0	1/2/2018 3:46 PM
49	100	1/2/2018 3:09 PM
50	31	1/2/2018 2:14 PM
51	81	1/2/2018 2:04 PM
52	93	1/2/2018 1:58 PM
53	56	1/2/2018 1:15 PM
54	100	1/2/2018 12:32 PM
55	95	1/2/2018 12:28 PM
56	2	1/2/2018 11:44 AM
57	100	1/2/2018 11:38 AM
58	74	1/2/2018 11:26 AM
59	99	1/2/2018 10:56 AM
60	87	1/2/2018 10:55 AM
61	75	1/2/2018 10:48 AM

62	80	1/2/2018 10:46 AM
63	48	1/2/2018 10:42 AM
64	88	1/2/2018 10:41 AM
65	75	1/2/2018 10:41 AM
66	50	1/2/2018 10:37 AM
67	80	1/2/2018 10:30 AM
68	80	1/2/2018 10:20 AM
69	100	1/2/2018 10:19 AM
70	90	12/29/2017 11:21 AM
71	65	12/26/2017 6:56 PM
72	100	12/26/2017 4:10 PM
73	100	12/26/2017 6:07 AM
74	91	12/23/2017 3:37 PM
75	68	12/23/2017 9:42 AM
76	100	12/23/2017 3:12 AM
77	75	12/22/2017 3:15 PM
78	100	12/22/2017 2:40 PM
79	90	12/22/2017 12:31 PM
80	100	12/22/2017 10:58 AM
81	31	12/22/2017 10:05 AM
82	70	12/22/2017 9:50 AM
83	89	12/22/2017 7:43 AM
84	45	12/22/2017 6:04 AM
85	14	12/22/2017 5:49 AM
86	72	12/21/2017 11:34 PM
87	70	12/21/2017 10:08 PM
88	72	12/21/2017 8:39 PM
89	99	12/21/2017 8:32 PM
90	43	12/21/2017 8:29 PM
91	92	12/21/2017 8:12 PM
92	90	12/21/2017 7:54 PM
93	93	12/21/2017 7:50 PM
94	72	12/21/2017 7:43 PM
95	75	12/21/2017 6:43 PM
96	69	12/21/2017 6:31 PM
97	95	12/21/2017 6:13 PM
98	100	12/21/2017 5:44 PM
99	50	12/21/2017 5:44 PM
100	40	12/21/2017 5:11 PM
101	50	12/21/2017 4:47 PM

Q22 Would you like to see more posters produced?

Answered: 94   Skipped: 14
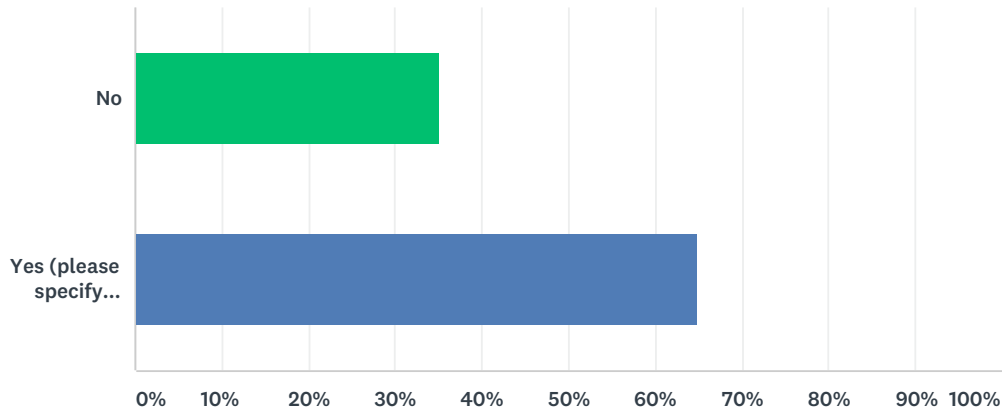
ANSWER CHOICES	RESPONSES	
No	35.11%	33
Yes (please specify topic/s)	64.89%	61
TOTAL		94

#	YES (PLEASE SPECIFY TOPIC/S)	DATE
1	packing	1/9/2018 3:47 PM
2	ANY THING TO HELP TRAIN STAFF IS USEFUL	1/9/2018 12:04 PM
3	Orentation of tree to sunlight	1/9/2018 9:52 AM
4	about anything which is helpful	1/8/2018 8:47 PM
5	phenological stages for water,nutrition etc	1/8/2018 6:39 PM
6	Dry matter	1/8/2018 5:39 PM
7	replicated trials of canopy management	1/8/2018 1:20 PM
8	FIOWERING ROOT ACTIVITY TIMES	1/8/2018 1:08 PM
9	Nutrition timing and applications	1/8/2018 9:59 AM
10	N/A	1/8/2018 9:57 AM
11	Better packing guidelines	1/8/2018 9:37 AM
12	on all varietys in the Tri Sate area	1/4/2018 5:33 PM
13	an updated quality packing poster	1/4/2018 9:58 AM
14	mulching and canopy management.	1/4/2018 8:46 AM
15	fertilising fertigating	1/3/2018 6:56 PM
16	If I have the wall space to hang the poster, I would love to have to do lists monthly through the year.	1/3/2018 4:14 PM
17	Related topics	1/3/2018 2:47 PM
18	Fertilising schedules. Watering schedules	1/3/2018 12:40 PM
19	Quick disease identification and pruning	1/3/2018 11:26 AM
20	handling fruit	1/3/2018 10:05 AM

21	how to manage different irrigation systems	1/3/2018 8:49 AM
22	identifying pests	1/3/2018 8:44 AM
23	tree and Soils health	1/3/2018 8:27 AM
24	Pests and their beneficial predators	1/2/2018 9:35 PM
25	On anything that can helps to look at for a quick reference	1/2/2018 6:00 PM
26	Canopy management, young tree training	1/2/2018 5:23 PM
27	consistent cropping	1/2/2018 3:46 PM
28	Fertiliser timing	1/2/2018 3:09 PM
29	n/c	1/2/2018 2:04 PM
30	Overall growing timing issues	1/2/2018 1:58 PM
31	Nutrition, Physiology	1/2/2018 1:15 PM
32	Irrigation Management	1/2/2018 12:32 PM
33	Spotting bug, fruit fly	1/2/2018 12:28 PM
34	Canopy managment	1/2/2018 11:44 AM
35	budding, flowering and fruit development	1/2/2018 11:38 AM
36	Na	1/2/2018 11:26 AM
37	Picking QA. inc fruit readiness and handling, from pickers to shed	1/2/2018 10:56 AM
38	Boron	1/2/2018 10:41 AM
39	Application timings of phos acid, and a insecticide roster of what they target a when to best apply them.	1/2/2018 10:37 AM
40	priority issues for growers	1/2/2018 10:30 AM
41	Phellinus root rot	1/2/2018 10:20 AM
42	sun burn, pruning	1/2/2018 10:19 AM
43	Canopy management	12/26/2017 6:56 PM
44	Root Management	12/23/2017 3:37 PM
45	An integrated poster (overlying the Manage Phytophthora Root Rot poster) which includes fertilisation periods (and %iles) etc	12/23/2017 3:12 AM
46	phenology cycle specific to each area	12/22/2017 12:31 PM
47	Posters like this are very useful and a constant reminder for us of what we should be thinking about. Also if they are placed on notice boards in staff rooms then new staff can read these as well. Educational aids.	12/22/2017 10:58 AM
48	any	12/22/2017 10:05 AM
49	Canopy management	12/22/2017 9:50 AM
50	anything relevent	12/22/2017 7:12 AM
51	all aspects	12/22/2017 6:04 AM
52	nutrition	12/22/2017 5:49 AM
53	Not sure sorry	12/21/2017 11:34 PM
54	Poster on Pruning	12/21/2017 8:39 PM
55	life cycle	12/21/2017 8:12 PM
56	Fertilizer timing, pruneing timing,variety assessment/timing	12/21/2017 7:54 PM
57	Nutitional deficiencies	12/21/2017 6:43 PM
58	maybe area specific avo alert type poster	12/21/2017 6:13 PM

59	nutrition/fertilizing	12/21/2017 5:44 PM
60	nutrition timing ,product lists (eg registered pesticides),	12/21/2017 5:44 PM
61	See above	12/21/2017 4:47 PM

Q23 Please provide any additional comments about the project here

Answered: 38   Skipped: 70

#	RESPONSES	DATE
1	More technical information	1/10/2018 7:19 AM
2	the projects were good for finding out latest developments in the industry and networking with people	1/9/2018 3:47 PM
3	Always looking forward to the next event, worthwhile project	1/9/2018 6:51 AM
4	more in w.a. please!	1/8/2018 6:39 PM
5	Pc affects every orchard. Growers just need to test roots annually and apply phos acid properly, every year to every tree.	1/8/2018 10:30 AM
6	Nil	1/8/2018 9:59 AM
7	N/A	1/8/2018 9:57 AM
8	should definitely be kept up	1/5/2018 8:35 AM
9	job well done	1/4/2018 5:33 PM
10	Great project to be a part of. Lots of topics were covered with great detail.	1/3/2018 8:49 AM
11	the project is well worth continuing & is needed to keep the industry improving	1/3/2018 8:44 AM
12	Any extra information for organic growing is a bonus Its important for organic growers to collect as much info as possible then try to work them into the organic proticols as much as possible with in the standard guidelines	1/3/2018 8:27 AM
13	Y	1/2/2018 5:40 PM
14	The Queensland presenters (Simon and Co) have had a significant impact in our area. The networking opportunities are excellent and the field walks a feature.	1/2/2018 5:23 PM
15	Was worthwhile, good to learn more about avocado's in general	1/2/2018 3:09 PM
16	n/c..	1/2/2018 2:04 PM
17	Best point about workshops is networking and ability to ask questions and get effective answers	1/2/2018 11:38 AM
18	Na	1/2/2018 11:26 AM
19	The Tristate meetings have been very informative and useful	1/2/2018 10:48 AM
20	I believe some case studies should be presented on examples of the relative economic benefit of spraying versus stem injection of phosphorous acid. On nutrition, some case studies of N and Ca (incl. fruit adequacy ranges) would be useful for fruit quality. I realise this may be a research project in itself.	1/2/2018 10:46 AM
21	All good.	1/2/2018 10:41 AM
22	Useful to keep in contact with growers and researchers and receive updates from research programs	1/2/2018 10:30 AM
23	this project is essential for connecting growers with researchers	12/26/2017 6:07 AM
24	Great work, definitely beneficial.	12/23/2017 3:12 AM
25	Overall we have found the majority of the topics/information beneficial in the long run.	12/22/2017 3:15 PM
26	Good to have the opportunity to meet other growers and discuss problems, possible solutions and success that have been experienced	12/22/2017 12:31 PM
27	The coverage of topics and the speakers this year have been excellent at the field days. Such a mazing amount of information is exchanged at these days, both with the speakers and with the interaction between the growers sharing personal experiences. Well done Simon and his team and thank you for the effort you have put in to arrange these days and have them go so smoothly.	12/22/2017 10:58 AM

28	sack our reps who supported harps	12/22/2017 10:05 AM
29	More project	12/22/2017 7:43 AM
30	keep up the good work	12/22/2017 6:04 AM
31	Thanks for your efforts	12/21/2017 11:34 PM
32	Overall health	12/21/2017 8:12 PM
33	With workshops remove repetitive presentations, stimulate more grower comunication,	12/21/2017 7:54 PM
34	all speakers are very enthustic simon is great	12/21/2017 7:43 PM
35	There has always been thoughtful presentations and every endeavour was made to address local problems -this can be very difficult for the organizers and they did a splendid job.	12/21/2017 6:43 PM
36	keep it going	12/21/2017 6:13 PM
37	pruning needs more attention	12/21/2017 5:44 PM
38	none	12/21/2017 4:47 PM

Q24 A new extension project will commence in 2018. What activities you would like to see included in the next avocado extension project?

Answered: 65   Skipped: 43

#	RESPONSES	DATE
1	Probably a higher level of advice, getting away from the basics	1/10/2018 7:19 AM
2	canopy management	1/9/2018 3:47 PM
3	PHELLINUS NOXIUS,AND AMBROSIA BEETLE	1/9/2018 12:04 PM
4	Soil health	1/9/2018 6:51 AM
5	getting to see new varieties;fruit and trees always open to new or not thought of practices	1/8/2018 6:39 PM
6	Application methods for nutrition and mulching New marketing practices ie packaging to reduce waste/stickers	1/8/2018 5:39 PM
7	Effective pruning for tree health and production	1/8/2018 2:25 PM
8	canopy & pollination management	1/8/2018 1:20 PM
9	Application of pesticides,fungicides weters as per different ages , canopy size of trees	1/8/2018 12:23 PM
10	the basics in pest and disease management have been covered many times over. we have missed the detail in: irrigation management as per phenology cycle nutrition as per phenology cycle calciun : nitrogen rations in fruit - how to measure and what does it mean cahbohydrate levels in tree trunk- often talked about never discussed the specifics- how to measure- how to manipulate- what does it mean. we need to open our researcher/ presenter pool much wider to open conversation on these subjects. We need to move away from metholodogy style presentations as we have seen in the latest FSB and the flower/temp presentation and move tp a more action/reaction/result format. Growers want to do , not listen and wonder so more direct directions as to best practice. We have tended to leave recommendation too open and vague and this growers a feeling of uncertainty and an option to opt out and do little or nothing because that is easier.	1/8/2018 10:30 AM
11	Review of the Best Practice information for field e.g Nutritional levels and application methods	1/8/2018 9:59 AM
12	N/A	1/8/2018 9:57 AM
13	more about pruning methods organic options for control of pests and disease	1/8/2018 9:43 AM
14	water monitoring	1/4/2018 5:33 PM
15	More alternative practises.... composting, making microbial/fungal brews and soil health. Been done but always good to be reminded of these practices	1/4/2018 9:58 AM
16	Area wide management to coordinate pest issues in particular regions better	1/4/2018 9:05 AM
17	dryland farming avocados.	1/4/2018 8:46 AM
18	maintaining healthy trees throughout season . And why some trees come out of winter yellow	1/3/2018 6:56 PM
19	Canopy Management	1/3/2018 11:29 AM
20	Pruning, labour tools (clock systems, etc.), new machines and tools for avos and soil health management.	1/3/2018 11:26 AM
21	fruit quality and how to improve	1/3/2018 10:05 AM
22	irrigation efficacy, soil health and how it can make you money.	1/3/2018 8:49 AM
23	Soil & leaf testing workshops & nutrition workshops	1/3/2018 8:44 AM
24	The topics have been varied and many. New systems of keeping trees healthy with natural ways without chemical fertilizers and chemical sprays.	1/3/2018 8:27 AM
25	Biological control of phytophthora	1/3/2018 6:10 AM

26	Sudden death	1/2/2018 8:13 PM
27	fertiliser application rates. What type of fertilisers e.g. granular, foliar, fertigation. There are a growing number of companies promoting application of various microbes incorporated into their granular mixes. ?effectiveness. Similarly, humates, pot.silicates, fish, seaweed, so called "mineral" fertilisers. Many growers use these products. Are we wasting our money?	1/2/2018 6:10 PM
28	What ever can help	1/2/2018 6:00 PM
29	Split the project into new growers v established growers.	1/2/2018 5:40 PM
30	Setting up young trees through shape pruning. Managing older trees - pruning to extend life, Beneficial soil microbes (Do they have a role)	1/2/2018 5:23 PM
31	UNDERSTANDING WHY EARLY FLOWER SET AND LATER FLOWERING HAVE DIFFERENT RATES OF FRUIT SET IMPROVING SPRING VEGATATIVE GROWTH	1/2/2018 5:06 PM
32	consistent cropping	1/2/2018 3:46 PM
33	Pruning ,soil health	1/2/2018 2:06 PM
34	n/c..	1/2/2018 2:04 PM
35	Soil and canopy managment	1/2/2018 11:44 AM
36	I think that is important to continue workshops and keep everyone updated of industry trends	1/2/2018 11:38 AM
37	Na	1/2/2018 11:26 AM
38	More information on density planting, management cost of management and expected returns per hectare. Alternate availability of pest and disease treatments, their effectivnes. Say, are 'Organic practices" cost effective in a commercial avocado orchard. If not how best to communicate to the consumer that care farmed fruit have high standards particularily in regards to residues. How to improve drainage in wetter areas by interrows works or diversions. New technology's, in fruit packing to better grade the crops to cut down on unsatisfied consumers because of hidden defects.	1/2/2018 10:56 AM
39	timing and application of herbicides and video	1/2/2018 10:55 AM
40	More farm walks Overhead cooling (Tristate topic) Canopy management Varieties and rootstocks Linkage with the Small Trees project	1/2/2018 10:48 AM
41	Fruit N & Ca levels Use of PGR's	1/2/2018 10:46 AM
42	Varieties,	1/2/2018 10:41 AM
43	Workshops on grower properties are a great way for growers to swap ideas and informally benchmark their performance against other growers. It is a great mechanism for getting growers who normally may not see other orchards or techniques to look outside their own fence.	1/2/2018 10:41 AM
44	Insecides availability (what products are avaliable and what pests they target) and what they target/ how and when to apply.	1/2/2018 10:37 AM
45	Scion cultivars and Increasing the use of PGR's for enhanced yield & decreasing vegetative growth	1/2/2018 10:20 AM
46	More in depth discussion around nutrition and water management Specific modules on Ca, K, N, B, P	12/29/2017 11:21 AM
47	Farm walks Canopy management demonstrations	12/26/2017 6:56 PM
48	more of the same, ie. connecting growers with the latest research, more on soil heath	12/26/2017 6:07 AM
49	As a grower, more on disease management. As an innovator (very much "unlike" Hort) real innovation in in-shop marketing (minimizing fruit handling - like they do in the Netherlands for instance) and most importantly sustainability (and how to derive benefit from the waste on the balance sheet - for example oil harvesting from marked / seconds fruit (fruit which is perfect just ugly and considered unmarketable).).	12/23/2017 3:12 AM
50	FSB and Monolepta and irregular bearing	12/22/2017 3:15 PM
51	Tree grafting, mini congress/visits to other states eg WA	12/22/2017 12:31 PM

52	More information about new varieties and rootstocks as growers are always asking about the differences and which ones do best in their regions and soil types. Also, information on some of the newer varieties and how they are performing in different regions and their production figures compared to Hass. Sunburn of young trees is an issue and growers are always asking about the effect of painting them and whether to use DuoScreen and whether this affect the photosynthesis of the trees.	12/22/2017 10:58 AM
53	Canopy management options and pruning techniques	12/22/2017 9:50 AM
54	General info	12/22/2017 7:43 AM
55	avo health	12/22/2017 6:04 AM
56	Canopy management nutrition	12/21/2017 11:34 PM
57	growth regulants	12/21/2017 10:08 PM
58	Nutrition, Canopy management, frost management	12/21/2017 8:12 PM
59	Would like to see regional yield comparisons and management techniques,add a grower profile presentation with history	12/21/2017 7:54 PM
60	More information of pollination and fruit set	12/21/2017 7:50 PM
61	Some economic projections as to where current plantings are expected to take us, and potential impact on prices. Research directions towards dwarfing trees to minimise pruning to control height i	12/21/2017 6:43 PM
62	Work shops field days	12/21/2017 6:31 PM
63	detailed area specific fertiliser programs, tree grafting, research project reports on fert, pollination, fruit development, fruit shedding etc.	12/21/2017 6:13 PM
64	pruning	12/21/2017 5:44 PM
65	More Participation by myself :)	12/21/2017 4:47 PM

Appendix III: Avocado plant nutrition review

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AVOCADO PLANT NUTRITION REVIEW

Simon Newett, Peter Rigden and Bridie Carr, Department of Agriculture and Fisheries, Nambour, Queensland

January 2018

Contents

1. SURVEY OF AVOCADO PLANT NUTRITION PRACTICES IN AUSTRALIA

The earliest fertiliser guidelines used for avocados were based on the programme developed for citrus in California. The current nutrition guidelines in Australia were first prepared for the 2001 Agrilink Avocado Information Guide and many of these guidelines were based on the needs of the variety 'Fuerte'. This variety was the most popular variety before 'Hass' dominated the industry and it is a very vegetative tree which responds unproductively to moderate levels of nitrogen whereas we have discovered that 'Hass' needs to be treated quite differently to maximise production.

Research and grower experience has produced new insights into fertilising 'Hass' trees and our Australian avocado nutrition guidelines need to be updated.

To gain a snapshot of current grower nutrition practices a questionnaire was developed and growers were individually contacted to invite their participation in the survey. A total of 42 growers were contacted across the eight production regions and 34 survey forms were completed. There was no attempt to invite the whole industry to respond to the survey, rather a sample of growers were chosen from each production region who were most likely to be able to provide the information required. Growers were asked to choose an above average block on their orchard and answer the questions for this block. Growers were also asked if possible to submit a recent soil and leaf analysis for the chosen block.

The results were entered into a large spreadsheet and the results are discussed below. This information was supplied to participants in the meeting of nutrition experts.

Regional distribution of participants was as follows:

- North Queensland   5
- Central Queensland   5
- SEQ   2
- South Queensland   4
- NNSW/Tamborine   4
- Central NSW   2
- Tristate   7
- Western Australia   5

Not all growers were able to complete the questionnaires comprehensively or provide leaf and soil analysis results.

Use of agronomists
Interestingly 26 out of 34 respondents (76%) use an agronomist to assist with developing their nutrition programme; this is a higher result than expected and acknowledges the complexity of the topic and therefore the willingness of growers to seek expert advice. However, in some cases the advice given by agronomists was not always appropriate for avocados.

Leaf and soil tests
The number of growers conducting an annual leaf tissue nutrient analysis of the autumn flush (the traditional time for sampling) was 76% whilst 59% have also adopted an annual leaf test of the spring flush which is a relatively recent development. This is an encouraging result. 47% of growers also conduct an annual soil test, 41% do one every 2-3 years and 6% 'occasionally'. One grower

conducts a leaf and soil analysis every two months but it is not known against what standard the out-of-season samples are compared against. 12% of respondents conduct sap tests.

For the leaf analysis results provided the vast majority of leaf nutrient levels were within the currently recommended optimum ranges. The exceptions included excessive chloride where irrigation water quality was poor, two instances where boron was excessive and one where zinc was deficient.

Soil cation exchange capacities ranged from 2 to 22 meq/100g highlighting the fact that because of this and many other reasons including climate differences that nutrition programmes need to be tailored to every farm. Soil pH ranged from 4.6 to 8.4.

Irrigation and nutrition

There was wide acknowledgement of the need for good irrigation to achieve an effective nutrition programme.

Mini-sprinklers are the most common type of irrigation with only three using drippers (all of whom farm in hot, dry environments with sandy soils). All growers had some system for monitoring soil moisture. Nearly all either have capacitance probes, tensiometers, G-bugs or G-dots. Six growers dig holes (most as a backup to one of the above instruments) and one relies solely on evaporation rate data.

Table 1. How often growers check their soil moisture during peak demand

	Continuously	Twice daily	Daily	Every 2 days	Twice a week	Weekly	Fortnightly
No. of growers	2	2	8	5	3	4	1

Mulch and compost

59% of respondents apply mulch materials under the tree and 21% apply compost.

PGRs

59% of respondents use Plant Growth Regulants annually or in some years.

Fertiliser application method

88% use fertigation, half of these also broadcast fertiliser whilst the remaining 12% use broadcasting only.

59% apply foliar boron sprays at flowering time.

Aside from foliar boron applications, 15% of the growers surveyed apply seaweed products and trace elements as foliar sprays. One of these growers also applies potassium nitrate and urea as foliar sprays during times of leaf flush.

Fertiliser products used

A very wide range of nutrition products are used by growers. Some growers use basic fertilisers such as lime, gypsum, urea, sulphate of potash, potassium sulphate, superphosphate, iron sulphate, zinc sulphate and Solubor. Others use more complex fertiliser products. Quite often those using very basic fertilisers are achieving higher yields. If the programmes used by each grower were costed out, there would be a vast range in the fertiliser cost per hectare.

A number of growers are trying to improve soil health through application of products aimed at improving soil biology.

Fertiliser application intervals

Overall, growers are using much shorter intervals between fertiliser applications than they used to and there is general adoption of a "little and often" approach. Not only is this better for plant growth but it is better for the environment too since it will result in less chance of applied nutrient reaching streams and subsurface water.

Nitrogen

One of the particular aims of the survey was to gather information on nitrogen fertiliser rates, timing and application intervals. Recent trends are to use higher rates than in the past and to increase the rates further if the fruitset and crop load is heavy. Whilst the average N rate was 212 kg N/ha/year, some growers apply as little as 69 and others as high as 528.

The higher rates sometimes correlate with above average yields but the lower rates are also associated with reasonably good yields. 35% of respondents increase their nitrogen rates in the presence of a heavy crop load in the belief that this extra nitrogen not only feeds the current crop but also sets the tree up for the next season – generating a healthy canopy and enough wood for the next flowering. However, given that the balance between nitrogen and calcium affects fruit quality and that too much nitrogen depresses calcium so are we risking poor fruit quality by increasing rates of nitrogen?

Table 2. Kg nitrogen applied /ha/year

Range of N	<101	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550
No. of growers	5	7	10	3	1	4	2		1	1
Ave yield t/ha	17	12	16	15	16.5	12	23		16	29

Table 3. Frequency of nitrogen fertiliser application

Frequency	Every irrigation	Weekly	Fortnightly	Monthly	Less often than monthly
No. of growers	2	3	4	9	4

Most growers apply nitrogen all year but reduce rates or avoid applications for 2 or 3 months between late winter and a month or so after fruitset.

Table 4. Leaf nitrogen levels

Leaf N % range	<2%	2 to 2.25%	2.26 to 2.5%	2.51 to 2.75%	2.76 to 3%	>3%
No. of results in each category	1	2	6	5	1	1

Phosphorus

Phosphorus use ranged from 0 to 100 kg P/ha/year and averaged 31 kg P.

Potassium

Potassium use ranged from 0 to 320 kg/ha/year and averaged 146 kg K.

Calcium

Most growers are aware of the link between high fruit calcium and fruit quality and that there is a limited window of opportunity when calcium is deposited in the fruit (the first 6 to 8 weeks after fruitset). However, is a soil calcium content of 65 to 70% of the base saturation sufficient to supply this or is it necessary to apply extra calcium at this time? Many growers now apply the very soluble (and expensive) calcium thiosulphate during this window but is it necessary or making a difference to fruit quality? Many others apply an ultra-fine form of gypsum or lime. Are growers risking an imbalance of cations due to excessive applications of calcium and thus for example a shortage of magnesium or potassium in the plant? Perhaps the extra calcium applications are complementing the increased rates of nitrogen and keeping the balance of N:Ca where it should be for fruit quality?

Adjusting the nutrition programme during the year

Almost all growers modify their nutrition programmes through the year based on appearance of trees, crop load and rainfall.

Particular issues or difficulties

24% of respondents reported difficulty getting boron levels right. Difficulty keeping zinc levels adequate was also mentioned a few times. The other issues that came up included knowing how much nitrogen to apply, getting a balance between nitrogen and calcium, and adjusting fertiliser rates after heavy rain. One grower also reported difficulty getting adequate iron and phosphorous levels.

Yields and yield variation

Bearing in mind that growers were asked to select an above average block for the survey, average yields on mature trees varied from 5 (two young orchards reported this yield) to 29 t/ha and the average across all respondents was 16.2 t/ha. 26% of respondents reported that their yields varied by less than 30% each year, 32% that they varied between 30 and 50%, and 15% that they varied by more than 50% (the remaining 27% of growers did not answer the question).

What growers consider are key factors for a successful nutrition programme

- Keeping water up.
- Monitor and adjust (mainly N) according to crop load, flowering & flush. Add 10% more N if PGRs used.
- A little bit often
- Do what a good agronomist tells you to do
- Visit and rate tree health every block every fortnight. Adjust fertiliser according to observations of health & crop load. Get irrigation right. Apply fertiliser at frequent intervals. Use granular where possible because cheaper.
- Irrigation. There is a point in Mar/Apr when the tree appears to switch from extracting moisture from shallow to deeper soil & you must be ready for it in terms of optimum soil moisture, or tree

- will go into stress, which will affect fruitset later. Growcal & Ca thiosulphate appeared to have increased fruit size.
- Have a good feel for your trees. Experience. Closely follow soil moisture. Check how efficiently you are applying your fertiliser.
- Getting soil biology up & active with fungi & healthy microbes while trickling on the nutrition w/o damage.
- Timing, little & often, compost for soil health.
- Follow recommendations. If heavy fruitset increase nitrogen.
- Frequency, visual observation, leaf tests.
- Work with consultant/agronomist. Timing of applications. Monitoring trees. Combination of water & feed. Feeding of the tree/crop ratio. Timing of elements with respect to growth cycle - buds, flowers, flush & fruitset.
- Having timely relevant data from leaf analysis, observation of tree health/condition & accurate assessment of crop load to be both proactive & reactive to adjust application & quantity of elements required for growth & removed from orchard by crop.
- Emphasize using less N at flowering & immediately after to limit fruit drop since I want to limit tall growth of trees on sloping land. I note that NZ uses much more N.
- Twice yearly leaf analysis & interpretation from agronomist.
- Leaf & soil analysis by consultant.
- Frequent applications of small amounts (fertigation). Good organic matter levels maintained under tree. Historical yields improved significantly when fertigation introduced 6 years ago. Average yield 20 t/ha for 6 years.
- Successful irrigation - a good irrigator makes a good fertiliser applicator.
- Treat each patch on its merits. Nitrogen management clearly the biggest challenge nutritionally. Setting a good crop makes it easier to manage and push trees as opposed to managing growth.
- Spread fertiliser over whole year. Get out & look at trees every day if possible. Cost of fertiliser = $1600/ha
- Adjust (through the year).
- No roots = no tree   Managing water & nitrogen
- Good irrigation infrastructure and management.
- Get better advice, I am still learning, listen to what others may be doing then make an informed decision.
- Have regular nutrient input, e.g. fertigation done every fortnight.
- Monitor tree health, flowering & fruit load and apply what I think will be extracted by the fruit, difficult as some of this data is to find.
- a) Knowledge of avocado growth physiology is most critical. b) Implement nutrition program based on regular soil & leaf test. c) Implement primary & secondary nutrients based on crop growth stage. E.g. Spring flush - avoid too much N, fruit set - lots of Ca and trace elements, fruit fill - K to fill the expanded fruit cells and so on.
- Weekly applications. Have professional advice.

Conclusions

Nutrition is a complex subject and every orchard has different needs. Although this was a limited survey it has provided a snap shot of Australian avocado growers' practices, included those of very

successful producers, and in doing so has provided a starting point for commencing the discussion to update the nutrition guidelines. The standard of practices of growers surveyed was generally high and nutrient analyses and yield results bear this out. Those surveyed generally show a high level of adoption of recommended practices and have taken on board recent developments.

Some of the questions to arise from this survey are:

- What are the most appropriate rates of nitrogen and calcium to optimise yield and fruit quality?
- What level of nitrogen is safe to apply through the flowering and fruitset period?
- Does extra nitrogen applied when fruitset/crop load is high help combat irregular bearing?
- Is it necessary to purchase special forms of fertiliser or will basic fertilisers achieve the same result in most situations if used correctly?

These and other questions were discussed at the webinar of experts held on 31 October and minuted below.

2. MINUTES OF WEBINAR HELD WITH AGRONOMISTS ON 31 OCTOBER 2017

Participants (9): Tim Heath (GT Ag Services, Mareeba), Lisa Martin (Ripe Horticulture, Bundaberg), Geoff Dickinson, Simon Newett & Peter Rigden (DAF), Chris Searle (Stahmann Farms), Denis Roe (SFFCS), Ben Thomas (BTC), Graeme Thomas (GLT)

Apologies (2): Alan Blight (AVOWEST), Dudley Mitchell (HCMS)

General comments on survey results

Graeme Thomas prefaced the meeting by pointing out that before a nutrition programme is considered *Phytophthora cinnamomi* root rot has to be under control in order to have a healthy root system and soil moisture management needs to be good.

Ben Thomas remarked that there was good adoption of leaf testing amongst the survey respondents. Simon qualified this by pointing out that the survey had an element of bias since growers were picked for the survey that were most likely to be able to answer the questions.

Nitrogen

Graeme Thomas pointed out that nitrogen needs vary tremendously between localities.

Graeme Thomas said that if the leaf N was 1.9% for 'Hass' he would be comfortable to keep applying N through flowering but if the level was 2.6% he wouldn't. Bear in mind that, although fruit will continue to grow for its entire life by means of cell division, fruit size is mainly determined in the first 12 weeks after fruitset, so it is important to ensure that there is sufficient nutrient available to feed these growing fruitlets so that they don't end up as small fruit.

With the variety 'Shepard' it is a different story.

Comparing Hass trees growing in NQ vs WA, where there are two crops hanging on the trees in WA he would apply about double the rate of N than he would to trees in NQ. However Graeme would still back off the rates for the two months around flowering time especially if leaf N levels at the last analysis were in the 2.6 to 2.7% N range. It is a case of 'horses for courses' and to keep monitoring leaf nutrient levels.

On the question of whether we should be aiming for higher leaf nitrogen levels Chris Searle pointed out that in the late 1990s leaf nitrogen levels reached 2.6 to 3% in orchards at Palmwoods, Mt Tamborine (Gold Coast hinterland) and an orchard at Childers was really ramping up the nitrogen, this orchard grew enormous trees but it took a fair while to get the nitrogen levels back down. The trees became too vegetative with enormous water shoots and there was also enormous variability between the yields of individual trees within the same blocks from equivalent to 6 up to 30 t/ha. Back then all the nitrogen was applied in a small number of big doses. These high nitrogen applications raised concern about fruit quality and triggered some research into calcium. Chris said you will get a very different result by applying the same amount of nitrogen in one or two applications vs. say a dozen small applications. If the heavy doses were applied around warm wet weather and fruitset then you would lose crop.

More frequent applications – 4 or 5 times per year.

Geoff Dickinson described how a Shepard orchard in NQ known to pump up their nitrogen rates had a problem with fruit breakdown. Work done by Kaila Ridgway in NQ recently showed post-harvest breakdown of fruit that were high in fruit flesh nitrogen and low in calcium. There was a very good

inverse relationship between the amount of calcium in the flesh and the amount of breakdown. Leaf N levels were not measured but were expected to be very high in N since the sap tests were. Tim Heath mentioned that there would have been a variation in flowering time with Shepard which might have had some effect on the results.

Chris Searle pointed out that in the calcium research there was actually more variability between individual trees than between treatments suggesting that the rootstock had a very large effect on calcium levels.

Work by Peter Hofman showed that by overdosing with calcium the potassium levels fall, thus an imbalance in cations was induced.

How do you get the benefits of high nitrogen without dropping fruit calcium and putting fruit quality at risk? Perhaps have different N:Ca ratios at different stages of the growth cycle?

There is concern that by going for higher nitrogen applications (e.g. to try and overcome irregular bearing) and associated higher leaf N that we might be putting fruit quality at risk (given that higher flesh N means lower flesh Ca). However if we use calcium nitrate does that help keep the two elements in balance?

Chris Searle – Peter Hofman's work showed that as well as the N:Ca balance it was also the Ca:Mg:K balance that was important.

Graeme Thomas – should we look at the cation balance and look at changing it marginally for the first 12 weeks after flowering? Don't know – the headache may be in getting it back to a balance after this 12 week period. Difficult to do on a research level but maybe encourage growers to measure levels in flesh and leaves at this time and build up a database of this information.

Chris Searle said that some years ago it was decided to put off further nutrition research work until there were a sufficient number of blocks of clonal trees on which to conduct the research since there is too much variability in blocks of seedling trees.

Lisa Martin reported that in her work over the past 13 years (irrespective of the region in Australia) it showed that the worst 'offender' in displacing other cations was potassium. Potassium is always too high and even if you haven't recently put any out, the plant is still taking it up in high levels and this is inhibiting the uptake of calcium, even if you are putting out calcium and nitrogen in a 1:1 ratio.

Graeme mentioned that some work in the Bundaberg area a few years ago that indicated that potassium stays in the soil better than calcium does.

Chris Searle reported on some work he had been involved in which showed that high doses of one cation will displace the other cations, e.g. high doses of potassium will displace calcium on the exchange sites in the soil but it does depend on the soil type.

The practice of increasing nitrogen doses if the fruit set looks heavy
There was general agreement that the nitrogen rates need to be increased if there is a large crop set. Tim Heath felt that in NQ this doesn't work as well on trees older than about 15 years. Graeme Thomas said that it does depend on the locality.

Graeme – it depends on the stage when you increase the nitrogen but yes by using this practice in WA he has been able to get 59 t/ha one year and over 30 t/ha the next.

Tim Heath agreed with the approach but feels that once the trees get older, say from about 15 years old, you don't get a response anyway.

Graeme said that on individual trees with a heavy crop in Pemberton WA he was putting on an extra 5 kg of calcium nitrate per tree per month from January till October. Leaf analysis showed that the N level in these trees were actually lower than in those trees with the lower crop that were not getting the extra nitrogen. And the heavy cropping trees are now flowering quite reasonably again. The high yielding trees were picked the other day and the yield from them was equivalent to about 80 t/ha. Graeme feels that if he hadn't put the extra N on these trees the N leaf level would be about 1.8% and they wouldn't have much crop next year.

Calcium

Question: Is it necessary to apply large amounts of calcium in that 6 weeks following fruitset (to try and improve fruit Ca levels) through application of finely ground lime and gypsum, calcium thiosulphate etc? Or if the cation balance is good in the soil and there is good soil moisture available will there be sufficient uptake anyway without these extra applications?

Lisa just doesn't think it is that easy. You have to use all tools in your tool box to get the uptake that you require and this depends on tree size (the bigger the tree the harder it is). Lisa has found that in high pH soils calcium thiosulphate is the only thing that works. Even calcium nitrate wasn't that effective because you can't get levels too high in the soil without upsetting the balance of other nutrients. Soil biology needs to be watched too. Lisa prefers liquid gypsum because of its solubility.

Graeme pointed out that the leaf Ca level increases with leaf age. Chris Searle said that it depends on the level of root rot too, without healthy roots you are not going to get much calcium in the tree whatever you apply. Chris argues that Ca uptake is largely a function of root health which in turn is a function of your ability to manage Phytophthora root rot. No root tips = no calcium uptake.

Ben Thomas – in the Tristate he is largely dealing with high pH soils and what he has been seeing (in avocados and in other crops) is that we can't get enough Ca up at particular times so there is a transient deficiency issue. So leaf testing may not give you the information that is relevant to what is available say in that first 6 weeks after fruitset.

Chris added that this is why we need to look at fruit sampling at a range of times instead of relying solely on leaf levels.

What has sap testing shown? Lisa – has been testing a range of tissues and at different ages. For example she has found the highest Ca levels are in the roots. The whole apple industry collaborated in a study doing weekly sap tests on the flesh of little fruit in the first 8 weeks then they were able to fine tune the calcium levels and found out that with a calcium level below 50ppm the fruit would develop bitter rot but above 50ppm they wouldn't. A lot of samples are required for this sort of study.

Lisa has tried a range of different calcium products and application methods but the sap test sampling results have been too varied to make any sense out of what has worked better.

A fruit skin test to measure the Ca:N ratio it might be a good option because Liz Dann's work has shown that this can be correlated well with disease susceptibility.

Simon – is most of the calcium held as cations in the soil at a deeper level than the feeder roots? Is this why growers are advised to fertigate it through the critical period? Lisa – soil tests in the Tristate show that there is heaps of calcium in the soil but none of it is available.

Magnesium

Important in relation to the cation balance. More danger of upsetting the cation balance in sandier soils.

Potassium

Do we really need to apply as much K as we do?

Lisa thinks that perhaps there is too much potassium going on. Lisa recommends its application at several growth stages.

Geoff – one thing we tend to overlook is that mulch has a very high proportion of potassium in it, about 4% and with typical levels of mulch we might be applying about 500 kg k/ha/yr with annual mulch applications of setaria and even with the poorer mulches around 100 kg K/ha/yr. Potassium is generally the most abundant nutrients in hay.

Graeme – in terms of best practice – rely on leaf analysis results. There are times when he wouldn't recommend any K.

Simon – K is viewed as one of those elements that leaches easily and therefore growers feel it is one of those elements that needs to be applied regularly as a maintenance dressing.

Graeme – many growers use compound fertiliser blends where NPK is in the product whether you need it or not and thus it can be overdone especially if mulch is used as well.

Ben – there is usually plenty of K in the soil but in some soils the movement of K into the soil solution may be too slow at particular times, and it may occur below where the feeder roots are (especially in sandy soils).

Chris – feels that it is imbedded in the psyche that you can't grow a crop of anything without putting heaps of potassium on. In macadamia in a 4 t/ha crop you are removing only 8 kg K/ha, but some growers are applying up to 300 kg K/ha in fertiliser – so what is happening to the remaining 292 kg of K?

Denis finds it very difficult to make a potassium recommendation based on leaf levels so relies on the soil K level. Denis believes that if there is enough K in the soil it will get into the tree. Graeme has records of about 4,000 leaf nutrient tests and reckons that there wouldn't be many with a deficient level (i.e. below about 0.8% K).

Phosphorus

Avner Silber in his recent lecture tour suggested that perhaps we need to apply higher levels of P (based on the fat that avocados are a high energy product and P is involved in energy transfer within the plant).

Graeme – many growers apply P as part of a compound fertiliser blend but he has one grower in WA with a soil Colwell test of 854 ppm P and this is causing a major tie up of Zn in the soil and deficient leaf levels but a leaf P test of not much over 0.2%. So even though soil P levels are massive it doesn't push the leaf P level very high. A really low soil Colwell P level of 11ppm at Hampton (near Toowoomba) still gave a leaf P level of 0.18% P (within the optimum range) in the leaf. So Graeme feels that phosphorus is significantly overdone in Australia.

Ben – in the Tristate soils we don't have much P, so it depends where you are. The Mallee soils are notoriously low in P largely a result of the calcareous soils and applications of P don't seem to make much difference in making P available. One of the challenges is to try and find the P that has been

applied. For this reason Ben works out rates based on nutrient budgets for what the crop has removed. The leaf P levels don't move much in the leaf in the Tristate, they are not deficient. Growers tend to apply P regularly in the Tristate but doesn't believe it is overdone in that region.

Chris – like Graeme, tends to see more cases where P is overdone and the resulting induced deficiency of Zn.

Chris – does anyone use P buffer index to adjust levels? Ben said he did.

Silicon

Simon - quite a lot of interest in Si at present.

Lisa – it's hard to measure. Now including it in sap tests. Feels its uptake is similar to calcium. Has seen it work well in annual crops for holding of fruit and post-harvest quality but couldn't currently say whether it is necessary for avocado.

Ben has never worried about Si for avocado.

Denis – considered as a micro-nutrient so is only needed in very small quantities.

Graeme – current attitude is that if Liz Dann's work shows that we can improve fruit quality then we will apply it but in the meantime won't be recommending it.

Molybdenum

Graeme – its role in melons is absolutely critical. Tony Whiley commented that Mo plays no role in the physiology of the avocado but Nigel Wolstenholme (University of Natal in South Africa) thinks that it does.

Ben – Mo has been a problem in grapevines where deficiency affected fruitset, this mainly occurs in the acid soils rather than the calcareous soils.

Lisa – has noticed that the Mo level in sap analyses is quite seasonal and weather dependent. E.g. a dry summer correlates with low Mo in the plant.

Simon – so we should treat Si and Mo as both 'watching briefs'?

Lisa – if there is a problem with levels of nitrate or ammonia then look at Mo levels.

Application methods

Foliar applications

Simon - foliar applications of nutrients not generally considered effective in avocados

Lisa – agrees with Simon that foliar nutrient applications are a "band-aid" measure but reports some success with foliar zinc applications in correcting deficiency symptoms, particularly with Zn EDTA. It works to a lesser degree for iron using iron chelate.

Ben says that Zn nutrition is an issue in the Tristate with tie ups. It needs to be applied when the leaf is the most receptive – before it has hardened off (no point in applying it after this). Ben has tried foliar iron sprays over the years but wouldn't bother.

Chris – zinc banding works to a certain extent – making "feeding stations". Apply it in a concentrated band close to where there is a high density of roots and where organic matter is highest.

Iron and zinc deficiency can occur in spring time because soils are too cold for uptake.

Fertigation

Can be issues of acidification in the wetted zone. Especially with drippers which create more of a point source where the fertilisers are placed. They never thought they'd see a problem of acidification in the Tristate but is happening in the wetted zone.

Lisa – a build-up of salts in your soil as a result of fertigation is becoming a bit of an issue, this can also be related to the quality of fertilisers being used.

Ben – recommends regular lime banded along the wetted zone – easier on sandy soils. Work out the rate required to maintain the soil pH where you want it and put it on every year as a matter of course.

Chris Searle – on krasnozem soils because of the high tie-up of phosphorus – banding is more effective than broadcasting.

Timing

We have some idea of the timing of calcium, nitrogen and boron but what do we know about the timing needs of the other nutrients?

Lisa – timing of potassium, puts a little on throughout the season with a higher application in about May to coincide with the root flush depending on the soil levels and if it is needed. Phosphorus applied then too. To capitalize on uptake whilst the roots are flushing.

Probably need to do some more definitive work on appropriate timing of N, P & K.

Nutrient monitoring

Frequency of soil testing. May need to be done more often in light soils if you are trying to drive a change in order to monitor progress.

Important to monitor soil boron. Many growers and resellers unaware that there are different optimum soil boron ranges for different soil textures.

Leaf testing

Spring leaf testing is commonly used now in addition to autumn leaf testing. Graeme has been conducting spring leaf tests since the mid-1990s and is comfortable that we can use the same optimum levels that were worked out for the autumn leaf test, just make sure you always take leaves from a non-bearing branch. Tony Whiley is comfortable with this. Just need to bear in mind that in the regions where you have two crops hanging on the tree at the same time that the levels can drop quite quickly.

Use the same norms.

Lisa – given that some growers are getting higher yields now do we need to re-visit the optimum ranges? Graeme says that you might have to put more fertiliser on but the optimum levels to aim for are still the same.

May need some more discussion on where in the block and the tree you take the sample from. It is a good monitoring tool but one of several.

Chris Searle – hyperspectral analysis (a remote sensing technology) will allow many more samples to be tested because it is much cheaper than traditional laboratory based leaf analysis, it will help us pick the right leaf. An analogy of the cost would be comparing digital photos vs. rolls of film that need developing.

Sap testing

Lisa – really good for all nutrients except for nitrogen when you are testing new leaves. Also using it for testing chlorophyll levels in the leaf. It's not something that everyone could use. Sap testing leaves, leaf petioles, and fruit.

K, P and micro nutrients are good – e.g. if you are putting nutrients out and want to see if they are being taken up then sap testing is useful for showing this.

Fruit testing

Have to work out what part of the fruit and when to test it.

Apple testing was conducted by AgVita lab in Tasmania over a 4 year period to work out the best time to sample, what to sample etc.

Seemed to be interest by the group for investigating the potential for following nutrient levels in fruit.

Different costs of fertiliser programmes

There are certain times you may need to specific products.

Ben strong on straights.

Denis – depends on what the client wants. Straights are better to use because you have more control over what goes on.

Geoff – Kaila found that some growers were reluctant to tell her what products they were using.

Graeme – with the current high price of avocados the cost of fertiliser is a small proportion.

Tim – soluble solids in layers in the 1 tonne bulk bags – tipped into fertigation tank. Some concerns about this practice.

Final comments

Chris Searle - *Phytophthora cinnamomi* root rot management and soil management are paramount. Need to maintain very viable root system. And very important to build the organic matter level in the soil which is a very important part of the nutrition programme.

Ben – ditto for having a good irrigation programme.

Graeme – many growers don't have good *Phytophthora cinnamomi* root rot or soil moisture management.

Most of the nutrient uptake is from the top 15cm of soil and this can dry out in a single day – therefore nutrient availability can be very restricted.

Need more emphasis on *Phytophthora cinnamomi* root rot and water management in the nutrition review notes in BPR.

Tim – get growers to work towards a fruit testing system. These levels won't lie.

3. LITERATURE REVIEW OF RECENT AVOCADO PLANT NUTRITION RESEARCH AND PRACTICES

Management of Phytophthora root rot and irrigation for effective nutrition

In avocado since the feeder roots must take up the vast majority of nutrients, an essential pre-requisite for an effective nutrition programme is a healthy root system (good control of *Phytophthora cinnamomi* root rot) and good soil moisture. These two pre-requisites are intrinsically linked since trees infected with phytophthora root rot cannot take up sufficient moisture or nutrients. Remember too that most of the tree's feeder roots are in the top 15cm of soil, this has implications for watering and fertilising and helps explain why small doses of fertiliser applied often works well for avocado.

In a trial to test different root rot control treatments Whiley *et al* (1986) reported that avocado trees protected from phytophthora root rot had greater fruit yields and less ring neck (a symptom of moisture stress). Trees with the least disease had a combined two-year yield that was 82% higher than untreated diseased trees.

Kiggundu *et al* (2012) conducted a trial to determine the effect of fertiliser rate and irrigation scheduling on water use, nutrient leaching and fruit yield of young avocado trees in Florida. Seven nutrient and irrigation management practices were evaluated that compared a combination of treatments that included irrigation scheduling based on evapotranspiration, by a set schedule or by irrigating when soil moisture potential reached – 15 kPa, and the application of 50%, 100% or 200% of standard fertiliser rates. Yield was measured for four years when the trees were between three and six years old. The treatment with the best yield, highest water use efficiency and least phosphorus leaching was from the trees that were irrigated when soil moisture potential reached – 15 kPa and 100% of the standard fertiliser rate was applied. The trigger for irrigating closely matches the recommendation of Thomas, G. (personal communication, 2017) which is to irrigate when soil moisture potential reaches -14 kPa.

Typical fertiliser rates

The following examples give an idea of the range of fertiliser rates applied to avocado at different locations around the world, naturally rates will vary according to climate and other environment and orchard factors.

Australia

The current standard nitrogen recommendation in the Best Practice Resource for mature trees with an optimum leaf nitrogen level (2.2 to 2.6% for Hass) is about 110 kg N/ha/year (14 g N/m^2 of canopy area). This is assuming a spacing of about 9x4m (278 trees/ha) and with the canopy covering about 78% the total orchard floor (continuous hedgerow and 2m wide interow space for machinery access). For the same orchard and assuming that the leaf potassium is optimum (0.75 to 2% for Hass) the typical annual recommended rate is about 80 kg K/ha/year.

Newett (2017), in a survey of Australian avocado growers' nutrition practices, found that there was a vast range in the rates of nitrogen used. This ranged from 69 to 528 kg N/ha/year with an average of 212 kg N. Phosphorus use ranged from 0 to 100 kg P/ha/year and averaged 31 kg P, and potassium use ranged from 0 to 320 kg/ha/year and averaged 146 kg K.

Hall (2015) reported that nitrogen use by the 10 most profitable growers (out of the 55 measured) ranged from 85 to 140 kg N/ha/year.

Brazil

Cantuarias-Aviles, T. (personal communication, 2018) provided the guidelines developed by the Instituto Agronômico de Campinas (IAC) many years ago for bearing avocado orchards in Brazil. http://www.iac.sp.gov.br/areasdepesquisa/frutas/frutiferas_cont.php?nome=Abacate. Note that 90% of avocado orchards in Brazil are rain fed only and the rainy season occurs in summer from October until March. For an expected yield of 10 to 25 tonnes/ha, the recommendations are to apply 60 to 120 kg/ha of N when leaf N is below 2%, and according to soil analysis, apply between 9 to 53 kg phosphorus/ha and 28 to 140 kg potassium/ha. It is recommended that the annual fertiliser rate, especially the nitrogen and potassium, be split into three applications through the rainy season. Recent research has established that April is the best month for taking leaf samples, optimum leaf levels have been defined for three varieties including 'Hass' and the mineral content of fruit has also recently been established.

California

The annual rate of nitrogen used in two separate nutrition studies has been 140 kg N/ha/year (Lovatt, 2001 and Salvo and Lovatt, 2016). Lovatt and Witney (2001) report that 101 kg N/ha/year are required to produce a yield of 12.35 t/ha.

Faber, B. (personal communication 2018) believes that while good nutrition is important it is relatively simple and irrigation is much more important.

Nutrition guidelines are available for Californian growers at: https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Avocado.html

The nitrogen and potassium rate guidelines are based on crop removal. For example for a yield of 10 t/ha, the guidelines recommend 72 kg N and 65 kg K/ha, whilst for a yield of 20 t/ha, 100 kg N and 130 kg K/ha are recommended.

Chile

Atucha *et al* (2013) listed the typical macro nutrient application to a mature field of avocados growing on hillsides in central Chile to be:

- 120 – 250 kg N/ha/yr
- 50 – 80 kg P/ha/yr
- 50 kg K/ha/yr

Newett (2015a) reported that the range of nitrogen being used on the ultra-high density 'Hass' orchards at Llay Llay in Chile (Mediterranean climate, soil types mainly clay or clay loam with pH $_{water}$ about 7.4) was between 115 and 150 kg N/ha/year and yields of 30 t/ha were being achieved with these rates. Mena, F. (personal communication, 2015) said that on these orchards potassium was only applied when the leaf levels dropped below 0.55%; the optimum potassium range used in Australia is 0.75 to 2.0% so the target level in Chile is significantly lower. Zinc rates depend on leaf levels but are very high compared to Australia, possibly because of the relatively high clay content of the soils (clay is known to tie up zinc in the soil). If leaf zinc levels are below 40 ppm, 66 kg Zn/ha/year (300 kg of zinc sulphate heptahydrate) is applied; if leaf levels are between 40 to 70 ppm, 51 kg Zn/ha/year (230 kg of zinc sulphate heptahydrate); and if leaf levels are above 70 ppm none is applied (the optimum leaf zinc level used in Australia is 40 to 80 ppm).

At this orchard great importance is placed on the correct sampling of leaves; here they sample the spring leaf flush, and care is taken to only sample mature, hardened, spring leaf flush from stems

that do not have fruit. Great importance is also placed on looking at the trees and observing the colour, shine and size of the leaves.

A Chilean fertiliser company funded a trial to test different forms of nutrients including N, P, K, S, Mg, Zn, B and Mn at this site and this was compared against the standard programme used by the orchard. After four years they found no differences in crop performance but the cost of the fertiliser company's program was USD2,000/ha whilst the orchard's standard program cost just USD300/ha.

Florida

Kiggundu *et al* (2012) applied the following amounts to 3 year old 'Simmonds' avocados growing in a very gravelly soil overlying limestone in Florida.

- 156 kg N/ha/yr
- 25 kg P/ha/yr
- 146 kg K/ha/yr
- 58 kg Mg/ha/yr

Israel

Noy, M. (personal communication, 2018) explained that in Israel (Mediterranean climate) where irrigation is mainly only applied in the warmer (dry) months (from spring to autumn), nutrients are generally applied with every irrigation (as fertigation) and this includes nitrogen at 40 to 50 ppm in the water. Approximately 300 kg N, 50 kg P and 300 kg K are applied per hectare per year to high yielding orchards. Iron must also be regularly applied because of the high soil pH and calcareous soils. Since much of the irrigation water in Israel is recycled, the nutrient content of this water must be considered.

New Zealand

Partridge, C. (personal communication, 2018) provided an example of an annual nutrient application program he recommended this current season. It was for an orchard consisting of large trees in a high yielding orchard on wide spacing, growing in a well-drained soil derived from volcanic ash in the Bay of Plenty. Leaf nutrient levels were in the optimum range. The fertiliser rates he recommended were 280 N, 36 P and 165 K (kg nutrient/ha/year). The rate is split into seven applications through the year - June 5%, August 7%, late October 16%, December 12%, January 21%, March 23% and April 16%. Partridge noted that programmes would be different for orchards established in sandy or higher clay soils and adjusted during the season depending on factors such as crop loading or planned canopy management actions.

Peru

Newett (2015b) gathered information on the nutrition programmes of orchards visited in Peru in 2015. The first four orchards listed in the table below were for young orchards established on desert sands where organic matter is incorporated before planting.

Table 5. Typical ranges of fertiliser used in the orchards visited in Peru in 2015 (Newett, 2015b)

Orchard	Soil	N	P	K	Comment
		kg element/ha/yr			
'Casablanca' near Chiclayo	Sand	200	?	160	For a yield of 32 t/ha.
'Agricola Cerro Prieto' near Chiclayo	Sand	380	76	373	Nitrogen daily with lower dose in winter and higher dose during flowering. 6 year old trees yield between 20 – 26 t/ha.

'Arato Montegrande', near Trujillo	Sand	260	100	300	Trees 4 yrs and older. Yields on 'Lula' rootstock are about 17 t/ha.
'En Sueno', near Trujillo	Sand	240	60	300	Nitrogen rates are increased during pre-flowering, flowering and fruitset, reduced during the first fruitlet shedding, increased again during fruit growth then gradually reduced during the latter stages of fruit growth. Potassium rates are lowest pre-flowering, start to increase during flowering and reach their peak just before harvest. Yields average about 16t/ha.
'La Calera' Chincha Valley south of Lima	Alluvial loam	200	48	332	Mostly applied as chicken manure. Yields are in the region of 20 t/ha.
'Hoja Redondo' Chincha Valley south of Lima	Alluvial loam	180	44	208	Typical yields are 18 t/ha.

South Africa

Lutge, A. (personal communication, 2018) reports that in South Africa Snijder and Stassen (2000) established kilograms of element (nitrogen, phosphorus, potassium, calcium and magnesium) that must be replenished each year per tonne of crop removed for each of three different soil types. As an alternative, they also provided rates of these nutrients to apply per centimetre of trunk circumference for unpruned trees. These base levels are adjusted according to leaf and soil analyses and crop vigour and are adapted for each farm over a number of years of observations. The nitrogen rate is increased by up to 20% where thunderstorms do not occur.

Table 6. Macro element fertiliser guidelines established for 'Hass' in South Africa based on crop removal (Snijder & Stassen, 2000)

Soil texture	kg of element recommended to be applied/tonne of yield				
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Sandy (0-12% clay)	7.1	1.2	10.2	3.3	2.3
Medium potential soils (13-24% clay)	5.7	1	8.2	2.6	1.8
High potential soils (more than 24% clay)	4.5	0.8	6.5	2.1	1.5

Lutge reports that for a 'Hass' orchard growing on a soil high in clay and yielding about 20 t/ha, Westfalia Fruit Estates apply roughly 90-110 kg N/ha, 20 kg P/ha and 140-160 kg K/ha. This is adjusted up or down according to leaf and soil analysis. Nitrogen is split into eight applications by hand through the year starting in August and ending in April with higher rates applied from February to April. Where fertigation is used small amounts of nitrogen and potassium are also applied through

the winter months. Nitrogen and potassium are generally applied together, phosphorus is split into two applications during root flushes and zinc and boron are applied at flowering and again in March/April.

Estimate of nutrients (kg of element) removed from the field by avocados

Some growers and agronomists use estimates of the nutrients removed in the harvested crop as a basis for calculating fertiliser rates to apply and then multiply these estimates by factors to allow for leaching, volatilisation and other losses.

Table 7. Various estimates of nutrients (kg nutrient) removed by one tonne of avocado fruit

Researcher	N	P	K	Ca	Mg
Rosecrance, R. *et al* (2012) 'Hass'	2.2	0.4	3	0.1	0.3
Stassen, P. *et al* (2010) 'Hass'	2.4	0.6	5.3	0.1	0.3
Dirou, J. and Huett, D. (2001) 'Hass'	3.8	0.66	5.7	0.48	0.55
Snijder, B. (2015) 'Maluma'	5.3				

Nitrogen rates and timing

There is strong evidence that timing of nitrogen application is an important factor in influencing Hass yield (Lovatt, 2001 and Lovatt and Salvo, 2016).

Lovatt (2001) proposed supplying sufficiently high amounts of nitrogen to meet the demands of the competing growth processes so that floral shoot development, fruit set, fruit growth and vegetative shoot growth would not compromise yield. In the trial, all trees received 140 kg N/ha (as ammonium nitrate) split into five applications of 28 kg N/ha. These were applied in the southern hemisphere equivalent months of July, August, October (full bloom), December and May, then a double dose was applied to different plots of trees for each of these months (thus receiving a total of 168 kg N/ha/year). The control treatment received no extra nitrogen. The research demonstrated that in Californian conditions applying a double dose of nitrogen at full bloom or in autumn (after cessation of leaf growth) significantly increased cumulative four year yields and fruit size, compared with applying 5 equal applications every second month from spring through till autumn. The higher dose at flowering also reduced the severity of alternate bearing.

The success of the extra application at full bloom was explained by supplying sufficient nitrogen so that the flowering/fruit set process was not competing with the developing leaf flush for nitrogen. The theory of supplying extra nitrogen in autumn was to pre-load the tree with nitrogen to increase flowering, fruit set and fruit retention. In a subsequent trial, the researchers established that it was unnecessary to apply a double dose as it was the correct timing that produced the beneficial result.

In the ultra-high density orchards in Chile, Mena, F. (reported by Newett, 2015a) explained that 30 to 40% of the nitrogen was applied at flowering time for fruit development and spring leaf flush with the amount being adjusted according to the intensity of the flowering – the greater the intensity the higher the rate. 20 to 30% was applied in January for fruit sizing and summer flush (harvest is conducted between September and January at this orchard), and the remaining 40% was applied in April to start building the tree up for a good flowering. Nitrogen was once not recommended at flowering, but this has since changed. Mena reported that there was a problem if nitrogen was applied a month prior to flowering in this environment.

In Australia, Whiley, A. (personal communication, 2018) does not recommend any nitrogen be applied through early to mid-winter unless the autumn leaf analysis indicates it is needed. Nitrogen

applications are commenced with a relatively high dose at the cauliflower stage of flower bud development then reduced until mid to late autumn when 30% of the annual rate is applied. The autumn leaf analysis is taken after the last application has had enough time to be taken up by the tree.

Lovatt and Salvo (2016) investigated nitrogen fertilisation strategies to increase yield without decreasing fruit size. The research project was conducted over four consecutive seasons in California (Mediterranean climate) on 17-year-old Hass trees, on Duke 7 clonal rootstocks, growing in a loam soil. The phenological cycle in California is most like that of trees growing in SW Western Australia and Tristate. Trees were harvested 16 months after flowering (equivalent to February in Australia, so quite late).

All treatments (with one exception) received 140 kg nitrogen/ha/year split into 5 doses throughout the year at the times listed below in Table 7. Ammonium nitrate was used as the nitrogen source with the exception of the foliar application where low biuret urea was used. The 'control' treatment received equal doses at each of the five stages whilst the other treatments received different proportions at these five stages. The exception received just 45 kg nitrogen/ha/year split into two doses, namely in January and February (southern hemisphere equivalents).

The lower yield associated with treatment number 3 where 40% was applied at flowering and 40% again in autumn may appear to contradict the results achieved by Lovatt (2001) discussed above. However it was likely to be the consequence of applying only 14% of the annual nitrogen dose through the summer growing period, thus highlighting the importance of supplying enough nitrogen at this time.

Leaf N levels in the trial site were high, 2.71% at the start of the experiment, and high residual nitrogen in the soil may have been responsible for sustaining the performance of the trees in all treatments including No. 8 which received much lower rates of N than the others. The result in treatment 8 may also reinforce the importance of nitrogen applications in summer since this was the only time that this treatment received nitrogen fertiliser applications. The leaf levels decreased over the life of the project and average levels over the four year period were in the 2.54 to 2.62% range for all treatments, except the low nitrogen treatment which averaged 2.46%. However by year four the leaf nitrogen levels had dropped to a 2.31 to 2.45% range with the low dose treatment (8) at 2.28%. This indicates that residual nitrogen levels in the soil may have been quite high initially and suggests that an annual dose of 140 kg N/ha/year may not be sufficient in the long term.

Salvo & Lovatt (2016) state that in California summer vegetative shoots contribute to 60-70% of the total inflorescences in the subsequent flowering. This suggests that N fertiliser should be applied to the soil during the summer at an adequate rate to mitigate June drop and support competing growth processes of the fruit and summer vegetative shoots.

The highest leaf N was found in Treatment 6 (averaging 2.62% N over the four-year experiment and finishing at 2.45% N by year 4). This treatment received 60% of its annual N dose at flowering but the yield was only just higher than the average, suggesting that insufficient nitrogen was being applied at other times.

Table 8. Salvo and Lovatt (2016) nitrogen treatments and result

	Timing of N applications (S. hemisphere, WA & Tristate equivalents)						
	Jul	Oct	Jan	Feb	May		
Treatment number	Flower bud swell	Flowering, fruitset & initiation of spring leaf flush	Shedding of small fruitlets, initiation of exponential fruit growth and summer leaf flush	Exponential fruit growth, initiation of next season's flowers	Floral buds are committed to floral development, end of leaf growth	% of 140 kg N/ha/year	
	Percentage of the total annual dose of 140 kg N/ha/year						Result over 4 years
1	20%	20%	20%	20%	20%	100%	Good yield, average fruit size
2	15%	**40%**	15%	15%	15%	100%	Highest yield but smaller fruit & greatest degree of alternate bearing.
3	7%	**40%**	7%	7%	**40%**	100%	Lower yield
4	15%	15%	15%	**40%**	15%	100%	
5	15%	15%	15%	15%	**40%**	100%	Good fruit size
6	10%	**60%**	10%	10%	10%	100%	Highest leaf N.
7	10%	**60%** foliar	10%	10%	10%	100%	Low yield but lowest number of small fruit.
8	-	-	16%	16%	-	32%	Good fruit size. Highest number (but not statistically significant) of commercially valuable sized fruit.

There were no significant differences in fruit quality between the treatments.

This study reinforces the strategy of applying nitrogen 'little and often' throughout the year. In the experiment the annual dose was 140 kg N/ha/year. With a tree density of 271 trees/ha (5.5 x 6.7m tree spacing) the average annual yield was 15.5 t/ha but the average Alternate Bearing Index was

0.48 (meaning that the average yield in an 'on' year was about 23 t/ha but dropped to about 8 t/ha in the 'off' year).

Silber (2015 & 2017) investigated when the critical periodic demand for water and nutrients occurred in avocado. Lysimeter and field experiments were conducted to better understand and thus overcome the low avocado yields (10 t/ha) in Israel caused predominantly by the summer fruit shedding event and alternate bearing. The results can be summarised as follows.

Table 9. Silber (2015 & 2017) research treatments

	Fertiliser treatment (S. hemisphere equivalents)	Comment
1	Continuous fertigation (NPK + trace elements) over the whole year	Best results
2	No fertiliser until mid- September (just before flowering) then same as Trt 1.	Nutrient deficiency induced (a) leaf abscission (b) fruitlet and fruit drop
3	No fertiliser until mid- November (after fruitset) then same as Trt 1.	Flower development was delayed. Leaf drop occurred at flowering.

Different irrigation treatments induced significant differences in fruitlet drop. Silber (2015 & 2017) concluded that the differences in plant response to the irrigation treatments might point towards water and/or nutrient availability. He argues that unavailability of water and/or nutrients may lead to a malfunction of the embryo or seed and that fruitlet drop was the final step in a multifaceted process that started weeks or even months before. He emphasised the importance of fertilising the tree prior to flowering and of continuous application of all the necessary macro and micro nutrients throughout the growth period, recommending that a special effort should be made to match demand for water and nutrients during the flowering and fruitset processes. He showed that whereas fruit nitrogen levels built up at a constant level in the fruit as it developed, the rate of phosphorus and potassium accumulation intensified in the latter stages of fruit development.

Rosecrance et al (2012) found that in California nitrogen fertilisation in spring increased both fruit size, yield, and reduced the severity of alternate bearing compared with trees receiving nitrogen at any other time of the year except flowering. Nitrogen fertilisation at flowering and fruitset appears to be critical for fruit set of the new crop, for growth of the vegetative shoot flushes, and to support fruit growth of the maturing crop. In their study, they followed the accumulation of nutrients in avocado fruit. Calcium only accumulated during early fruit development and for this reason it was recommended that an abundant supply of calcium should be available during early fruit development. This concurs with the current understanding in Australia that calcium can only accumulate in the fruit during the first 6 to 8 weeks of its development i.e. before its stomata close permanently and turn into lenticels, and that soil moisture has to be optimal at this time too to facilitate uptake. The rate of nitrogen and phosphorus accumulation in the fruit continued at moderate levels as the fruit matured whilst the rate of potassium, magnesium and sulphur appeared to increase quite markedly in the final few months of fruit growth. These findings have implications for the timing of nutrient applications.

Thomas, G. (personal communication, 2017) and Mena, F. (personal communication, 2015) recommend that fruitset be closely followed and if it appears to be heavy then as soon as the early shedding of small fruit is over then nitrogen rates need to be increased. This is to feed this heavy crop and ensure there is also sufficient for leaf growth too. Newett (2015a) reported that Mena was investigating more efficient ways of assessing flowering and fruitset intensity (e.g. remote sensing

with drones) for determining this nitrogen adjustment as well as for timing of PGR application. Thomas, G. aims to supply enough extra nitrogen (up to another 50% of the annual rate if leaf nitrogen is deficient and fruitset is exceptional) over the next two or three months in order to grow about 45cm of leaf flush beyond the young fruit. As described below under 'Foliar applied nutrients', if flowering is heavy and a big leaf drop is expected, Roe, D. (personal communication, 2018) recommends foliar low biuret urea sprays at flowering to delay leaf drop.

Timing of nutrient applications other than nitrogen

Lovatt (2001) found that applications of phosphorus and potassium (at 4.2 kg P/ha and 25 kg K/ha) in January and again in February (southern hemisphere equivalents) in combination with 28 kg N/ha at the same time had a positive effect on yield and fruit size compared with trees receiving nitrogen only at this time. Applications of P and K at the other times did not significantly increase yield or fruit size.

Lovatt (2013) reported that in California there was a growing trend to divide the annual amount of fertiliser into six or twelve small equal applications. However she pointed out that this ignores the crop cycle and nutrient demand, so it is possible that transient periods of insufficiency of particular nutrients could occur during key stages in the tree's phenology and these could have a negative effect on yield, fruit size, fruit quality and the next flowering.

Rosecrance et al (2012) recommended basing the timing of fertiliser applications on the timing of nutrient accumulation in developing fruit. Following this approach in California (Mediterranean climate where fruit remains on the tree for about 16 months) nitrogen, phosphorus, magnesium, sulphur, iron and zinc need to be applied during the spring growing season after full bloom and repeated again the second year during the same period. This is in order to supply nutrients to the recently pollinated flowers as well as the maturing fruit. Potassium and boron are accumulated more rapidly in fruit in the latter stages of fruit development (in California during the second season of fruit development) so should be applied in order to be available for this stage; a higher application may be needed depending on fruit load. Since most of the calcium is accumulated during early fruit development, an abundant supply must be available at this early stage.

In Australia, Whiley, A. (personal communication, 2018) commences calcium applications from mid-flowering and continues them for 12 weeks. He does not recommend applying potassium until calcium applications are over because potassium replaces calcium at the root absorption sites. Potassium is applied from mid-summer through until the end of autumn, which matches the recommendation of Rosecrance et al (2012) to apply it in the latter stages of fruit development. Whiley recommends boron in the months when trees are actively growing and magnesium is applied if necessary during spring. Other elements are applied at any time when required. Martin, L. (personal communication, 2017) believes that potassium is the worst offender in displacing other cations particularly calcium.

Calcium

Lahav et al (2013) states that whilst gypsum was the most effective treatment for increasing soil calcium, it also displaced potassium and magnesium from the topsoil and subsoil. Gypsum increased calcium levels to deeper levels than achieved by dolomitic products.

Silicon

The role of silicon as an essential nutrient in avocado has attracted research over the past 10 years or so but has often given inconsistent results (Bekker et al, 2007 and Smith et al, 2011). The function of silicon as a plant nutrient is thought to be one of making plant cells more resistant to disease

attack, partly by enhancing physical barriers to infection and possibly also through a direct fungicidal effect. Recently, Dann and Le (2017) undertook a literature review and conducted trials with two silicon products. One product was soluble potassium silicate and the other was a slow-release milled by-product from the building industry which contains 5% soluble silicon. There were mixed and inconsistent results from using soluble potassium silicate although in some cases improvements were recorded in tree health and in fruit yield and quality. However, results from the slow release product were more promising, improving tree health and raising silicon levels in leaves and fruit peel. The authors concluded that products that deliver silicon consistently for uptake, i.e. slow-release products, are likely to be most successful in perennial crops but that further field trials are warranted.

Molybdenum

Brusca and Haas (1955) showed clear avocado growth responses to the addition of sodium molybdate in pot trials that compared nutrient solutions without molybdenum with those receiving a range of concentrations of this trace element. Growth was stunted in the nil treatment whilst the best growth was achieved with a concentration of 0.5 ppm molybdenum, however at concentrations of 5, 25 and 50 ppm growth declined proportionately suggesting that toxic levels had been reached.

Wolstenholme (2017) undertook a short review of the role and importance of molybdenum in plant nutrition. He pointed out that molybdenum is an essential plant trace element and has a number of roles including being closely involved with nitrogen metabolism (which includes nitrogen fixation in legumes) and as a co-factor (molybdenum co-factor, or 'Mo-co' for short) for several essential enzymes. Deficiency symptoms can appear the same as those for nitrogen deficiency, because of its role in nitrogen metabolism. Molybdenum is required in such trace amounts that in most orchards it is likely to be present in sufficient quantities, but adequate amounts may also be inadvertently supplied as impurities in commonly used fertilisers. It is the only nutrient whose availability increases with pH, i.e. the higher (more alkaline) the soil pH the more available it is, but in acid soils the availability of molybdenum is very low. There is an inverse relationship between molybdenum and manganese so soils high in available manganese (e.g. where there are toxic levels of manganese in acid soils with high water content) can be deficient in molybdenum, especially if organic matter levels are low. In addition, sulphate and molybdate ions compete strongly during root uptake from the soil so sulphate based fertilisers including gypsum will suppress uptake of molybdenum.

Since molybdenum is required in such small amounts and because it is highly phloem-mobile, foliar sprays are likely to be successful in addressing deficiencies.

In summary molybdenum is more likely to be deficient in highly leached, very acid soils especially if they are low in organic matter and have high levels of manganese and sulphates, however it is easy to correct.

Foliar applied nutrients

Newett (2000) conducted a literature review on foliar nutrient applications in avocado and found at that time that there was little evidence to support the use of foliar applied nutrients in avocado. The topic was reviewed for this report.

Lovatt (2013a) claims there is a place for foliar applied nutrients in avocado, e.g. where cold wet soils in spring can restrict nutrient uptake when needed for spring growth, in the presence of soil salinity, where pH is not suitable and where soil chemistry (e.g. nutrient tie-ups) restricts sufficient root absorption. If the plant absorbs a foliar applied nutrient, it also needs to be phloem-mobile in order to be transported to where it is needed. Nutrients listed as phloem-mobile are nitrogen,

phosphorus, potassium, chlorine and sulphur. Partially phloem-mobile are zinc, iron, manganese, molybdenum and boron. Calcium is not phloem mobile. It should also be noted that nutrients can have vastly different rates of leaf absorption e.g. in pistachio six months elapsed before an increase in the leaf zinc level was detected following a foliar zinc spray.

Applying foliar nutrients is not widely recommended for avocados because mature avocado leaves have a thick waxy cuticle and only small amounts can be absorbed at best, however some uptake of foliar urea has been achieved through leaves that were only 2/3 expanded (Nevin *et al,* 1990).

Results are not always consistent, for example in California mature leaves did not take up foliar applied urea (Nevin *et al,* 1990) but mature leaves in Israel did (Zilkah *et al,* 1987).

In Spain, Torres *et al* (2002) experimented with foliar applications of boron, copper and zinc on mature Hass trees on Mexican rootstock and on potted trees. In their first experiment boron, copper and zinc sprays were applied to mature trees over a period of three years but none of the sprays affected vegetative growth or yield, and no increase in leaf nutrient levels was achieved. In their second experiment, boron sprays were applied to flowers and this did result in higher boron levels in autumn sampled leaves. In the third experiment, the area to one side of the midrib of the leaf (top and bottom) was sponged with a boron solution but this had no effect on the boron concentration in the other half of the leaf. In a fourth experiment foliar boron sprays were applied to potted trees but even when very young expanding leaves were sprayed no major increase in boron content of the following leaf flush or shoot bark were registered. Addition of wetting agents or acidifiers to the spray did not consistently influence boron levels.

Nevertheless, recent research has indicated that there are instances in some growing environments where well-timed applications of some nutrients applied to immature leaves are able to elicit a response. The chances of success can be improved if nutrients are applied to developing leaves (1/3 to 1/2 expanded) or to plant organs other than leaves (e.g. flowers), and wetting agents and more soluble fertiliser formulations are used.

Jaganath and Lovatt (1998), and Lovatt (1999) in studies with 'Hass' in California reported that a foliar spray of Solubor® (at 6 g B/tree) <u>or</u> of low biuret urea (at 160 g N/tree) targeting the cauliflower stage of flowering (not the leaf) significantly increased cumulative yield over the three year period of the research. This increase was by 12 and 11 t/ha respectively. However, urea sprays were not recommended because of the possible negative effects of urea when the ambient temperature exceeds 32°C. A combination spray of Solubor® and urea resulted in a yield not significantly different from the untreated trees in this experiment. Salazar-Garcia (reported by Lovatt, 2013) and Jaganath (1993) reported that including urea in the spray caused a deformation of flower carpels and Salazar Garcia in Mexico reported a significant reduction in yield from a combined boron plus urea spray.

Roe, D. (personal communication, 2018) recommends three 1% low biuret urea sprays a week apart starting at budburst if a heavy flowering is imminent and a big leaf drop is expected. He reports that this has the effect of keeping the leaves on the tree for longer.

In Mexico, Cossio-Vergas *et al* (2009) reported that in an unirrigated orchard displaying boron deficiency symptoms, a foliar spray of boron at 2 kg B/ha applied at early fruit set improved fruit size. In another treatment a spray at fruit set at 1 kg B/ha followed by a second spray a month later increased both yield and fruit size.

Dixon *et al* (2005) conducted a study on two Hass orchards (one irrigated and the other not) in New Zealand to determine if applying foliar boron (1 g Solubor®/litre), nitrogen (1% solution of low biuret urea) and boron and nitrogen combined (at these same concentrations) would increase fruit set. Sprays were applied when the flower buds had started to expand. The sprays had an inconsistent effect on fruit set that was orchard dependant. The optimum boron concentration in the <u>flower</u> for maximum fruit number was found to be between 50 and 65ppm. This was also reported by Robbertse *et al* (1992) in South Africa. However, there was no advantage in exceeding 65ppm boron level in the flowers e.g. by applying multiple sprays. This may help explain why there are variable results from orchard to orchard. Dixon suggested that fruit set might be negatively affected at levels both above and below the optimum and that multiple sprays were a waste of time. Research by Smith *et al* (1997) confirmed this notion, reporting that foliar boron sprays at flowering only induced a response if the <u>leaf</u> boron level was below 30 ppm (i.e. deficient). Dixon (2006) in a follow up experiment found that multiple sprays of boron are not required for good fruit set and did not overcome the effect of alternate bearing. The experiments found that applying boron as a single or multiple foliar spray at the cauliflower stage of flowering on adequately fertilised 'Hass' trees in New Zealand conditions did not enhance fruit set, this may have been because boron levels were already sufficient.

In California Lovatt (2013b) found that a spray of potassium phosphite at 6.5 L/ha to the cauliflower stage of flower development significantly increased the three year cumulative yield of commercially valuable sized fruit without reducing total yield. Phosphite is more readily absorbed into plant tissues than phosphate. In Mexico Salazar-García (unpublished but reported by Lovatt, 2013) significantly increased fruit size and yield by applying two sprays of potassium phosphite at about 3.5 L/ha each, the first at the beginning of the exponential fruit growth period and the second a month later. However, it is not clear from either of the investigations how much of the benefits were the result of improvements in nutrient status and how much were from possible improvements in tree health because of the fungicidal properties on Phytophthora root rot, although the timing was wrong for root rot treatment.

In Australia, Martin, L. (personal communication, 2017) reports some success in curing zinc deficiency symptoms in leaves with foliar applications of zinc chelate EDTA. Thomas, B (personal communication, 2017) reports that zinc deficiency can be a problem in the South Australia/Victoria region due to tie up in the soil and possibly cold soil temperatures in spring, and claims some success with foliar zinc sprays if applied to new leaf flush before it hardens.

However, Salazar-Garcia *et al* (2008) found over a four year trial in Mexico that zinc sulphate foliar sprays (applied at cauliflower stage of flower buds with new leaf flush already emerging) were ineffective in correcting zinc deficiency and had no positive effect on yield and fruit size. But he did find that two soil applications of 0.75 kg zinc sulphate per tree per year were effective in increasing yield, fruit size and fruit shape. A poor relationship was found between the amount of zinc applied and the zinc leaf level.

Nutrient monitoring

The recommended time in Australia to monitor nutrient levels in leaves is autumn (sampling mature summer flush) and this is widely practiced however it is becoming a common and accepted practice to also sample in early summer (mature spring flush from shoots without fruit) (Newett, 2017). Soil nutrient status is generally examined once every one to three years.

Leaf analysis is the most common method for monitoring nutrient status but it has limitations. Firstly, it is well documented that 'Hass' avocado yield and fruit size in California are not related to

leaf nitrogen concentration (Arpaia *et al*, 1996; Embleton and Jones, 1972; Embleton *et al,* 1968; Lovatt, 2001; Lovatt and Witney, 2001; Yates *et al,* 1993; reported by Salvo and Lovatt, 2016). Secondly many elements (e.g. calcium and magnesium) accumulate with leaf age so the result for these elements tends to reflect the age of the leaf sampled rather than the calcium and magnesium status in the tree. Thirdly it is easy to select the wrong leaf for analysis. Fourthly, leaf iron levels are not considered a reliable indicator for plant usable iron, the leaf may have deficiency symptoms but the analysis may indicate ample levels are present. Finally, the timing of sampling is such that no action can be taken to rectify deficiencies or imbalances for the current crop, only for the next one.

Salazar-Garcia *et al* (2015) conducted a very thorough investigation in order to establish the best time to take leaf samples from orchards in the hot subhumid climate in the state of Nayarit in Mexico for each of the two main leaf flushes per year. Leaves were sampled and analysed monthly until abscission, with nutrient content curves established which allowed the most stable and therefore appropriate timing for sampling to be determined. These curves are a useful reference to demonstrate how the levels of each element change as the leaves gets older and how levels differ between the two different flushes. Leaf flush patterns are different in Nayarit compared with Australia but for their winter flush leaves the best time was when leaves were 6.6 to 7.9 months old and for the summer leaf flush the best time to sample was when leaves were only 3.9 to 4.9 months old. The summer flush leaves grew faster than the winter ones as expected but they had an average lifespan of just 7.8 months while the winter flush leaves lived for an average of 12.5 months.

Dann *et al* (2016) found a link between the N:Ca ratio in fruit skin and fruit quality. The higher the calcium the lower the incidence of fruit rot.

Silber (2017) argues that one needs to replace the quantities of nutrients removed by the crop and therefore we should be analysing nutrient concentrations in the fruit (instead of the leaves) and using this information and the yield to calculate what to apply (with appropriate efficiency factors to account for losses due to leaching, volatilisation etc).

Campisi-Pinto *et al* (2017) in California attempted to identify which 'Hass' avocado tissue had nutrient concentrations that best predicted yields of greater than 40 kg fruit per tree (more than about 11 t/ha). They discovered that nutrient content of flower buds at the cauliflower stage was the best predictor of yield for crop to be borne by those flowers. These cauliflower stage buds were better predictors than inflorescences at full bloom, fruit pedicels at five different stages, or six-month-old spring flush leaves. They found that the concentration of seven nutrients, viz. nitrogen, phosphorus, potassium, magnesium, sulphur and zinc in the flower buds at the cauliflower stage were predictive of trees producing greater than 40 kg fruit annually. Interestingly, the trees producing high yields had nutrient levels for the seven nutrients at the <u>low</u> end of the nutrient ranges measured across all trees in the experiment, whereas those producing low yields were at the high end. Optimum ratios of nutrients were also derived. Calcium, manganese and boron levels in the flower buds were not correlated with high yield, however no deficiency symptoms for any nutrients were visible in the experiment so it is likely that these nutrients were present at sufficient levels. They found that the nutrient status of cauliflower stage flower buds was not related to the nutrient status of leaves sampled at the standard autumn time. The results also indicated that current fertiliser practices (timing or amounts) might be causing nutrient imbalances at this stage of avocado phenology that are limiting productivity. This research is an exciting development that could result in the development of a useful tool and warrants further investigation. One of the potential advantages of this approach could be that you could take immediate action to correct nutrient deficiencies, toxicities or imbalances in time to benefit the crop as it set and developed. Another advantage is that the cauliflower stage of flower bud development is a discrete

developmental stage of short duration that is easy to identify and collect compared to the difficulties of sampling the correct leaf for nutrient testing.

Osborne *et al* (2002) showed how remote sensing using hyperspectral analysis has the potential for rapid and non-destructive nutrient analysis of a commercially grown crop. Robson, A. (personal communication, 2016) has been investigating the use of remote sensing to determine nitrogen levels in sugarcane crops in Queensland. This technology may have potential for avocado orchards in the future.

However, recent work by Crowley *et al* (2015 & 2016), and also reported by Span (2016), has 'data mined' hundreds of leaf analysis results and corresponding yields which has shed new light on optimum ratios between leaf nutrients and has established new optimum ranges for leaf nutrient levels in California that correlate with higher yields. This work suggests that leaf nutrient analysis will remain a useful tool into the future. This work is discussed in more detail below.

Correlating leaf nutrient levels with yield and establishing new optimum leaf ranges and ratios

Crowley *et al* (2015 and 2016) and Span (2016) describe how data was collected from hundreds of avocado trees from production areas in Southern California in order to model the relationships between leaf nutrient concentrations and the yields of avocado trees. Using advanced statistical methods and artificial neural network models (a type of machine learning software) they have thrown new light on optimum nutrient levels and relationships between nutrients that correlate with both higher and lower yields.

A significant outcome has been the release of new optimum ranges for leaf nutrients in California. The table below compares Australia's current guidelines with the new ones developed by Crowley *et al* (2015).

Crowley's upper limit (0.15%) for his suggested new optimum range for leaf phosphorus compares closely with Lahav *et al* (2013) who states that when leaf phosphorus is above 0.14% no phosphorus fertiliser should be applied. Similarly for potassium, Lahav *et al* (2013) states that if leaf potassium is above 1.2% no potassium fertiliser should be applied, whilst Crowley goes one step further by suggesting that the upper limit for leaf potassium should be lowered from 2.0% to 0.9%. As mentioned earlier Mena, F. (personal communication, 2015) does not apply potassium fertiliser once the leaf level rises above 0.55% K.

The advanced statistical analysis has also revealed that there are multiple interactions between different nutrients, i.e. as certain nutrient levels go up yields can be further increased by re-optimising other nutrients to obtain the optimum nutrient ratios.

Table 10. New avocado leaf nutrient optimum ranges for 'Hass' grown in California developed by Crowley et al (2015) compared with Australia's current optimum guidelines (hardened summer flush sampled in autumn in both cases)

Nutrient	Existing optimum range used in Australia (Embleton & Jones, 1964) & (Whiley *et al*, 1996)	New optimum range established for California (Crowley, 2015)	Comment on the change
Nitrogen %	2.2 – 2.6	2.25 – 2.9*	Higher range. *N.B. - may be too high for subtropical and tropical production regions.
Phosphorus %	0.08 – 0.25	0.1 – 0.15	Upper limit has been lowered. Narrower range.
Potassium %	0.75 – 2.0	0.7 – 0.9	Upper limit has been lowered. Narrower range.
Calcium %	1.0 – 3.0	1.8 – 2.0	Narrower range.
Magnesium %	0.25 – 0.8	0.6 – 0.9	Narrower range, higher lower limit.
Sulphur %	0.2 – 0.6	0.45 – 0.53	Narrower range.
Zinc ppm	40 – 80	50 – 80	Lower limit has been raised.
Copper ppm	5 - 15	4 - 7	Narrower range, lower upper limit.
Iron ppm	50 – 200	55 – 80	Much narrower range, lower upper limit.
Manganese ppm	30 – 500	110 - 145	Much narrower range, higher lower limit and lower upper limit.
Boron ppm	40 - 60	38 – 60	

A number of other major findings have emerged. Crowley *et al* (2015) state that they can predict yield losses as nutrient levels exceed optimum values, Californian growers may be applying too much nitrogen and potassium which could be causing 'huge losses' in production, large nutrient imbalances between nitrogen and potassium are closely associated with alternate bearing trees, chloride toxicity leads to greatly reduced shelf life whilst increasing calcium can offset this, and the balance between iron and potassium is critical. Another focus of this research was the study of soil salinity and chloride toxicity on avocado yields, and the extent to which this might be controlled by managing tree fertilisation, soil water monitoring, and leaching practices.

Findings from the project will be used to develop a Decision Support Tool that can help growers improve fertilisation and nutrient management while minimising the effects of soil salinity.

Effect of rootstock

Dann *et al* (2016) reported on the effect of rootstock on fruit mineral content and susceptibility to fruit flesh body rots from data collected in the rootstock trials conducted across Australia. Fruit peel samples were collected at harvest and analysed for concentrations of nitrogen, potassium, calcium and magnesium. Fruit were assessed for stem end rot and anthracnose. Rootstock significantly affected marketability of fruit (no stem end rot and less than 5% anthracnose) in 58% of the trials evaluated, with better quality fruit harvested from 'Hass' grafted to Guatemalan and West Indian rootstocks such as 'A10' and 'Velvick'. Fruit quality was frequently poor from trees grafted to Mexican race rootstocks, regardless of growing location. Fruit from rootstocks with superior fruit

quality was often associated with lower skin nitrogen and higher calcium concentrations. N:Ca ratios in the skin of unripe avocado fruit may provide one of the best indicators of potential postharvest disease in ripe fruit, and may have implications for fertiliser regimes.

Mycorrhizae

Menge *et al* (1980) found that the introduction of two isolates of the mycorrhiza *Glomus fasciculatus* improved avocado seedling growth by 49 to 254% compared to seedlings grown in sterile soil without mycorrhizae. Both mycorrhizal isolates increased absorption of nitrogen, phosphorus and copper whilst the other also increased absorption of zinc. Fertilisation with phosphorus did not alter phosphorus concentrations in leaves of non-mycorrhizal seedlings but did in inoculated seedlings.

Research conducted by Violi (2005) demonstrated that mycorrhizal fungi colonise avocado roots and increase the uptake of phosphorus, zinc and iron.

Montoya and Osorio (2009) investigated the growth of avocado seedlings in the greenhouse for 150 days in response to the use of arbuscular mycorrhizal fungi *(Glomus fasciculatum)* at three different levels of soil solution phosphorus (0.002, 0.02 and 0.2 mg/L). The mycorrhizal inoculation significantly increased shoot dry weight at 0.002 and 0.02 mg/L soil phosphorus by 48% and 35% respectively but this decreased to 26% at 0.2 mg/L of phosphorus. The results suggested that avocado would benefit considerably from mycorrhizal inoculation when soil phosphorus levels are low.

4. SUMMARY AND SUGGESTIONS

Root rot and soil moisture management

Good phytophthora root rot control and soil moisture management are essential pre-requisites for having an effective plant nutrition programme and achieving high yields of good quality fruit.

- Ensure that *Phytophthora cinnamomi* root rot is under control because no roots = no nutrition or water uptake = no fruit.
- Soil moisture must be very well managed. Adequate water must be available at all times to allow nutrient uptake but not excessive to the point of asphyxiating avocado roots nor facilitating the spread of *Phytophthora cinnamomi* disease through movement of disease zoospores in free water.
- If fertigation is used check the uniformity of the irrigation system at least annually. Uneven watering through the orchard will mean uneven nutrition.
- View the 'Checking irrigation uniformity in avocado orchards' video on the Best Practice Resource.
- Remember that most of the tree's feeder roots are in the top 15cm of soil, so irrigate and fertilise the tree with this in mind.

Customisation of nutrition programmes

Nutrition is a complex subject and there is no 'one size fits all'. For example avocado trees behave differently when grown in a Mediterranean climate (e.g. Tristate and SW Western Australia) compared with a subtropical climate. In the cooler environments it behaves more like a deciduous tree in that it builds up stored carbohydrate levels through summer and autumn which it draws upon for flowering and fruitset, however in a subtropical climate stored carbohydrate levels are never high and the tree is dependent on current photosynthesis to supply the energy for flowering and fruitset, i.e. a more 'hand to mouth' existence. The other obvious difference between these two climates is that average temperatures in a subtropical environment are higher and warmer for longer periods which will produce excessive vegetative growth in response to a high nitrogen regime. This is possibly at the expense of fruit yield and quality. The Mediterranean climate is cooler and high levels of nitrogen fertiliser will not produce the same degree of unwanted vegetative growth. Thus, a programme that works best for a particular environment and/or variety may not be the best approach for another and nutrition practices (especially for nitrogen) need to be customised for each situation.

- Nutrition programmes need to be based on science and tailored to suit each orchard environment.
- Regularly monitor nutrient levels in the leaf and soil, the health of the canopy and feeder roots, and soil moisture.
- Adjust the nutrition programme to take into account management practices such as pruning and late harvest.
- The optimum ratio of cations (calcium, magnesium, potassium and sodium) in the soil is well known and remains relevant.
- Be aware of the different stages of the growth cycle as they occur.
- Be prepared to modify the nutrition programme during the year because each season is different.
- Fertilisers can change soil pH so monitor the soil pH in the wetted zone where the fertigation is applied or where fertiliser is broadcast and correct if necessary.

Nutrient monitoring

As well as following the recommended guidelines to sample leaves for nutrient analysis, namely fully expanded summer flush leaves in autumn from branchlets without fruit, it has become widely accepted that a useful mid-season gauge of tree nutritional status can also be gained from sampling the fully expanded spring flush leaves in summer provided these leaves are taken from shoots without fruit. It is essential that the correct leaves are sampled since sampling mistakes will compromise results.

In some exciting new work in California using advanced statistical methods to analyse leaf analysis and yield data has refined the optimum leaf level ranges and established a clearer picture of desired ratios between some nutrients.

At least four other ways of measuring the nutrient status of the tree have been proposed. The first is to monitor the nutrient content of the fruit as they develop in order to supply particular nutrients at appropriate rates as they are needed. The second is to establish the N:Ca ratio of the skin of unripe fruit as an indicator of fruit quality. Recent research on the nutrient status of flower buds at the cauliflower stage has revealed that it is a very good predictor of yield, furthermore sample selection is straightforward and results are received early enough to correct imbalances that would otherwise impact on yield. Finally, remote sensing using hyperspectral analysis may have a future for determining plant nutrient status as it is quicker, potentially cheaper and non-destructive. More work is needed on all of these approaches to develop them into useful and practical tools.

Sap testing is practiced on a limited scale and is useful for monitoring some nutrients but not all, and it requires a specialist to interpret the data.

- It is still essential to base nutrition programmes on the results of recent leaf and soil analysis and to take into account crop load and tree health. Note however that nutrient analysis results will be meaningless and misleading if trees are suffering from anything worse than mild levels of Phytophthora root rot.
- Leaf analysis should be done at least annually in autumn whilst soil analysis is generally necessary every two to four years.
- It is now acceptable to also test the nutrient status of spring flush leaves once hardened in summer provided they are taken from non-bearing branchlets.
- Continue to use the current Australian optimum level guidelines but you may also want to compare your levels against the refined guidelines recently established for California.
- Be aware that there are different optimum soil boron levels for each of five different soil textures.

Nitrogen rates

Nitrogen has been described as the 'dynamite' of plant growth and, assuming other nutrient levels are in balance and available in adequate amounts, the management of nitrogen applications offers the greatest potential for manipulating productivity. However, like dynamite, it must be handled with care as it can have both negative and positive effects on yield and fruit quality. Rates and timing are the critical aspects. Too much nitrogen and/or poor timing of applications can result in large unproductive vegetative trees and poor quality fruit but insufficient nitrogen can result in depressed yields and alternate or irregular bearing. Achieving the right balance with nitrogen is one of the big challenges for avocado growers.

Nitrogen fertiliser rates vary across the world according to the growing environment. The following are some examples for mature orchards; amounts are in kg of N/ha/year:

- 2001 Australian guidelines when leaf N levels are optimum   110 N
- Australia (wide range of growing environments and soils)   70 – 500 N
- Brazil (rain fed)   60 – 120 N
- California (Mediterranean climate)   100 – 140 N
- Chile (Mediterranean climate, generally heavy soils)   115 - 250 N
- Israel (Mediterranean climate)   300 N
- New Zealand (cool climate, for large, high yielding trees)   280 N
- Peru (infertile sands and desert environment)   180 – 380 N
- South Africa (for a 20 t/ha crop on a high clay soil)   90 – 110 N

Estimates of nutrients removed from the field by one tonne of 'Hass' avocados average about 2.8 kg N, 0.5 kg P and 4.7 kg K. However, trying to calculate application rates based on these figures with correction factors to allow for losses due to leaching, volatilisation, uptake efficiency etc can be difficult and factors will vary from season to season. Other methods are arguably just as difficult but whatever approach is used, knowledge of the orchard environment including the soil properties and most importantly, monitoring of the season, weather, tree health, crop load, and plant and soil nutrient levels are essential in order to adjust the nutrition programme accordingly.

Nutrient levels in the leaf reflect the results of your fertiliser rates, products, timing and the impact the season has had and should be used to learn about their impact and how the programme can be fine-tuned for the next season.

Growers should also be aware of the negative effects on the environment that nutrients leaching into groundwater and streams can have. Steps to minimise nutrient leaching include not applying nutrients excess to requirements, splitting applications into several smaller doses (especially on light soils where there is more potential for leaching) and increasing organic matter content of soils.

There has been some useful recent research relating to avocado nitrogen requirements in Mediterranean climates (mainly from California) but very little for subtropical climates.

It is now generally accepted that vegetative and reproductive growth in avocado are in direct competition with each other and growers need to ensure that sufficient nitrogen is available to satisfy the needs of both. To achieve this, rates and timing of nitrogen applications need to be carefully considered. Growers also need to be thinking beyond the immediate needs of the tree and including sufficient and well timed nitrogen applications to produce the summer flush which is going to produce the canopy needed to bear the flowers and generate the carbohydrate needed to fuel the development of the subsequent crop. This must be achieved without upsetting the vegetative/reproductive balance which, if overdone, could result in too much vegetative growth, excessive fruit shedding and poor quality fruit (high fruit nitrogen is accompanied by low fruit calcium). On the other hand, if nitrogen is underdone it will starve the tree and encourage alternate bearing. This is not an easy balance to achieve.

It is now also clear that the annual nitrogen dose should be split into several applications throughout the year, including winter (at low rates) if the autumn leaf analysis indicates that it is needed. Importantly the grower needs to monitor the trees and conditions throughout the year and adjust rates in response to factors including leaf analysis, tree appearance, crop load and weather.

A common emerging practice is to ensure that there is adequate nitrogen available in the tree at flowering so that fruitset, early fruit growth and spring leaf flush are not competing for this nutrient. Some agronomists recommend relatively high applications at or shortly before flowering whilst others are more cautious and, provided nitrogen levels are not deficient, hold off until after the first fruitlet thinning event is over. The higher dose at flowering in California was found to reduce the severity of alternate bearing.

It is also becoming common practice to increase nitrogen rates in response to heavy fruitset and to do this as soon as the first fruit shedding event is over.

- Use a starting rate of between 100 and 200 kg N/ha/year for a mature healthy crop, the lower end for tropical and subtropical regions and the higher end for cool regions where two crops are typically on the tree for some of the year. Adjust it up or down according to leaf nitrogen level, canopy health and crop load. Also take into account other sources of nitrogen that are applied such as mulch and compost, the amount of leaching rain received and the organic matter content of the soil. Refine this rate each year as you get a better understanding of the orchard.
- To manage nitrogen more effectively conduct two leaf analyses per year. Take one sample in autumn of the hardened summer leaf flush (non-bearing branchlets) and the other in summer of hardened spring leaf flush (also from non-bearing branchlets). Ensure that the correct leaf is sampled and continue to use the long established optimum range for leaf nitrogen, namely 2.2 to 2.6%, until new guidelines are established. Fine tune nutrient rates according to leaf test results.
- Observations of the leaf colour, gloss and size are also important indicators of the nitrogen status (and tree health).
- Ensure that there is sufficient nitrogen available by flowering time to supply the needs of both the new crop and the spring leaf flush about to develop.
- Ensure that there is sufficient nitrogen available in summer to not only supply the immediate needs of the tree but also to set it up for the next season. A good application in summer can also reduce the magnitude of alternate bearing.
- If a heavy crop is set then after the first natural shedding of fruitlets start to apply extra nitrogen fertiliser. If leaf levels were deficient in autumn and fruit set is massive then apply up to 50% extra nitrogen above the annual rate, proportionately less if leaf levels were within the optimum range or if fruit set is large but not massive. This extra nitrogen should be applied in several split applications (weekly to monthly) over the ensuing 2 or 3 months. The intention is to promote the growth of about 45cm of spring leaf flush over the developing fruit.
- If plant growth regulants are used at flowering then extra nitrogen needs to be applied, usually about 10%.
- Split the annual nitrogen dose into several applications through the season (see nitrogen timing below).

Nitrogen timing

The timing of nitrogen applications has been the subject of many studies, especially in California and Israel which both have a Mediterranean climate and some common threads are appearing out of the research which provide some useful guidelines for this growing environment.

Suggested guidelines for the timing of nitrogen for a Mediterranean climate

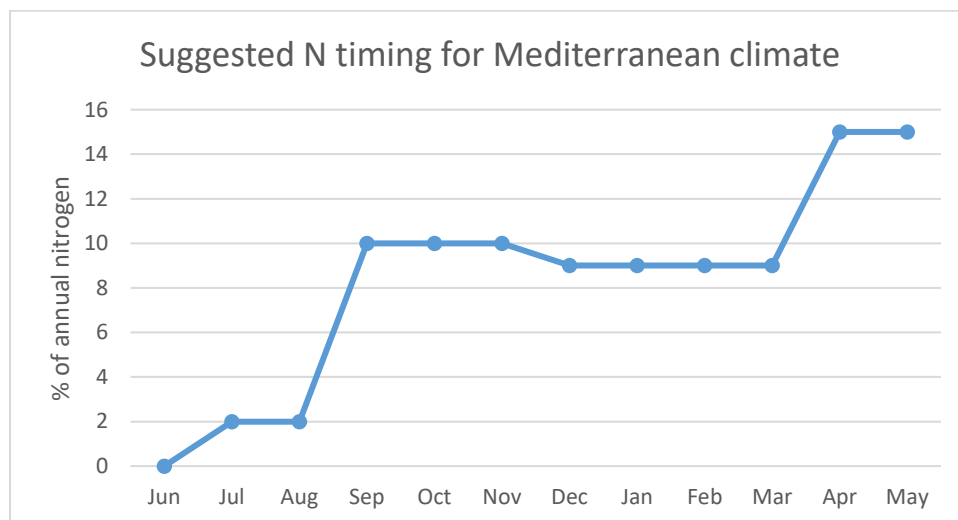The following guidelines are based on a 'best fit' from the recent research discussed in this report.

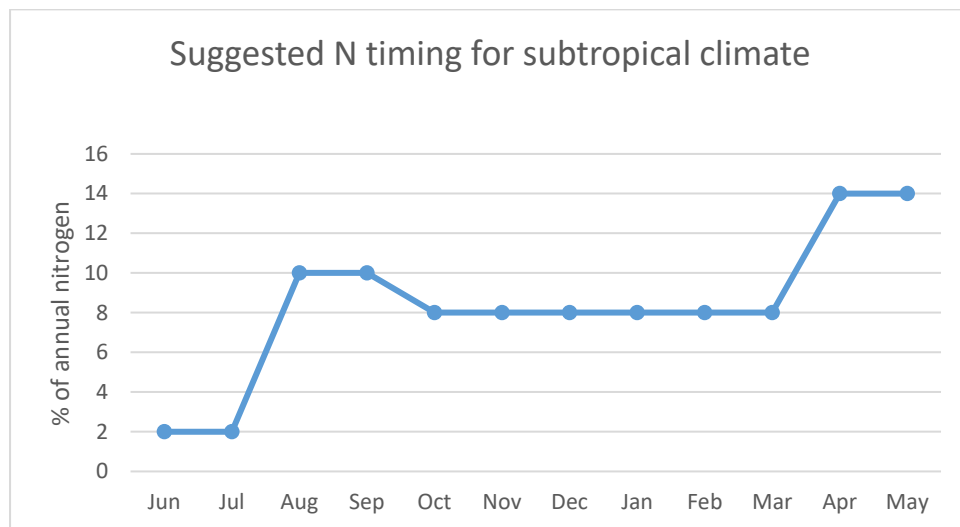*Figure 1. Suggested nitrogen application timing for a Mediterranean climate in Australia*

Table 11. Nitrogen timing suggestions for a Mediterranean climate

Growth cycle stage	Flower bud swell	Cauli-flower stage of flower bud	Flowering, fruitset & initiation of spring leaf flush	Shedding of small fruitlets, initiation of exponential fruit growth and summer leaf flush.		Exponential fruit growth, initiation of next season's flowers	Floral buds are committed to floral development, end of leaf growth
The need	Maintain-ing tree growth, albeit at a low rate.		To ensure sufficient N to meet the needs of flowering, fruitset and the new spring leaf flush. Reduce severity of alternate bearing.	Meeting the needs of developing and maturing fruit, summer leaf flush and mitigating fruitlet shedding.		Meeting the needs of developing fruit and leaf flush.	Setting the tree up for the next flowering and fruitset
Monitor			Gauge the intensity of fruit set.	Analyse spring leaf flush once fully expanded and adjust N rate if needed.			Analyse summer leaf flush once fully expanded, adjust N rates accordingly.
Month in Tristate/ SW WA	Jul	Aug	Sep	Oct (flower -ing)	Nov (fruitset)	Dec <u>After</u> 1st fruitlet shedding.	Jan	Feb	Mar	Apr	May
Suggest-ed propor-tion	2%	2%	10%	10%	10%	9% **+**	9% **+**	9% **+**	9%	15%	15%

+ . . . . apply extra nitrogen if big crop set

Suggested guidelines for the timing of nitrogen for a subtropical climate

As already mentioned there is an absence of recent nutrition research for avocados in subtropical environments. The following is based on recent trends and current thinking.

Figure 2. Suggested nitrogen application timing for a subtropical climate in Australia

Table 12. Nitrogen timing suggestions for a subtropical climate

The suggested proportions and timing for a subtropical climate are as follows:

Growth cycle stage	Flower bud swell			Flowering, fruitset & start of spring leaf flush		Spring leaf flush. Initiation of exponential fruit growth. After shedding of small fruitlets.		Fruit growth. Summer leaf flush. Initiation of next season's flowers.			Floral buds are committed to floral development, end of leaf growth	
The need	Maintaining tree growth, albeit at a low rate.			Sufficient N to meet the needs of flowering, fruitset and the new spring leaf flush and reduce alternate bearing.		Meeting the needs of developing fruit and spring leaf flush.		Meeting the needs of developing fruit and summer leaf flush.			Setting the tree up for the next flowering and fruitset.	
Monitor				Gauge the intensity of fruit set.		Analyse spring leaf flush once fully expanded and adjust N rate if needed.					Analyse summer leaf flush once fully expanded and adjust N rates accordingly.	
Month in Central & SE Queensland	Jun	Jul	Aug	Sep flower	Oct fruitset	Nov after first fruitlet shedding	Dec	Jan	Feb	Mar	Apr	May
Suggested proportion	2%	2%	10%	10%	8%	8% **+**	8% **+**	8% **+**	8%	8%	14%	14%

+ . . . . apply extra nitrogen if big crop set

Nitrogen timing for other varieties and regions

Use the most appropriate of the two guidelines outlined above but ensure that nutrient application timings match with events in the growth cycle of your trees (rather than months of the year). Until more specific research is conducted, growers in tropical and subtropical growing regions growers need to be more conservative with nitrogen rates especially around the time of flowering and the first fruit shedding event.

Timing of other nutrients

The 'little and often' approach for all nutrients is supported by research and has gained traction in different parts of the avocado growing world but there are times in the growth cycle that are particularly important for particular nutrients. A study of nutrient accumulation in developing fruit suggests that the latter stages of fruit growth require more potassium than the early stages so applications need to take this into account. Potential competition between calcium and potassium at the root absorption sites on the feeder roots also indicate that potassium applications should be withheld until mid-summer when calcium applications are over. According to nutrient accumulation patterns in developing fruit phosphorus, magnesium, sulphur, iron and zinc should be applied at least during the spring growing season after full bloom.

- Ensure there is a readily available supply of soluble calcium in the soil for the first six to eight weeks after fruitset and make especially sure that soil moisture during this time is optimum to enable uptake.
- Do not applying calcium and potassium fertiliser at the same time.
- If potassium is required apply most of it during the second half of fruit growth
- Where needed phosphorus, magnesium, sulphur, iron and zinc should be applied at least during the spring growing season after full bloom.

Calcium

Gypsum is the most effective product to increase soil calcium but it has the potential to displace potassium and magnesium from exchange sites in the soil

- If applying gypsum on a regular basis, monitor soil magnesium and potassium levels and correct with applications if necessary.

Potassium

It is highly likely that some growers are applying too much potassium and this may be having a negative effect on calcium and magnesium nutrition as well as yield and quality.

- If soil and leaf potassium levels are within the optimum range then it may not be necessary to apply any (very sandy soils may be an exception) but continue to monitor levels and if there is a major leaching event conduct a soil test to check whether there is still adequate potassium available in the soil.
- Never use potassium chloride (muriate of potash) or any other chloride based fertiliser.
- Be aware that most compound fertilisers contain potassium so avoid them if soil and leaf levels are adequate.

Phosphorus

In certain soils such as clays and red krasnozems phosphorus is tied up in the soil and it is recommended that phosphorus fertiliser is applied in a concentrated band along the drip line and applied on a relatively regular basis to compensate for the phosphorus that is tied up. However on other soil types it is possible that too much phosphorus is being applied. Crowley *et al* (2015) found

in California that as leaf phosphorus increases above 0.2% there are no high yielding trees, illustrating the potential for over-fertilisation or nutrient imbalance that can cause yield loss. Deficient levels of leaf phosphorus are very rare. If soil and leaf levels are adequate it may not be necessary to apply this element since excessive levels can create imbalances and tie up trace elements such as iron and zinc.

- If soil and leaf phosphorus levels are within the optimum range don't apply it (an exception may be soils such as clays where phosphorus can be tied up and be relatively unavailable) but continue to monitor levels regularly.
- Be aware that most compound fertilisers contain phosphorus so avoid them if soil and leaf levels are adequate.
- Where phosphorus fixation in the soil is a problem apply it in a narrow band along the drip line.
- In areas (such as on Mallee soils in the Tristate) where it can be a challenge to get sufficient phosphorus into the tree, experiment with foliar applied potassium phosphite at the cauliflower bud stage of flowering.

Boron

This nutrient needs to be managed very carefully. It is extremely important for avocado and is required in relatively large amounts (for a trace element) and for this reason soil application is the main method of satisfying requirements. However the optimum range between deficiency and toxicity is a narrow one. Applying too much (especially in light soils) will cause toxicity with serious consequences to fruit and foliage whilst deficiency will impact significantly on fruitset, yield and quality. It is very easy to reach toxicity on light soils, clays are more forgiving.

Several studies have been conducted around the world on the use of foliar sprays of boron at flowering. The need, timing and specifications of these sprays are now much clearer. It is important to note that it is not always appropriate to apply a foliar spray of boron.

Research in Mexico showed that in boron deficient orchards a spray at early fruitset followed by another a month later may increase yield and fruit size.

- It is very important to note that there is a different optimum soil boron range for each of five different soil textures. What might be adequate for a light soil is likely to be deficient for a clay soil for example. This is often the cause of error by nutrition laboratories when they judge whether a particular soil level is excessive, adequate or deficient.
- Split the annual boron dose into as many small applications as possible throughout the year whenever growth is occurring (this includes root growth).
- Boron is easily leached from the soil so rates should be adjusted to compensate for losses after major rain events.
- If the autumn boron leaf level was deficient (below 30ppm) apply one application of Solubor® at 1 g/L at the cauliflower stage of flower bud development. Do not add other nutrients to the spray and do not apply more than one application. It has been found that addition of urea to foliar boron sprays can cause deformation of the flower.
- Do not apply a foliar boron spray if the leaf level is adequate as there is evidence that elevating the boron level higher can be counterproductive.
- If a foliar boron spray at the cauliflower stage was recommended but missed there may be some benefit in applying two later ones, one at fruitset and another a month later.

- View the 'Getting boron right' video on the Best Practice Resource, use the associated 'Boron application rate worksheet' and seek expert advice.

Silicon

Research with silicon over the past 10 years or so has delivered inconsistent results but recent experiments are suggesting that what might be important is to have a constant supply of soluble silicon available in the soil. This could be supplied by a slow release product. Potential benefits are improved tree health and better quality fruit.

- Experiment with slow release forms of soluble silicon so that it is available throughout the year and compare fruit quality and tree health with an untreated section of orchard.

Molybdenum

Growth responses have been recorded in avocado from the addition of molybdenum but negative responses have also resulted from levels that were too high. A deficiency is more likely to occur in highly leached, very acid soils that are low in organic matter and/or have high levels of manganese and/or sulphate. This combination of soil properties exists in some of the avocado growing regions on the east coast of Australia (e.g. volcanic krasnozem soils with inherently high manganese levels). This essential trace element is required in particularly small amounts and it would be easy to correct with foliar (it is very phloem-mobile) or soil applications. Care should be taken to apply only a small amount to avoid potential toxicity.

- Where soils are very acid, highly leached, and low in organic matter but have high levels of manganese and sulphates, experiment with a low dose of sodium molybdate as a ground or foliar spray and compare tree health and yield with an untreated section of orchard.
- Only apply a very low dose.

Foliar applied nutrients

Foliar boron and molybdenum sprays are covered above.

Application of nutrients by means of foliar sprays should <u>not</u> be regarded as standard practice in avocado because the waxy leaf does not lend itself to absorption. In addition, if a foliar applied nutrient is absorbed by the plant it also needs to be phloem-mobile in order to be transported to where it is needed, for example in a trial where boron was sponged onto one half of a leaf it did not raise the boron level in the other half.

However there are situations where nutrient is absorbed and reaches parts of the plant in sufficient quantity to make a difference. This can be useful when circumstances such as cold spring soil temperatures, unsuitable soil pH, nutrient tie-ups and saline soils prevent soil applied nutrients being available to the plant at critical times.

Where soil phosphorus levels are very low and it is difficult to raise plant P levels, e.g. on the Mallee soils of the Tristate, foliar sprays of potassium phosphite at the cauliflower stage of flowering or during fruit development may be worth trying as they have resulted in yield and fruit size benefits in California and Mexico.

Mixed success has been reported from zinc foliar sprays (e.g. with zinc chelate) compared with the consistent results achieved by soil applications of zinc sulphate provided adequate rates are used.

- When circumstances such as cold spring soil temperatures, unsuitable soil pH, nutrient tie-ups and saline soils prevent soil applied nutrients being available to the plant at critical times

foliar sprays of phosphorus, zinc and iron sprays can experimented with using products such as potassium phosphite, zinc chelate EDTA and iron chelate.

- Apply when leaf flush is about 2/3 expanded, not older.
- Experiment with potassium phosphite sprays where it is difficult to raise plant phosphorus levels. Always leave an untreated section for comparison.

Rootstock

Research has shown that rootstocks can have a significant effect on yield and fruit quality. 'Hass' grafted onto certain Guatemalan and West Indian race rootstocks (e.g. 'A10' and 'Velvick') produce fruit that is higher in calcium and this is associated with lower levels of flesh rots, this is in contrast to 'Hass' grafted onto Mexican race rootstocks which produces fruit with lower calcium levels and a higher incidence of flesh rots such as anthracnose and stem end rot.

- Make every effort to use well proven rootstocks that are predominantly Guatemalan and/or West Indian race such as 'Velvick', 'Dusa®', 'A10', 'Plowman' and 'Kidd'. If possible avoid Mexican race rootstocks such as 'Zutano', 'Mexicola' and 'Duke 7' which are more susceptible to both *Phytophthora cinnamomi* root rot and body rots, the latter linked to low fruit calcium levels in trees.

Mycorrhizae

There may be merit in introducing appropriate species of mycorrhizae to the potting mix or orchard planting site to improve avocado root uptake of elements including phosphorus, iron, copper and zinc although research has shown that if the phosphorus content of the growing medium is increased the mycorrhizal activity diminishes. It is worthy of further research as mycorrhizae could have other benefits including better moisture uptake.

- Experiment with mycorrhizae species that are known to be beneficial to avocado and compare tree health and yield with an untreated section of orchard.

Raising soil organic matter levels

Good mulching and composting practices can result in huge improvements to tree health and nutritional status however it is important to know what the material contains. For compost and other organic amendments ask for an analysis or have a sample analysed yourself before buying and using. Feedlot and chicken manure can contain high levels of chloride, some municipal waste products can contain heavy metals and chicken manure has high levels of phosphorus which could be counterproductive in your situation. Mulch material can add significant amounts of potassium to the soil based on the large volumes applied.

An increasing number of Australian growers are starting to recognise the benefits of higher organic matter levels in the soil. Not only do they increase the amount of nutrients that the soil can hold but they also reduce nutrient leaching, make nutrients more available to the tree and improve the moisture holding capacity and soil health in general. The simplest and surest way to achieve this is to add mulch and/or compost on a regular basis. The rate at which soil organic matter will rise is slow, taking several years for significant improvements to be achieved but the benefits are evident in the health of the trees and their productivity.

The regular use of good quality compost has a greater positive effect on soil health than mulch and its effect can be transformational for the orchard, relieving soil compaction and raising levels of organic activity in the soil with associated benefits including greater suppression of soil pathogens including *Phytophthora cinnamomi*.

- Wherever possible mulch trees regularly, and/or regularly apply <u>good</u> quality compost under trees.
- Check the analysis of any compost or manure for any problems before using it.
- Include the nutrient content of mulch and compost in the annual nutrition budget but also allow for the fact that these nutrients may only be released slowly.

5. SUGGESTED TOPICS FOR NUTRITION RESEARCH

1. Development of additional or better nutrition monitoring tools:
   - Investigate whether the new optimum leaf nutrient ranges and ratios established in California are applicable to Australia.
   - Back research to develop the analysis and interpretation of nutrient levels using the cauliflower stage of flower buds as a monitoring tool for nutrition.
   - Consider the monitoring of nutrient levels in developing fruit as a possible monitoring tool.
   - Investigate the potential of hyperspectral analysis of the orchard canopy as a practical and effective way to monitor avocado nutrient status.
2. Investigate the specific nutritional needs of 'Shepard' and 'Hass' growing in the tropical and subtropical regions of Australia (including timing and rates of nitrogen in particular) and whether it is necessary to set a different range of optimum leaf nutrient levels for 'Shepard'.
3. Conduct any future nutrition trials on clonal plantings to avoid the variation inherent in seedling rootstocks.
4. Investigate nitrogen, calcium, magnesium and potassium together in order to:
   - Establish upper limits to nitrogen applications before fruit quality is impacted through the suppression of calcium levels in fruit.
   - Establish whether optimum levels of calcium in the soil are adequate to supply the calcium needs of fruit during their early development or whether it is necessary during this period to apply additional and/or different forms of calcium such as more soluble products.
   - Learn more about the role and crop needs of magnesium in avocado.
   - Establish whether we are over applying potassium and the effect of excessive potassium applications on yield and fruit calcium (and magnesium) levels and thus quality.
   - Establish whether we are over applying phosphorus and the effect of excessive phosphorus applications on yield.
5. Further research the benefits and practicalities of using mycorrhizae in avocado production.

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DISCLAIMER

BIBLIOGRAPHY

1. Atucha, A., Merwin, I.A., Brown, M.G., Gardiazabal, F., Mena, F., Adriazola, C. and Lehmann, J. (2013). Soil erosion, runoff and nutrient losses in an avocado (Persea americana Mill) hillside orchard under different groundcover management systems. Plant and Soil 368: 393-406.

2. Arpaia, M.L., Meyer, J.L., Witney, G.W.; Bender, G.S., Stottlemyer, D.S., and Robinson, P.R. (1996). The Cashin Creek nitrogen fertilization trial – what did we learn? California Avocado Soc. Yrbk. 80: 85-98.

3. Bekker, T. F., Labuschagne, N., Aveling, T. and Kaiser, C. (2007). Efficacy of water soluble potassium silicate against Phytophthora root rot of avocado under field conditions. South African Avocado Grower Association yearbook. 2007, 30, 39 – 48.

4. Brusca, J. N. and Haas, A. R. C. (1955). Effect of molybdenum on avocado trees. California Avocado Society 1955 Yearbook 39: 175 – 178.

5. Campisi-Pinto, S., Zheng, Y., Rolshausen, P., Crowley, D., Faber, B., Bender, G., Bianchi, M., Khuong, T. and Lovatt, C. (2017). Optimal nutrient concentration ranges of 'Hass' avocado cauliflower stage inflorescences – potential diagnostic tool to optimise tree nutrient status and increase yield. HortScience 52 (12): 1707- 1715.

6. Crowley, D., Campisi, S., Escalera, J. and Lovatt, C. (2015). Decision support tools for avocado fertilization and salinity management: preview to the final report. From the Grove - Fall 2015: 25-28.

7. Crowley, D., Campisi, S., Lovatt, C., Rolshausen, P., Arpaia, M., Dinar, A. and Escalera, J. (2016).Decision support tools for management of avocado nutrition and chloride toxicity, final report. http://www.californiaavocadogrowers.com/research-library/decision-support-tools-management-avocado-nutrition-and-chloride-toxicity-final

8. Cossio-Vergas, L. E., Salzar-García, S. and Gonzáles-Durán, I. J. L. (2009). Respuesta del aguacate 'Hass' a la fertilización con boro en huertos sin riego. III Congreso Latinoamerica del Aguacate. Medellín, Colombia. 11 – 13 Nov. Memorias, 4 – 17.

9. Dann, E. K., Coates, L. M., Pegg, K. G., Dean, J. R., Cooke, A. W., Smith, L. A., Shuey, L., Whiley, A. W., Hofman, P. J., Marques, R. and Stubbings, B. (2016). Rootstock selection, nitrogen and calcium influence postharvest disease in avocado. Acta Horticulturae 1120: 391-397.

10. Dann, E. K. and Le, D. P. (2017). Effects of silicon amendment on soilborne and fruit diseases of avocado. Plants 2017, 6, 51; doi: 10.3390/plants6040051. www.mdpi.com/journal/plants

11. Dirou, J. and Huett, D. (2001). Crop nutrient replacement for avocado. Talking Avocados. 12 (1): 25 – 27.

12. Dixon, J., Smith, D.B., Elmsly, T.A. and Fields, F. P. (2005). The impact of foliar applications of nitrogen and boron on 'Hass' avocado fruitset in 2004. New Zealand Avocado Growers' Association Annual Research Report 5: 27-34.

13. Dixon, J., Smith, D.B., Elmsly, T.A., Greenwood, A.C. and Dixon, E.M. (2006). The impact of foliar applications of nitrogen and boron on 'Hass' avocado fruit set. New Zealand Avocado Growers' Association Annual Research Report 6: 35-46.

14. Embleton, T.W. and Jones, W.W. (1964). Avocado nutrition in California. Proceedings of the Florida State Horticultural Society 77: 401 – 405.

15. Embleton, T.W. and Jones, W.W. (1972). Development of nitrogen fertiliser programs for California avocados. California Avocado Soc. Yrbk. 56: 90-96.

16. Embleton, T.W., Jones, W.W., Garber, M.J., and Boswell, S.B. (1968). Nitrogen fertilization of the Hass avocado. California Avocado Soc. Yrbk. 52: 131-134.

17. Hall, H. (2015). Australian avocado benchmarking program development. Horticulture Innovation Australia final report for project AV11026.

18. Jaganath, I. (1993). Effect of boron and/or nitrogen on pollen tube growth, ovule viability and yield in 'Hass' avocado. Univ. Calif., Riverside, MS Thesis.

19. Jaganath, I. and Lovatt, C. (1998). Efficacy studies on prebloom canopy applications of boron and/or urea to 'Hass' avocado. Acta Hort. 1: 181 – 184.

20. Lahav, E., Whiley, A. W. and Turner, D. W. (2013). Irrigation and mineral nutrition. In: Schaffer, B., Wolstenholme, B. N. and Whiley, A.W. (eds) *The Avocado: Botany, Production and Uses, 2nd Edition.* CAB International, Wallingford, UK, pp. 301 -341.

21. Kiggundu, N., Migliaccio, K. W., Schaffer, B., Li, Y. and Crane, J. (2012). Water savings, nutrient leaching, and fruit yield in a young avocado orchard as affected by irrigation and nutrient management. Irrigation Science 30 (4): 275-286.

22. Lovatt, C. J. (1999). Timing citrus and avocado foliar nutrient applications to increase fruit set and size. HortTechnology. 9 (4): 607 – 612.

23. Lovatt, C. J. (2001). Properly timed soil-applied nitrogen fertilizer increases yield and fruit size of 'Hass' avocado. J. Amer. Soc. Hort. Sci. 125: 555 – 559.

24. Lovatt, C. J. and Witney, G. (2001). Nitrogen fertilization of the 'Hass' avocado in California. AvoResearch 1 (3); 1 – 4.

25. Lovatt, C. J. (2013a). Hass avocado nutrition research in California. California Avocado Society Yearbook 96, 74 – 105.

26. Lovatt, C. J. (2013b). Properly timing foliar-applied fertilisers increases efficiency: a review and update on timing foliar nutrient applications to citrus and avocado. HortTechnology, Oct 2013 23 (5): 536 – 541.

27. Menge, J.A., LaRue, J., Labanauskas, C. K. and Johnson, E. L. V. (1980). The effect of two mycorrhizal fungi upon growth and nutrition of avocado seedlings grown with six fertilizer treatments. J. Amer. Soc. Hort. Sci. 105 (3): 400-404.

28. Montoya, B. and Osorio, W. (2009). Mycorrhizal dependency of avocado at different levels of soil solution phosphorus. Suelos Ecuatoriales. 39 (2); 143 – 147.

29. Newett, S. (2000). Little evidence to support the use of foliar applied nutrients in avocado. Talking Avocados. 11 (2): 24 – 27.

30. Newett, S. (2015a). Report on visit to avocado orchards in Chile, September 2015 (34 pp). Maroochy Research Station: Queensland Department of Agriculture and Fisheries.

31. Newett, S. (2015b). Report on avocado orchard visits in Peru, September 2015 (53 pp). Maroochy Research Station: Queensland Department of Agriculture and Fisheries.

32. Newett, S. (2017). Results from Australian avocado plant nutrition survey. Unpublished.

33. Nevin, J. M., Lovatt, C. J., and Embleton, T. W. (1990). Problems with urea-N foliar fertilization of avocado. Acta Hort. 2: 535 – 541.

34. Osbourne, S. L., Schepers, J. S., Francis, D. D. and Schlemmer, M. R. (2002). Detection of phosphorus and nitrogen deficiencies in corn using spectral radiance. Agronomy Journal. 94 (6): 1215 – 1221.

35. Robbertse, P. J., Coetzer, L.A. and Bessinger, F. (1992). Boron: Uptake by avocado leaves and influence on fruit production. Proc. Of Second World Avocado Congress. Vol. I: 173 – 178.

36. Rosecrance, R., Faber, B. and Lovatt, C. (2012). Patterns of nutrient accumulation in 'Hass' avocado fruit. Better Crops with Plant Food 96(1): 12-13

37. Salazar-García, S., Cossio-Vargas, L. E. and Gonzáles-Durán, I. J. L. (2008). Chronic zinc deficiency correction in 'Hass' avocado. Revista Chapingo, Serie Horticulture 14 (2): 153 – 159.

38. Salazar-García, S., Cossio-Vargas, L. E. and González-Durán, I. J. L. (2009). Site specific fertilization increased productivity of 'Hass' avocado in rainfed orchards. Agricultura Técnica en México 35(4): 439-448

39. Salazar-García, S., González-Durán, I. J. L. and Ibarra-Estrada, M. E. (2015). Identification of the appropriate leaf-sampling period for nutrient analysis in 'Hass' avocado. HortScience 50(1): 130-136

40. Salvo, J.E. and Lovatt, C.J. (2016). Nitrogen fertilization strategies for the 'Hass' avocado that increase total yield without reducing fruit size. Hort Technology August 2016 26 (4).

41. Silber, A., Noy, M., Naor, A., Levi, M., Keinan, A., Chudi, G., Assouline, S. (2015). Actually close the avocado stomata during a daytime? VIII Congreso Mundial de la Palta 2015 Proceedings.

42. Silber, A. (2017). Breaking the glass ceiling of 'Hass' avocado yields: providing the periodic demand for water and nutrients. Unpublished MS PowerPoint presentation, Australia.

43. Smith, L. A., Dann, E. K., Leonardi, J., Dean, J. R., and Cooke, A. W. 2011. Exploring non-traditional products for management of postharvest anthracnose and stem end rot in avocado. Proceedings of VII World Avocado Congress 2011 (Actas VII Congreso Mundial del Aguacate 2011), Cairns, Australia, 5 – 9 September 2011.

44. Smith, T.E., Stephenson, R.A., Asher, C.J. and Hetherington, S.E. (1997). Boron deficiency of avocado 1. Effects on pollen viability and fruit set. In Boron in Soils and Plants. R.W. Bell and B. Rerkasem (eds.). Kluwer Academic Publishers, Netherlands. pp. 131-133.

45. Snijder, B. and Stassen, P. J. C. (2000). Macro nutrient accumulation and requirement of 'Hass' avocado trees. South African Avocado Growers' Association Yearbook 2000. 23: 56-62.

46. Snijder, B. (2015). Fertilizer needs for Maluma - a case study. Proc VIII World Avocado Congress, Lima, Peru (392-395).

47. Span, T. (2016). Final report issued giving tools for fertilization and salinity management. From the Grove - Winter 2016: 26-29.

48. Stassen, P., Kangueehi, G. and Woolridge, J. (2010). Macro and micronutrient requirements of fruit trees. SA Fruit Journal 9(2): 44-45

49. Torres, M. D., Farré, J.M. and Hermoso, J.M. (2002). Foliar B, Cu and Zn applications to Hass avocado trees. Penetration, translocation and effects on tree growth and cropping. Acta Hort. 594. Proc. IS on foliar nutrition. Eds. M. Tagliavini *et al.*

50. Violi, H. (2005). Interactions among root colonizing fungi and Persea spp. (Lauraceae): Impact of carbon allocation to plant and fungi. Univ. Calif., Riverside, PhD Diss.

51. Whiley, A. W., Pegg, K. G., Saranah, J. B. and Forsberg, L. I. (1986). The control of Phytophthora root rot of avocado with fungicides and the effect of this disease on water relations, yield and ring neck. Aust. J. Exp. Agric. 26: 249 – 253.

52. Whiley, A. W., Smith, T. E., Saranah, J. B. and Wolstenholme, B. N. (1996). Boron nutrition of avocados. Talking Avocados, 7 (2): 12 – 15.

53. Wolstenholme, N. (2017). The avocado molybdenum story (unpublished).

54. Yates, M.V., Arpaia, M.L. and Faber, B. (1993). Minimizing fertilizer contamination of ground water by fertilizer and irrigation management of avocados. Proceedings California Avocado Res. Symp., Riverside , CA; 35 – 42.

55. Zilkah, S., Klein, I., Feigenbaum, S. and Weinbaum, S. A. (1987). Translocation of foliar-applied urea 15N to reproductive and vegetative sinks of avocado and its effect on initial fruit set. J. Amer. Soc. Hort. Sci. 112 (6): 1061 – 1065.