SENATE RURAL AND REGIONAL AFFAIRS AND TRANSPORT REFERENCES COMMITTEE

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Inquiry into industry structures and systems governing the imposition of and disbursement of marketing and research and development (R&D) levies in the agricultural sector

Friday, 20 February 2015
Perth

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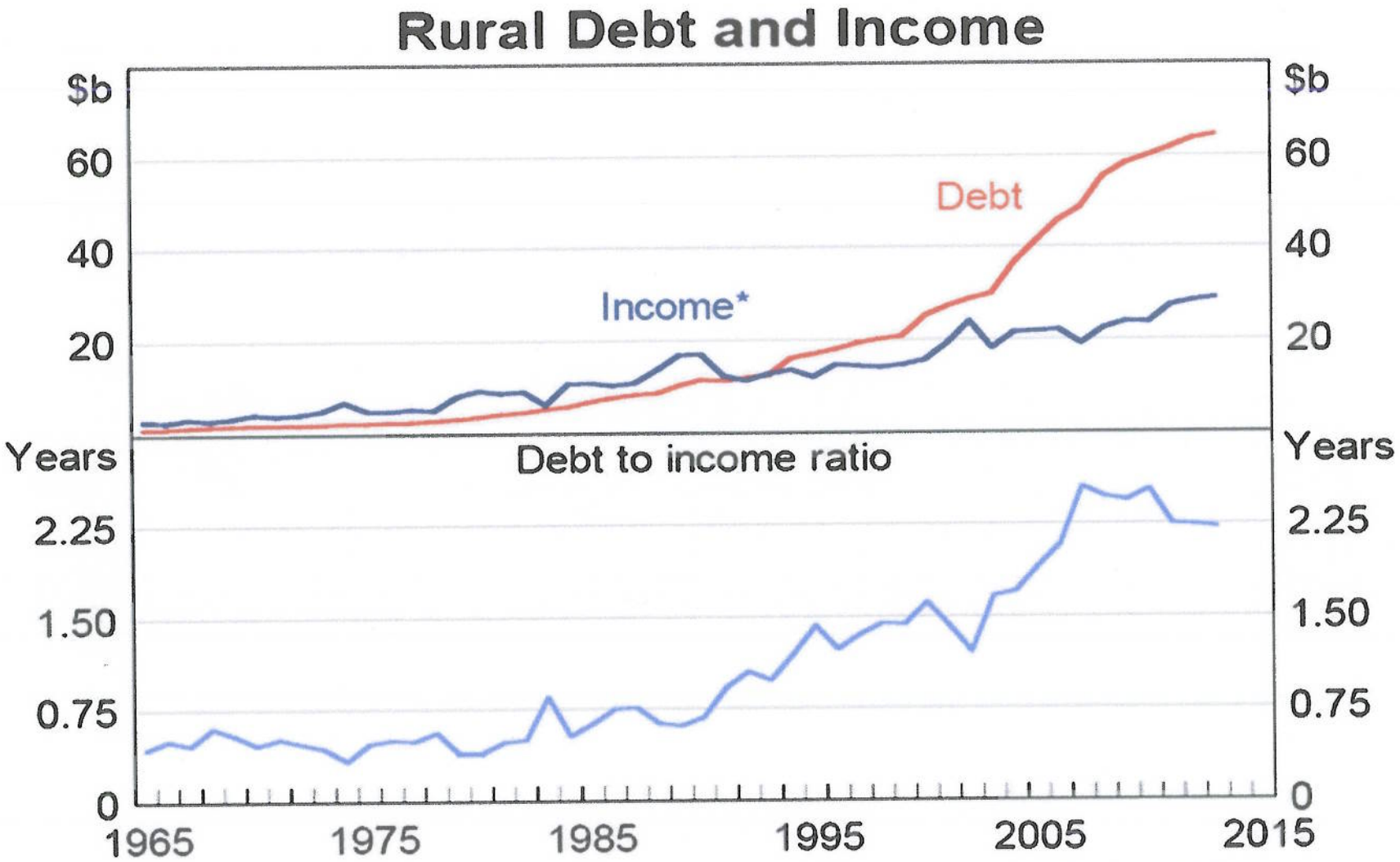

* Rural income is after deduction of taxes and subsidies on production and before deduction of depreciation, property income and COE

Sources: ABS; APRA; RBA Rural Debt Survey

Panel's rating of the different components of the current AB research proposal that was prepared by project manager Hugh King
AB panel meeting Thu 11 Oct 2012

Objective A Research integration and decision support system
Project A1 (Years 1 – 5) Integration of research outputs across ARC program
Project A2 (Year 1) Yield prediction model for California (UCR)
Rating = 1
Panel comments: In any project, extension is important but the DSS approach is questionable.

Objective B Determining environmental and biological triggers for alternate bearing
Project B1 (Years 1 – 2) Meta-analysis of alternate bearing (UCD) **Rating = 1**
Panel comments: ……..

Project B2 (Years 1 – 4) Phenological models for Mexico (INIFAP) **Rating = 1**
Panel comments: Not relevant to the Australian industry.

Objective C Regulating transition from vegetative to floral meristems in avocado
Project C1 (Years 1 – 5) Optimum timing of fruit removal for Australia and NZ (PFR) **Rating = 1**
Panel comments: Has already been done in Australia, although not translated yet to all regions

Project C2 (Years 1 – 2) Floral gene expression and hormonal status in California (UCR) **Rating = 1**
Panel comments: Not relevant to the Australian industry.

Project C3 (Years 1 – 5) Floral gene expression and hormonal status in Australia and NZ (PFR) **Rating = 3**
Panel comments: Almost 'blue-sky' research. Already done for the Bundaberg area??? (does this comment belong here or to C!?).This looks like the work Carol Lovatt was going to do to identify the hormonal changes associated with AB.

Project C4 (Years 1 – 5) Identity of phloem derived signals (PFR) (Note: This component funded through separate HAL/PFR proposal). **Rating = 2**
Panel comments: 'Blue-sky' research. $0.5m.

Project C5 (Years 1 – 5) Time of commitment to flowering in Australia and NZ (PFR) **Rating = 1**
Panel comments:

Project C6 (Years 1 – 5) Bud analysis for time of commitment to flowering (INIFAP) **Rating = 1**
Panel comments: Flower initiation is not considered to be an issue in Australia.

Objective D Improving flower quality, pollination, fertilization and fruit set in avocado

Project D1 (Years 1 – 5) Flower quality in Australia and NZ (PFR) **Rating = N/A**
(Note: This component funded through separate HAL/PFR proposal).
Panel comments: Boron work already done in Australia..

Project D2 (Years 1 – 5) Pollination requirements in Australia and NZ (PFR)
Rating = 1
Panel comments: Proposal includes no work on pollinisers.

Objective E Management strategies to mitigate alternate bearing in avocado

Project E1 (Years 1 – 5) Timing and severity of pruning in Australia and NZ (PFR)
Rating = 1
(Note: This component funded through separate HAL/PFR proposal).
Panel comments: Doesn't apply to Australia.

Project E2 (Years 1 – 4) Chemical thinning (PFR) **Rating = 1**
Panel comments:

Project E3 (Years 1 – 3) Development of propriety PGR product (UCR) **Rating = 1**
Panel comments: Australia already has uniconazole and propoconazole registered. This product not available in California.

Project E4 (Years 1 – 5) Field testing of PGR products in Australia and NZ (PFR)
Rating = 1
Panel comments: Chileans are already using uniconazole for this purpose.

Objective F Science program communication and planning
N/A

AV12028 (March 2013)

FINAL REPORT

SCOPING STUDY FOR AVOCADO ALTERNATE BEARING RESEARCH

Simon D. E. Newett

Agri-Science Queensland, Department of Agriculture, Fisheries and Forestry (DAFF), Queensland

AV12028

Simon D. E. Newett

Principal Extension Horticulturist

Agri-Science Queensland, a service of the Department of Agriculture, Fisheries and Forestry (DAFF), Queensland

Maroochy Research Facility, PO Box 5083 SCMC, NAMBOUR, QLD 4560

Telephone 07 54 535 926 Facsimile 07 54 535 901
Mobile 0400 56 57 84
Email simon.newett@daff.qld.gov.au

The purpose of this report is to describe the activities and outcomes associated with the project "Scoping study for avocado alternate bearing research" AV12028.

This project was funded by the Department of Agriculture, Fisheries and Forestry, Queensland (DAFF Queensland), Avocados Australia Ltd (AAL) and Horticulture Australia Ltd (HAL) using the avocado industry levy and matched funds from the Australian Government.

Queensland Government

Avocados Australia

HAL

Know-how for Horticulture™

March 2013

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SUMMARY

The Australian avocado industry initiated the concept of an international research project to investigate the problem of alternate bearing (AB) in avocados. The Avocado Research Council (ARC) was formed consisting of representatives from Australia, New Zealand, California and Mexico. The ARC received research proposals from several overseas research organisations for the proposed "International avocado alternate bearing program" AV12019. However before proceeding with this a scoping study, AV12028, was commissioned by the Australian industry to get a better idea of the existence and magnitude of AB in Australia.

Between July and October 2012, Mr Simon Newett (Principal Extension Horticulturist, DAFF Qld) visited all the major avocado production areas of Australia interviewing 54 growers, consultants, extension officers and packshed managers, and collecting information from 51 orchards about their environment, management and yield history.

The information was compiled and presented to an expert panel for consideration in October 2012.

It was the conclusion of the panel that Australia currently has only a minor problem with AB but does have a problem with irregular bearing (IB).

The Australian industry decided that the proposed AB research was not currently relevant for the Australian industry and recommended that IB be investigated instead.

INTRODUCTION

The Australian avocado industry initiated the idea for an international research project to investigate the problem of alternate bearing in avocados. A board of directors, namely the Avocado Research Consortium (ARC), was formed to direct this work and comprised representatives of the Australian, New Zealand, Mexican and Californian avocado industries. A project manager was appointed and an honorary three member Project Technical Director Group was also appointed comprising a representative from each of Australia, New Zealand and California. The ARC received three research proposals from different overseas research organisations for the proposed project "International avocado alternate bearing programme" AV12019 and these were assessed by the ARC and the Technical Director Group in September 2011. However, due to concerns by members of the Australian industry about the existence of AB in Australia it was decided that a scoping study AV12028 was necessary to get a better idea of the existence and magnitude of alternate bearing in Australia before proceeding with plans for AV12019.

The aims of the scoping study were to:

1. Determine the existence and magnitude of Alternate Bearing (AB) in Australia (by region)
2. Determine the existence and magnitude of Irregular Bearing (IB) in Australia (by region)
3. Collect growers' theories and observations about the causes & associations of AB & IB
4. Ascertain whether AB and IB occur on a national, regional, individual orchard, individual block or individual tree basis in the same year.

5. Determine the phenology patterns associated with the alternate/irregular bearing problem in each region. E.g. flowers but no fruit or fruit but few flowers or any other cropping pattern
6. Determine any typical circumstances surrounding the phenomenon in each region (e.g. low temperatures at flowering, dual crops, heavy crop loads etc) and gather theories and observations about potential causes of AB and IB from each region
7. Based on the findings of the survey, provide recommendations to the peak industry body (AAL) about the applicability of different parts of the proposed projects to the Australian industry, and if necessary how they might be changed to better address the situation in Australia.

Mr Simon Newett, Principal Extension Horticulturist with the Queensland Department of Agriculture, Fisheries and Forestry, conducted this scoping study and travelled to the major production regions of Australia to interview growers and collect data.

METHOD

Regional visits

Growers, consultants, extension officers and packers from each of the major production areas were visited and interviewed to ascertain the existence and magnitude of AB and IB in Australia. Local extension officers and consultants, as well as being interviewed for their own observations and understanding of AB and IB in their regions, were asked to suggest appropriate growers to interview and visit.

Most of these interviews were conducted face-to-face at the orchard and included a walk through the orchard with the owner or manager in order to better establish the circumstances associated with changes in yields between years and to get an appreciation for the orchard and its environment.

Growers chosen for the interviews were those regarded as good managers who were likely to have good records and good observation skills.

The data sought included:

- Orchard block yields, six contiguous years if possible.
- Details of each orchard block including age, variety, rootstock, soil type, canopy, general health and *Phytophthora* root rot status
- Phenology patterns associated with the alternate/irregular bearing problem in each region. E.g. flowers but no fruit, weak flowering.
- Major events such as hail, frost, wet spells, heat waves
- Other meteorological data (from the grower or local meteorological station)
- Typical circumstances surrounding the AB/IB phenomenon in each region (e.g. low temperatures at flowering, late harvest, heavy crop loads etc)
- The grower's observations on potential causes

The information was collected using a form designed for the exercise and each evening this information was entered into an MS Excel spreadsheet whilst the visit was still fresh in the mind. Refer to Appendix I.

Two to four days were spent visiting each region and two to four farms were visited per day depending on the distances involved.

The survey was conducted over a period of three months in between other commitments.

Meteorological data

Where necessary, daily meteorological records (mainly rainfall and temperature data) were collected from the orchard (where available) or from the Bureau of Meteorology website for the nearest meteorological station to the orchard.

Apart from gaining a general appreciation of weather extremes that may have affected the crop this data was also used in marginal growing areas such as SW Western Australia and the Toowoomba range to estimate how many days during the flowering season that pollination was possible. Refer to 'Pollination' in the discussion.

Alternate bearing index

The 'Alternate bearing index' was calculated for each pair of years that data was collected for. This index is used to indicate the extent of alternate bearing:

AB index = (Year 1 yield – Year 2 yield) / (Year 1 yield + Year 2 yield)

The greater the value of the index (regardless of whether it is +ve or –ve) the greater the degree of AB. A value of 0.8 is considered to indicate a high degree of AB whilst a value of 0.2 is regarded as being insignificant.

Orchard management rating

A rating was assigned to each orchard surveyed for how well it was being managed. This gave the panel an idea of how much value could be placed on each orchard's data.

Expert panel meeting

An expert panel consisting of horticulturists met on 11 October together with members of the Avocados Australia Ltd board and CEO, representatives of HAL, DAFF Queensland and some other growers to consider the data collected in the survey. There were presentations by Mr Simon Newett, Dr Tony Whiley, Dr John Wilkie and Mr Graeme Thomas. Apologies were received from Dr Simon Middleton who nevertheless provided his assessment of the data.

Those attending the meeting were:

- Dr Tony Whiley (Sunshine Horticultural Services)
- Mr Graeme Thomas (GLT Horticulture)
- Dr John Wilkie (DAFF Qld)
- Ms Kathryn Lee (HAL)
- Mr John Tyas (CEO AAL)
- Mr Daryl Boardman (AAL director West Moreton)
- Mr Chris Nelson (AAL director Central NSW)
- Mr Russell Delroy (AAL director Western Australia)
- Mr Peter Annand (AAL director Sunshine Coast)
- Mr Neil Delroy (grower Western Australia)
- Mr Travis Luzny (grower Western Australia)
- Mr Roger Broadley (DAFF Qld)
- Mr Simon Newett (DAFF Qld)

Panel members were supplied with the latest AB research project proposal and the amalgamated data from the survey several days prior to the meeting.

After the presentations and discussion panel members were asked to provide an analysis of the proposed alternate bearing project proposal to determine the degree to which it addressed the AB/IB problem in the Australian production regions and any significant gaps in the scope of the proposed projects in relation to the problem.

RESULTS

Survey results

A total of 54 interviews were conducted and 43 orchards visited across Queensland, NSW, Victoria, South Australia and Western Australia. In total 51 orchards provided data from a total of 85 different blocks of trees.

Table 1. Size of the survey

REGION	ORCHARDS SUPPLYING DATA	INDIVIDUAL BLOCK DATA	ORCHARDS VISITED	INTERVIEWS CONDUCTED	VARIETIES
NQ	6	16	6	6	Shepard & Hass
CQ	6	15	6	6	Hass, Shepard & Lamb Hass
SEQ	4	5	4	4	Hass, Wurtz
W Moreton	8	11	7	10	Hass, Fuerte
NSW	8	11	5	8	Hass, Lamb Hass, Pinkerton
Tristate	7	8	7	7	Hass
WA	12	19	8	13	Hass
TOTAL	**51**	**85**	**43**	**54**	

Dr Tony Whiley assessed the data collected on Hass and Shepard prior to the panel meeting, he excluded the three blocks of Lamb Hass and the single blocks of Wurtz, Pinkerton and Fuerte since they make up an insignificant part of the industry. He concluded that 25.2% of orchards displayed varying levels of AB from slight to significant and that the other 74.8% displayed varying levels of IB. Of the orchards considered to have some degree of AB he considered that only four orchards in total had significant AB. Dr Whiley pointed out that significant alternate bearing is unlikely to occur until yield reaches about 15t/ha.

Examples of significant alternate bearing (AB)

In all cases of significant AB weak flowering was associated with the "off" years.

Table 2. First example of alternate bearing, West Moreton region

Harvest year	Yield (t/ha)	AB index
2002	13.8	
2003	2.6	0.7
2004	25.5	0.8
2005	4.2	0.7
2006	24.2	0.7
2007	1.2	0.9
2008	18.2	0.9
2009	0.4	1.0
2010	23.4	1.0
2011	0.5	1.0

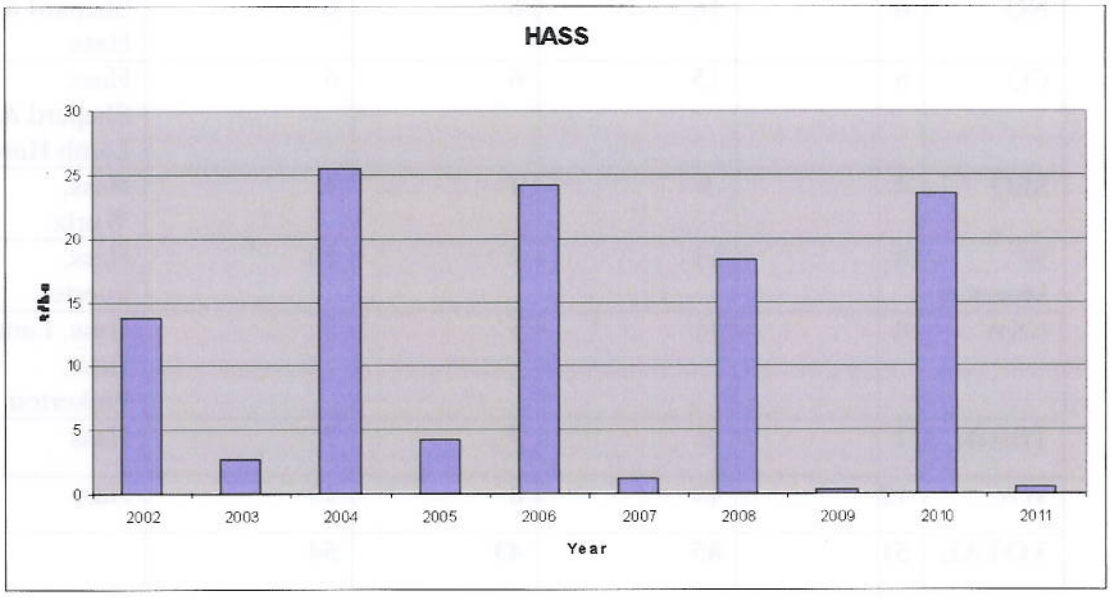

Figure 1. First example of alternate bearing, West Moreton region

Table 3. Second example of alternate bearing, NSW region

Harvest year	Tree age	Yield (t/ha)	AB index
2006/7	7	20.2	
2007/8	8	9.8	0.3
2008/9	9	36.2	0.6
2009/10	10	5.0	0.8
2010/11	11	31.1	0.7
2011/12	12	2.0	0.9

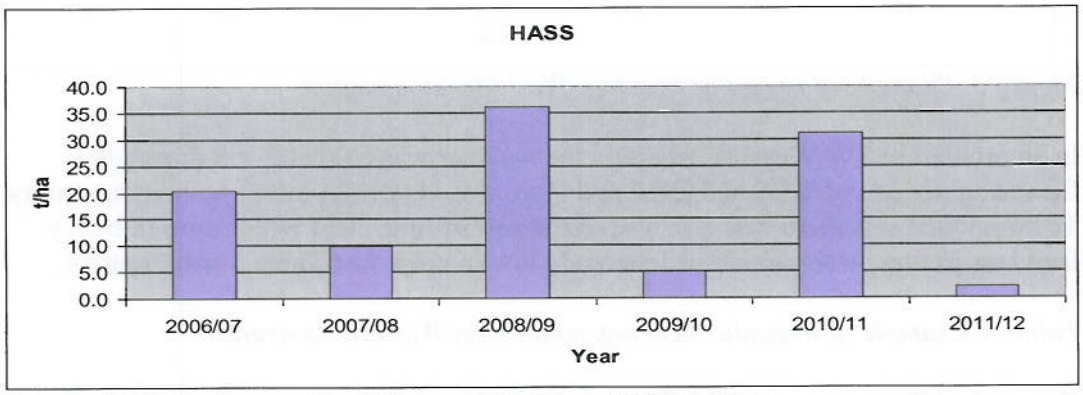

Figure 2. Second example of alternate bearing, NSW region

Examples of irregular bearing (IB)

In the West Moreton region in 2009 the hottest and driest September in six years occurred which coincided with the main flowering period. On 22nd and 23rd September then again on 26th and 27th September two of the biggest dust storms in living memory occurred which were characterised by hot and gusty winds and extremely low humidity. These conditions withered the flowers and any fruit that had already set.

During the flowering period in 2011 there was only one potential pollination event (period of three days in a row when minimum temperature was above 10°C) and this occurred right at the beginning of flowering. In many orchards this resulted in virtually no fruitset at all. See to Table 4 and Figure 3 below.

Table 4. Example of irregular bearing, West Moreton region

Harvest year	Tree age	Yield (t/ha)	AB index	Significant events that affected fruitset
2006	5	10.3		
2007	6	19.8	0.32	
2008	7	34.8	0.27	
2009	8	29.0	0.09	
2010	9	9.3	0.52	Hot dry winds at flowering desiccated flowers and early fruitset.
2011	10	25.9	0.47	
2012	11	0.0	1.00	Low night temperatures throughout flowering period

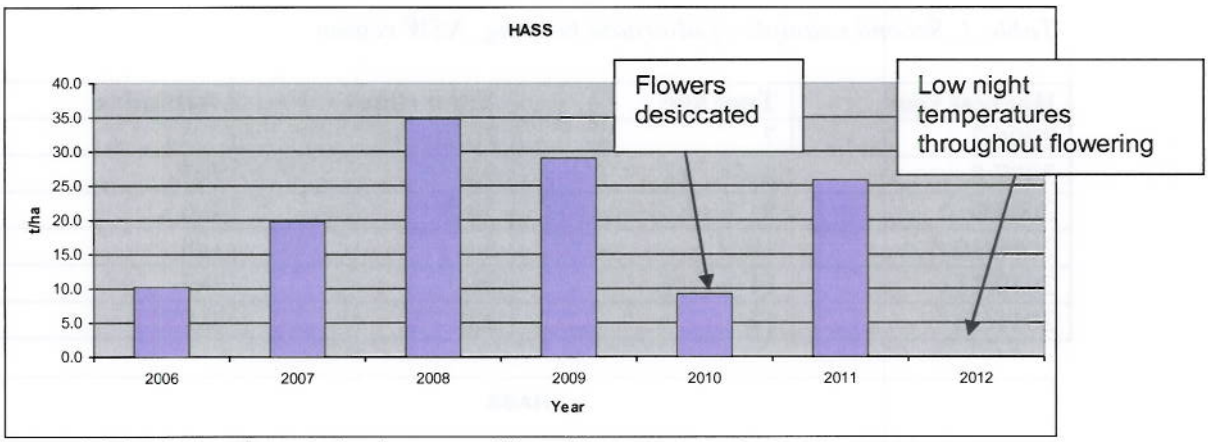

Figure 3. Example of irregular bearing, West Moreton region

In an orchard in SW Western Australia the weather was cold and wet during the flowering periods of 2008 and 2010 and there was very little insect pollinator activity. To compound this there was also a severe storm in June 2011 which caused heavy fruit loss in these trees which were already low in crop. See Table 5 and Figure 4.

Table 5. Example of irregular bearing, south west Western Australia

Harvest year	Tree age	Yield (t/ha)	AB index	Significant events that affected fruitset
2006/7	10	15.0		
2007/8	11	16.3	0.0	
2008/9	12	18.7	0.1	
2009/10	13	10.8	0.3	Cold and wet spring. Very little pollinator insect activity
2010/11	14	29.1	0.5	
2011/12	15	5.3	0.7	Cold and wet spring. Very little pollinator insect activity in orchard, plus severe storm in June causing heavy fruit loss.
2012/13	16	36.0 (est.)	0.7	

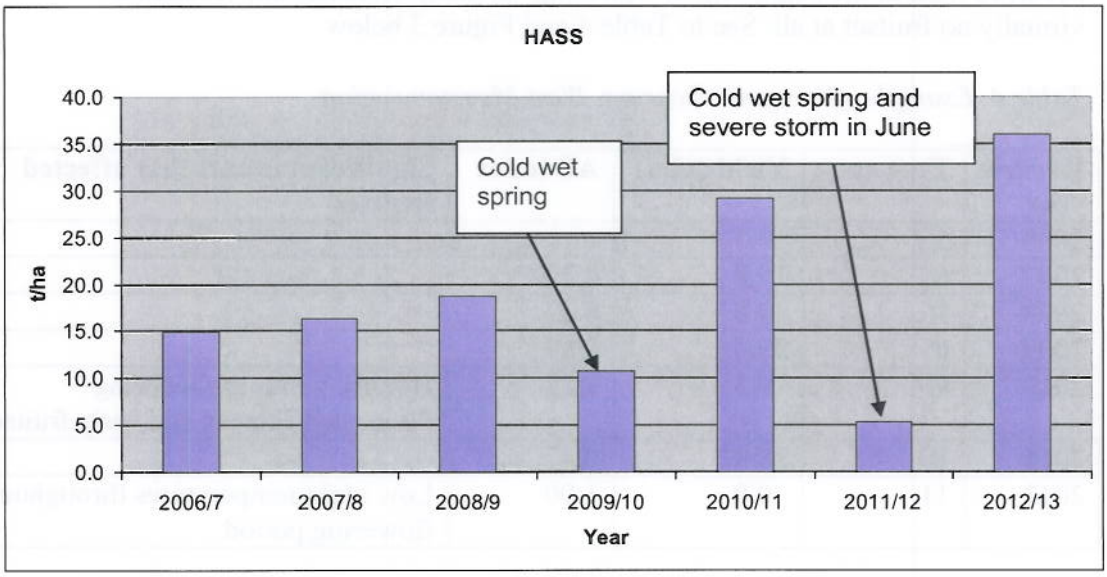

Figure 4. Example of irregular bearing, south west Western Australia

Yields of main varieties

The survey provided a snap shot of yields across the industry. The table below shows the average block yields of trees (4 years and older) for main stream varieties. It should be noted however that these yields are likely to be above average because of how interviewees were chosen.

Table 6. Orchard block yield averages and ranges by state (age 4 years & over)

Region	Blocks of mainstream varieties	Hass	Shepard	Lamb Hass	Yield range	All varieties
		Yield t/ha (number of blocks shown in brackets)				
NQ	16	13.2 (5)	13.2 (11)		4.6 – 20.6	**13.2**
CQ	13	12.8 (7)	14.4 (4)	16.7 (2)	5.9 – 18.8	**13.8**
SEQ	3	10.5 (3)			6.6 – 15.5	**10.5**
MORETON	10	10.0 (10)			4.0 – 18.4	**10.0**
NSW	7	14.2 (6)		7.8 (1)	6.9 – 22.6	**13.0**
TRISTATE	7	12.3 (7)			6.1 – 16.9	**12.3**
WA	19	14.1 (19)			7.7 – 20.6	**14.1**
All regions	**75**	**12.4**	**13.8**	**12.3**	**4.6 – 22.6**	**12.8**

A block of Hass in NSW proved the most consistent highest yielding once it had reached 6 years old. The trees were described as being the 'perfect' size for their 7x5m spacing and in 'perfect' health. Edranol was planted as a polliniser variety every 5th tree in every 3rd row.

Table 7. Highest consistent yield found during survey

Tree age	Harvest year	Yield (t/ha)	AB index
4	2005	4.4	
5	2006	2.1	0.4
6	2007	31.5	0.9
7	2008	35.2	0.1
8	2009	30.2	0.1
9	2010	22.6	0.1
10	2011	32.4	0.2
Average since 4 years old		*22.6*	
Average since 6 years old (5 seasons)		**30.4**	

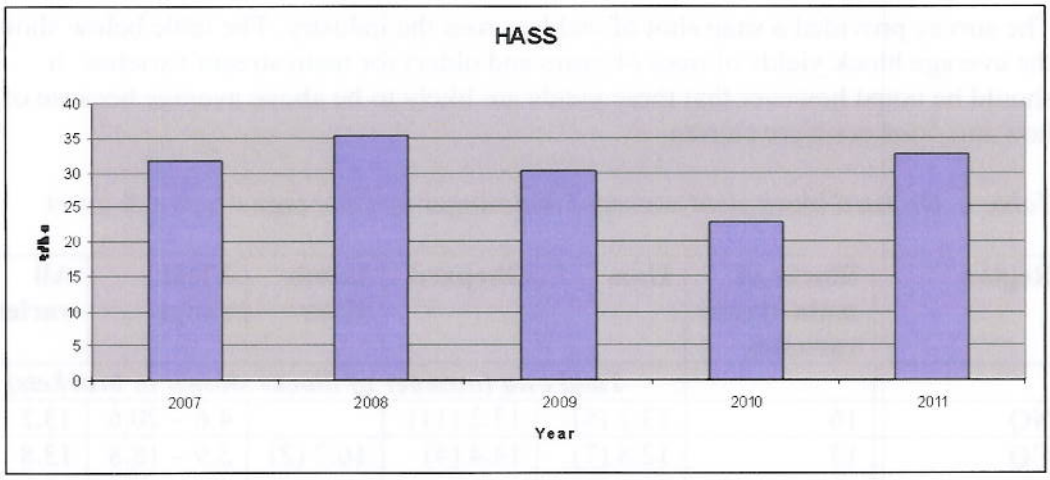

Figure 5. Highest consistent yield found during survey

DISCUSSION

Aims 1 & 2: Determine the existence and magnitude of Alternate Bearing (AB) and Irregular Bearing (IB) in Australia (by region)

A survey of growers across all five states in Australia where avocados are grown commercially collected data from 51 orchards but only found four orchards with significant AB in Hass and two orchards with AB in Lamb Hass. (Lamb Hass is a minor variety in Australia and has a well known pre-disposition to AB).

The assessment of the yield data concluded that 25.2% of orchards displayed varying levels of AB from slight to significant and that the other 74.8% displayed varying levels of IB.

Orchards with significant AB had weak flowering associated with "off" years, whilst in orchards with IB average to strong flowering occurred almost every year.

Some details of the four orchards where Hass was exhibiting significant AB are provided in the table below. In each of these four orchards weak flowering was associated with the low crop years and in three out of the four cases the typical harvest period each year was considered late.

Table 8. Information on the four orchards where significant AB was found in Hass

Location	Typical harvest period	Typical AB index range	Average "on" year yield	Average "off" year yield	Average AB index
West Moreton	Aug-Dec	0.7 to 1.0	21 t/ha	1.8 t/ha	0.84
W NNSW	Jul-Sep	0.8 to 1.0	29 t/ha	1.3 t/ha	0.91
Inland Central Coast NSW	Nov-Jan	0.3 to 0.9	31.7 t/ha	5.7 t/ha	0.7
SW WA	Dec-Feb	0.3 to 0.4	18.5 t/ha	8.6 t/ha	0.37

Aims 3 & 6: Collect theories and observations about the causes & associations of AB & IB and determine any typical circumstances surrounding the phenomenon in each region (e.g. low temperatures at flowering, dual crops, heavy crop loads etc)

Typical circumstances surrounding low fruit set in Australia

- Low temperatures during flowering
- Very low humidity during flowering and during fruit shedding periods
- Late harvest
- Poor management of *Phytophthora* root rot
- Poor soil moisture management
- Poor nutrition management
- Inappropriate canopy management techniques and timing
- Low levels of stored carbohydrate levels
- Low levels of pollen and nectar so flowers were unattractive to pollinators
- Conditions at flowering not conducive to pollinator activity e.g. too cool, wet, windy
- Lack of polliniser varieties in areas with a marginal climate

Mainly associated with cooler growing regions

- Lack of pollinators
- Rootstocks which are more conducive to the development of AB

Practices growers are using to minimise yield fluctuations

- Harvesting earlier
- Applying higher rates of nitrogen as soon as it is apparent that a big crop has been set – not only to feed the big crop but to generate leaf growth to produce carbohydrates for the next flowering and crop.
- Ensuring boron levels are adequate.
- Closer monitoring of soil moisture and being more responsive with irrigation applications, using more mulch, overhead misting in Tristate during heat waves
- Improving canopy management – timing, individual limb removal, pruning every year, cincturing limbs to be pruned off after harvest
- Judicial use of plant growth substances (PGRs)
- Introducing more bees, but not till 10 to 30% of flowers are open
- Interplanting with polliniser varieties (e.g. Ettinger and/or Edranol for Hass). The survey revealed that polliniser varieties were only planted in 10 of the 85 blocks for which data was collected, however there was growing interest to include pollinisers in orchards in Tristate and WA.
- Not planting varieties such as Lamb Hass and Wurtz that are prone to AB
- More careful rootstock selection
- Improving tree health (particularly with respect to *Phytophthora* management)

Harvest time

The data collected in this survey showed a strong correlation between late harvest and the occurrence of AB. Whiley *et al* (1996) showed how delaying harvest increased the incidence of alternate bearing. The graph of yield results from this research collected between 1988 and 1992 is shown below. Trees were split into five groups. Trees that were harvested as soon as the fruit dry matter levels reached 21% displayed virtually no AB (group on extreme left of graph). The middle group of trees on the graph had half their crop harvested when dry matter reached 21% and the other half not till it reached 30%, the graph shows how the variation in yields between alternate years is

increasing. Finally one set of trees was only harvested when dry matter reached 30% and this group of trees (right hand group on the graph) show significant alternate bearing across the four year period.

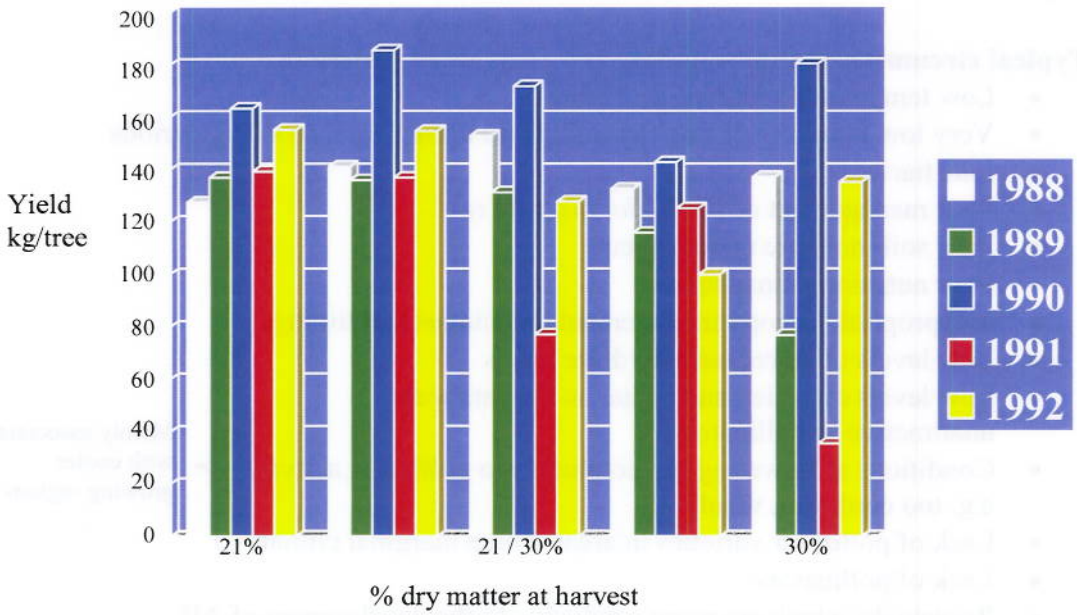

Figure 6. Effect on incidence of AB from delaying harvest (after Whiley et al , 1996)

Pollination

Fruitset is dependant on the number of pollination opportunities. This appears to be determined by (a) the activity of pollen vectors (e.g. bees) and (b) the number of 'pollination events'. One 'pollination event' is defined as three days in a row when the minimum daily temperature does not drop below 10°C (may need to be higher for the cold sensitive Shepard variety) and the maximum temperature reaches 17°C.

These temperatures are needed for the pollen grain to germinate on the stigma, the pollen tube to grow down the style and fertilise the ovule and for the embryo to reach a stage where it is less susceptible to low temperatures. If daytime temperatures do not reach 17°C then the female stage of the flower may not open but if it does then cocktail fruit (also known as 'cukes') are likely to develop instead of full sized fruit.

The fewer the number of 'Pollination events' the less chance there is of setting fruit for that season.

In areas such as the south west of Western Australia the number of pollination events in a season varied from zero to 21. There was a strong direct correlation between yield and pollination events. For example the yield from an orchard in the Busselton region was only 2 t/ha following a flowering season when the estimated number of pollination events was only 1, whereas in the previous season there were approximately 15 pollination events and the subsequent yield was 15 t/ha.

In the Gatton and Hampton/Toowoomba range areas (Queensland) there were only zero to 1 pollination events in the 2011 flowering season and the subsequent yields over the entire region were between zero and 8.5 t/ha. The previous year there were between 10 and 21 events and yields (excluding the orchard with strong AB) varied between 7.1 and 25.4 t/ha.

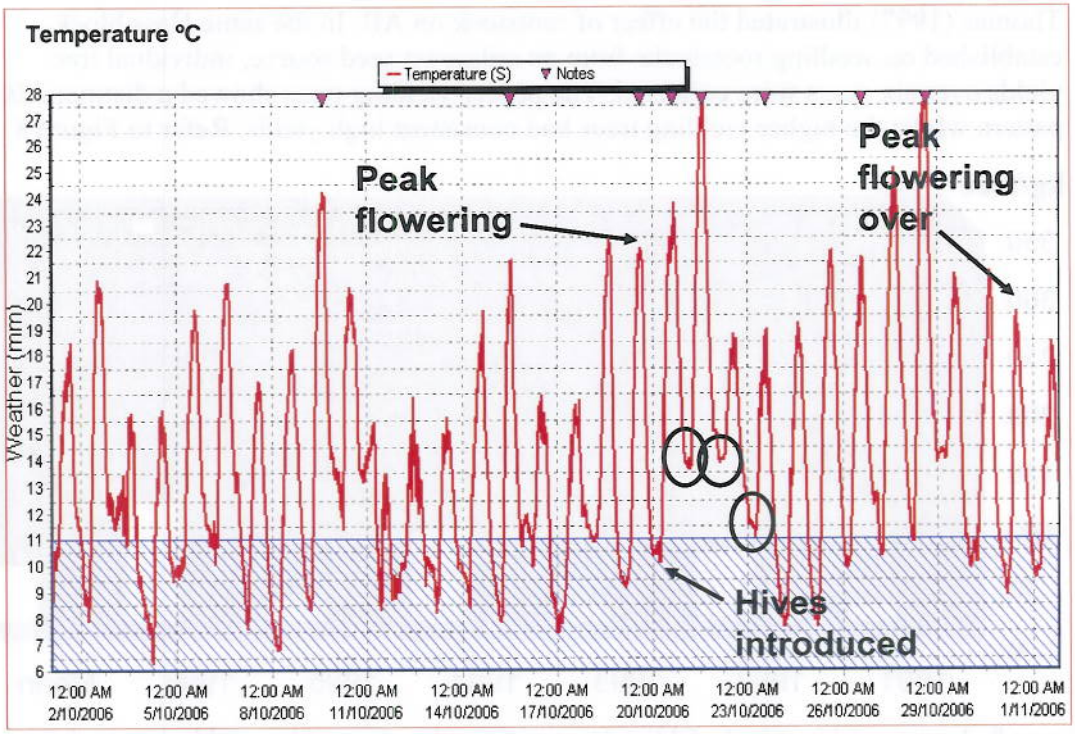

Figure 7. Temperature data collected in an orchard in Western Australia showing that for the flowering season in 2006 there was only one pollination event (the three days in a row with a minimum temperature above 10°C are circled). Graph and information courtesy of Paul Bidwell.

The attractiveness of avocado flowers to bees appears to be a significant factor in pollination and this was often raised by growers particularly in Western Australia. In some years even though flowering is moderate to heavy the bees prefer to go elsewhere. This could be (a) due to a more attractive source of nectar and/or pollen nearby e.g. a citrus orchard, or, unique to WA, the extensive blooming of native spring flowers which may coincide with avocado flowering, or (b) a variation in the nectar and pollen content of the flowers from year to year and perhaps this is linked to the level of carbohydrates stored in the tree.

Weather that is cold, wet and/or windy at flowering time (especially in SW Western Australia) deters the pollinators from foraging.

In some production areas, particularly NSW, several growers commented on the reduction in the feral bee population and some thought that it was associated with the spread of a honey bee pest called the small hive beetle.

Rootstock

Thomas (1997) illustrated the effect of rootstock on AB. In the same Hass block, established on seedling rootstocks from an unknown seed source, individual tree yields over six years were collected. The poorer yielding trees showed a distinct AB pattern whilst the higher yielding trees had consistent high yields. Refer to Figure 8.

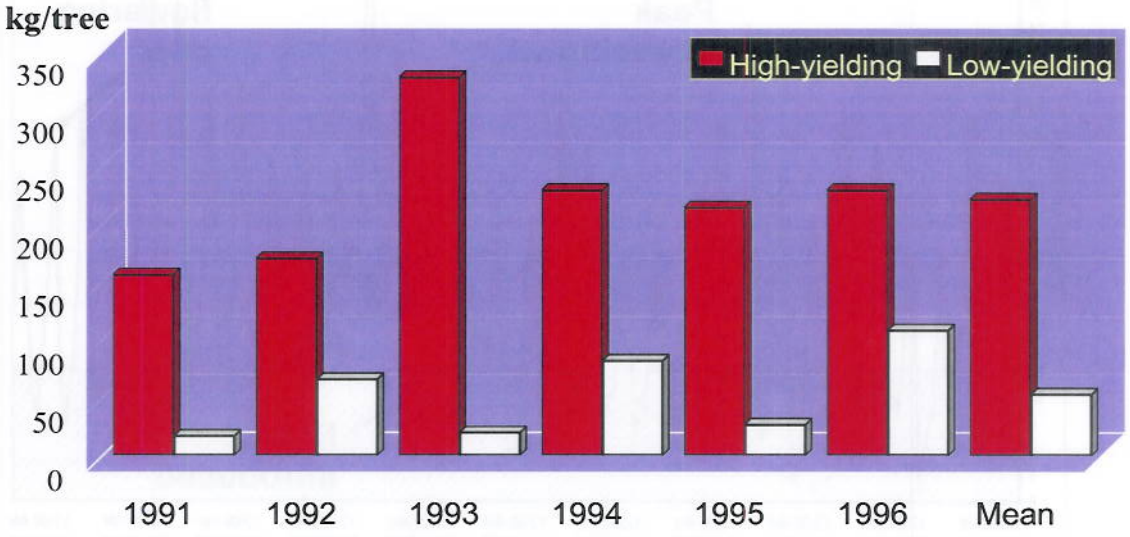

Figure 8. Average yields of high yielding trees compared to those of low yielding trees. Low yielding trees show AB. Differences were attributed to rootstock differences. (Source Thomas, 1997)

It was found in the survey that the majority of information about the rootstocks used in each block was too vague to be able to draw any conclusions. In 40% of blocks the rootstock source was unknown and in many cases where it was known there were several rootstock types used within the same block. The survey came across no blocks planted on clonal rootstocks.

Table 9. Information gathered on rootstocks used

Region	Unknown	"Guatemalan"	Velvick	Zutano	Reed	Other
NQ	9	3	4			
CQ	8	3	1			2 'Birdwood'
SEQ	1	1				1 Ploughman
WM	5	2	3		1	1 'Mexican'
NSW	4	1	3			1 Degania, 1 Wurtz
Tristate	1			7		
WA	5	2	3	1	6	1 Topa Topa, 1 A8, 1 A10, 1 'Birdwood', 1 Hass, 1 'Mexican'
Total	**33**	**12**	**14**	**8**	**7**	**10**

Aim 4: Ascertain whether AB and IB occur on a national, regional, individual orchard, individual block or individual tree basis in the same year.
AB and IB can occur in the same year to varying degrees on a regional, individual orchard, individual block (less common) and even individual tree basis. Due to the spread of the industry across large distances and different climate zones, AB and IB do not occur in the same year nationally. Weather events determine its occurrence when it occurs on a regional basis. Orchard management plays a major part where it occurs on an individual orchard and an individual block basis. Where it occurs on an individual tree basis (see photo below) the initial trigger may be a rootstock effect in orchards established on seedling rootstocks (which the vast majority are in Australia).

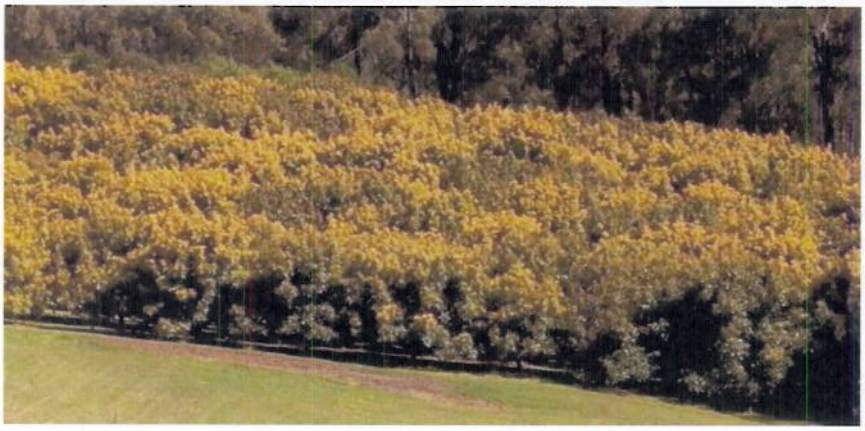

Figure 9. Orchard block at flowering time showing how some trees are flowering profusely whilst others appear to have few flowers, this illustrates AB in individual trees (Photo courtesy of Paul Bidwell)

Aim 5: Determine the phenology patterns associated with the alternate/irregular bearing problem in each region.

In all four cases where significant AB occurred, "off" years followed weak flowering.

In the AB orchard in West Moreton, when there was a heavy flowering (and subsequent "on" year) there was an associated heavy leaf loss at flowering (especially in weak trees) and in one year there was no spring leaf flush at all after the heavy fruit load had set. The weak flowering (leading to an "off" year) tended to occur a bit earlier compared with flowering in an "on" year. In "on" years fruit shedding was heavier – the tree apparently setting a much greater fruit load than it could sustain.

In the AB orchard in inland central NSW the spring leaf flush was weaker in an "on" year but summer leaf flush was reported to always be strong. The orchard exhibits excessive vegetative growth and the owner was removing a high proportional of individual limbs each year to try and manage this vigour. Individual limbs were cinctured the year before being removed.

In the AB orchard in Western Australia a weak summer leaf flush was reported in "on" years and vice versa.

Aim 7: Based on the findings of the survey, provide recommendations to the peak industry body (AAL) about the applicability of different parts of the proposed project to the Australian industry, and if necessary how they might be changed to better address the situation in Australia.

Panel members were presented with a recent project proposal for AV12019 and asked to judge how relevant it was to the situation in Australia revealed by the scoping survey. The panel was asked to rate the applicability of each of the 17 sections in the proposal to Australia on a 1 to 10 scale where 1 meant that it would not address Australian industry needs and 10 meant that it would fully address Australian industry needs.

Objective A. Research integration and decision support system

Project A1. (Years 1 – 5) Integration of research outputs across ARC program
Rating = 1 (i.e. does not address Australian industry needs)
Panel comments: In any project, extension is important but the DSS approach has questionable value, also, based on the assessment of the other sections this section is no longer relevant.

Project A2. (Year 1) Yield prediction model for California (UCR)
Rating = 1
Panel comments: Not relevant to the Australian industry.

Objective B. Determining environmental and biological triggers for alternate bearing

Project B1. (Years 1 – 2) Meta-analysis of alternate bearing (UCD)
Rating = 1
Panel comments: Since AB was not considered to be a problem of commercial concern across the Australian Industry it was not considered relevant to fund this section.

Project B2. (Years 1 – 4) Phenological models for Mexico (INIFAP)
Rating = 1
Panel comments: Not relevant to the Australian industry.

Objective C. Regulating transition from vegetative to floral meristems in avocado

Project C1. (Years 1 – 5) Optimum timing of fruit removal for Australia and NZ (PFR)
Rating = 1
Panel comments: Briefly this is a study on time of harvest and its impact on Alternate Bearing. It has already been done in Australia (Whiley et al., 1996, two published papers) and although not translated yet to all regions the phenological/physiological principles should hold.

Project C2. (Years 1 – 2) Floral gene expression and hormonal status in California (UCR)
Rating = 1
Panel comments: Not relevant to the Australian industry.

Project C3. (Years 1 – 5) Floral gene expression and hormonal status in Australia and NZ (PFR)

Rating = 3

Panel comments: High risk research in respect to developing a practical solution for grower management of the problem. Can't manage genes other than change the variety. Uniconazole is registered for use by Australian growers (not in California or Mexico) and it has demonstrated effect on changing floral expression. Technology is known and used by Australia growers.

Project C4. (Years 1 – 5) Identity of phloem derived signals (PFR) (Note: This component funded through separate HAL/PFR proposal).

Rating = 2

Panel comments: 'Blue-sky' research. $0.5m. Not likely to lead to practical solutions.

Project C5. (Years 1 – 5) Time of commitment to flowering in Australia and NZ (PFR)

Rating = 1

Panel comments: Pruning times which impact on floral development are known for Australia (Leonardi's work in the Canopy Management I project), e.g. pruning later than the middle of December in Bundaberg will impact negatively on next years flowers/crop.

Project C6. (Years 1 – 5) Bud analysis for time of commitment to flowering (INIFAP)

Rating = 1

Panel comments: Flowering is not considered to be a serious commercial issue in Australia.

Objective D. Improving flower quality, pollination, fertilization and fruit set in avocado

Project D1. (Years 1 – 5) Flower quality in Australia and NZ (PFR)

Rating = N/A

(Note: This component funded through separate HAL/PFR proposal).

Panel comments: Boron research in relation to pollination and fruit set has already been carried out and published in Australia (Smith et al. 1997, 2 papers). Standards to manage this nutrient have been established and recommendations developed for industry. Boron research in South Africa (Bard) has concurred with Australian results. Lovatt has found that foliar B at flowering will increase fruit set when weather conditions are marginal during flowering.

Project D2. (Years 1 – 5) Pollination requirements in Australia and NZ (PFR)

Rating = 1

Panel comments: Proposal includes no work on polliniser varieties which are seen as the key to providing the most assistance to reduce Irregular Bearing identified in the survey .

Objective E. Management strategies to mitigate alternate bearing in avocado

Project E1 (Years 1 – 5) Timing and severity of pruning in Australia and NZ (PFR)

Rating = 1

(Note: This component funded through separate HAL/PFR proposal).

Panel comments: Has been covered in Leonardi's Canopy Management I project.

Project E2. (Years 1 – 4) Chemical thinning (PFR)
Rating = 1
Panel comments: Since AB is not considered a significant commercial problem in Australia the research is irrelevant.

Project E3. (Years 1 – 3) Development of propriety PGR product (UCR)
Rating = 1
Panel comments: Australia already has uniconazole and paclobutrazole registered for use and research results published to provide floral management of the crop. These products not available for use in California and Mexico.

Project E4. (Years 1 – 5) Field testing of PGR products in Australia and NZ (PFR)
Rating = 1
Panel comments: Not relevant since products are already available to manipulate flowering.

Objective F. Science program communication and planning
Panel comments: No longer relevant.

In summary, 15 of the 17 sections of the project proposal were judged to be irrelevant or would not address Australian industry needs. The other two sections only scored a 2 and a 3.

CONCLUSIONS

There are three main stages in avocado phenology that affect yield:
1. Flower initiation
2. Pollination and fruitset
3. Fruit retention

The first one, flower initiation (which is associated with AB), does not appear to be a major issue in Australia. The second, pollination and fruitset, appears to be the biggest issue in Australia. The third, fruit retention, is the second biggest issue but good managers report that the second fruit shedding event in particular can be minimised through better management especially irrigation.

- In Australia the predominant issue is Irregular Bearing (IB), not Alternate Bearing (AB)
- Where AB is present, it is usually associated with late harvest
- Growers are learning to minimise AB through better management practices
- Some varieties e.g. Lamb Hass and Wurtz, are much more prone to AB than Hass
- There is more yield variation in cooler areas
- There is more yield variation in Shepard compared with Hass
- In cooler production areas variation in pollinator activity (e.g. honey bees) appears to be an important factor and is influenced by:
    - Competition from other flowering plants
    - Apparent variation in nectar and/or pollen content of flowers from year to year
    - Weather conditions at flowering that are not conducive to insect foraging e.g. too windy, cool, cloudy, or wet

The main factors contributing to IR in Australia appear to be (in order of importance):

- Cold nights at flowering
- Extended wet conditions at flowering
- Hot dry desiccating conditions at flowering and during the two main fruit shedding events

The assessment panel judged that 15 of the 17 sections of the most recent project proposal for AV12019 were irrelevant or would not address Australian industry needs. The other two sections were judged to be only slightly relevant and their possible outcomes to have questionable practical application.

RECOMMENDATIONS

The panel determined that the research proposal for AV12019 had low relevance to the current status of the industry in Australia and the recommendation to the AAL board was not to proceed with it.

As a possible alternative the panel recommended that the phenomenon of irregular bearing be looked at closer with the possibility of directing some resources to addressing this issue. It could involve improving the understanding of the different growing environments and the differences in avocado physiology in these different environments across Australia, i.e. a genetics x environment x management approach.

Other recommendations were:

- To build capacity amongst Australian scientists rather than to contract overseas scientists.
- To conduct further research into carbohydrate storage in Australian avocado trees.
- Investigate DNA fingerprinting of rootstocks to assist in the identification of variability and parentage
- Test the Chilean high density, small tree model in the cooler production areas of Australia
- Conduct a study into light requirements, effects and interception in avocado (similar to the study done for apples)

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A.W. Whiley, T.S. Rasmussen, J.B. Saranah, B.N. Wolstenholme. 1996. Delayed harvest effects on yield, fruit size and starch cycling in avocado *(Persea americana* Mill.) in subtropical environments. I. the early-maturing cv. Fuerte *Scientia Horticulturae 66 (1996). Pp* 23-34.

ACKNOWLEDGEMENTS

The project team would like to thank the growers, consultants and state government research and extension staff who generously gave their time and knowledge to the survey.

This project was funded by the Department of Agriculture, Fisheries and Forestry, Queensland (DAFF Queensland), Avocados Australia Ltd (AAL) and Horticulture Australia Ltd (HAL) using the avocado industry levy and matched funds from the Australian Government.

APPENDIX I:

Alternate Bearing Project Critique.pptx
Author: Dr Tony Whiley, Sunshine Horticultural Services, Dulong, Queensland.

APPENDIX II:

AB survey summary.ppt
Author: Simon Newett, DAFF Qld, Nambour, Queensland.

ARC Alternate Bearing Project Critique
October 2012

Tony Whiley
Sunshine Horticultural Services
Nambour QLD

Alternate Bearing - defined

AB is initiated by a "one-off" climatic or management event leading to an "on"/"off" cropping cycle that becomes entrenched through endogenous tree factors that affect the intensity of annual flowering.

Irregular Bearing - defined

IB is usually driven by climatic events (sometimes management, e.g. pesticide burn at flowering) that impacts negatively on fruit-set/crop load regardless of flowering intensity. There is no cyclic pattern to "on"/"off" years as with AB.

Whiley's Review of Newett's Data

1. Data was only included for Hass and Shepard.
2. AB patterns were only considered when yield exceeded 15 t/ha.
3. Ratings were developed from intensity scores and number of farms in the sample and expressed as a %age of the farm population.

Whiley's Review of Newett's Data

1. **25.2% of the farms presented displayed varying levels of AB (from slight to significant (4).**
2. **74.8% of the farms presented displayed varying levels of IB (from slight to significant).**

The Flowering Event

The success of flowering is dependent on the number of pollination opportunities which is determined by:

1. The activity of pollination vectors (bees etc), the availability of pollen when flowers are receptive.

2. A 72 hr window clear of temperatures below 10 C (for Hass). Shepard probably has a higher threshhold temperature for pollination and dichogamy.

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Pollen Availability Assessment – NZ 2010

Period of Study: 25 Oct-7 Dec, 2009

Within Hass: simultaneous F + M flowers – 3 events

Hass + Polliniser: Hass F + Polliniser M – 21 events

Events meeting temperature criteria: within Hass = 1
Hass + Pol. = 6

Temperature criteria: 72 hrs above 10 C

10 hives per ha.

Pollen Availability Assessment – NZ 2010

Hass fruit-set 2009

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The Flowering Event

The number of pollination opportunities is also determined by the length of the flowering event.

Heavy flowering lengthens the time available for pollination success.

Light flowering shortens the time available for pollination success.

One successful pollination event can result in a commercial crop.

AB and Genetics

Breeding new varieties and pairing them with rootstocks is ultimately the best protection against significant annual yield variations

- Calypso mango yields 3 x better than other commercial varieties.
- Mature orchards are regular and show little annual variation in yield.
- Trees are grafted to polyembryonic KP seedlings which reduce tree vigour.

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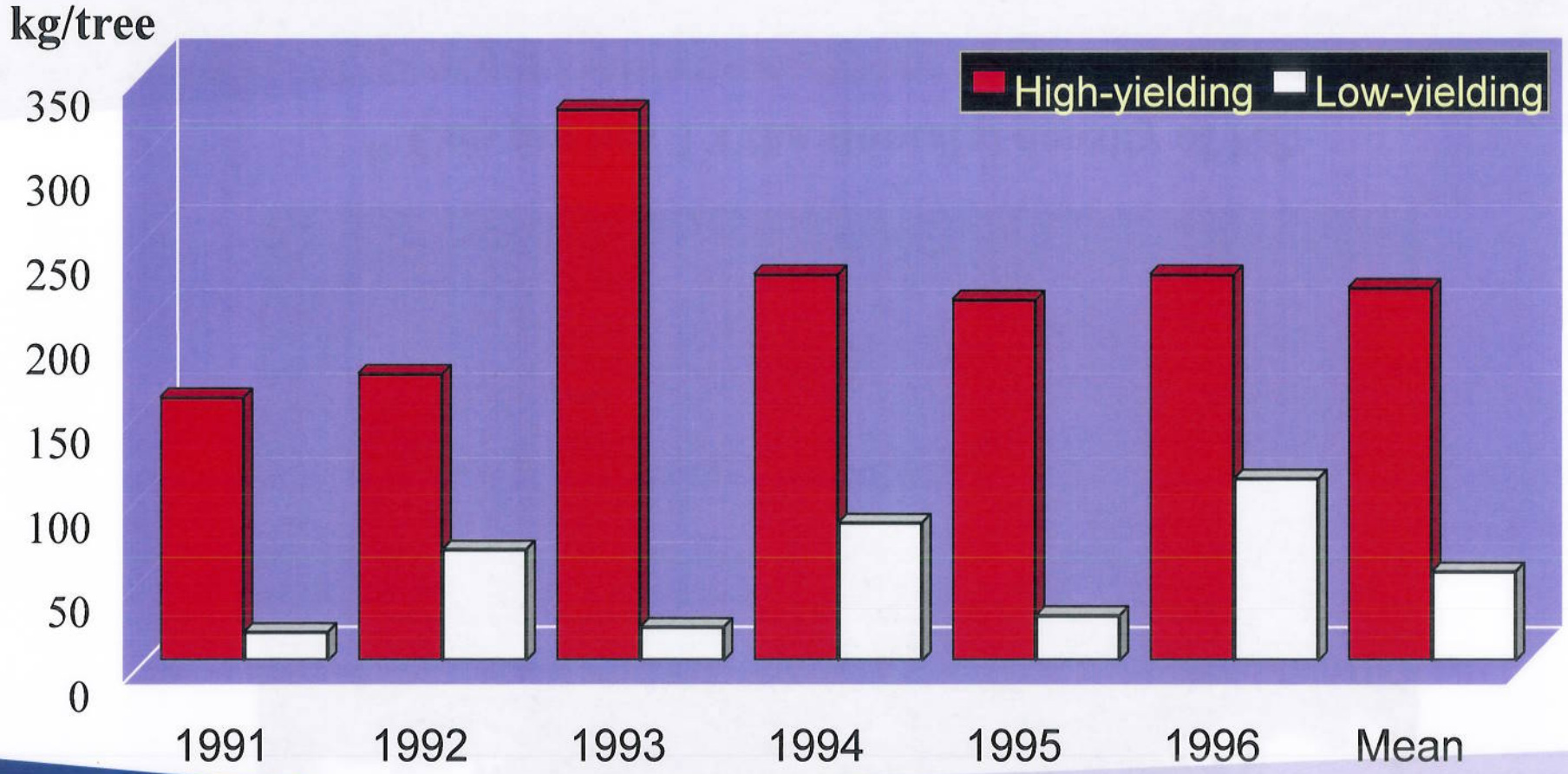
AB and Genetics

- Calypso has 3 x the stomatal density of KP.

Effect of Rootstock on Yield of Avocados



Source: Thomas, 1997

Orchard Composition

- In a typical mature orchard each year trees will be in varying stages of cropping potential. Some will be entering an “on” year while others will be entering an “off” year.
- The sum of the production of all trees in the orchard determines the yield (kg/ha).

Orchard Composition

	2007	2008	2009	2010	2011	2012
1	13.8	66.4	0.0	121.8	6.8	163.7
2	12.5	45.2	111.2	119.9	218.6	30.1
3	3.3	56.1	94.5	154.2	144.3	158.0
4	14.8	55.0	92.9	33.0	227.9	0.0
5	11.8	65.1	53.6	96.0	43.2	183.4
6	31.9	21.2	52.0	52.1	159.5	0.8
7	14.0	37.1	73.6	75.8	163.9	6.1
8	8.9	47.6	81.0	110.9	181.6	43.1
9	6.2	49.9	107.3	78.7	224.3	13.0
10	11.9	57.4	61.3	93.7	210.2	12.0
Means	12.9	50.1	72.7	93.6	158.0	61.0

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Orchard Composition

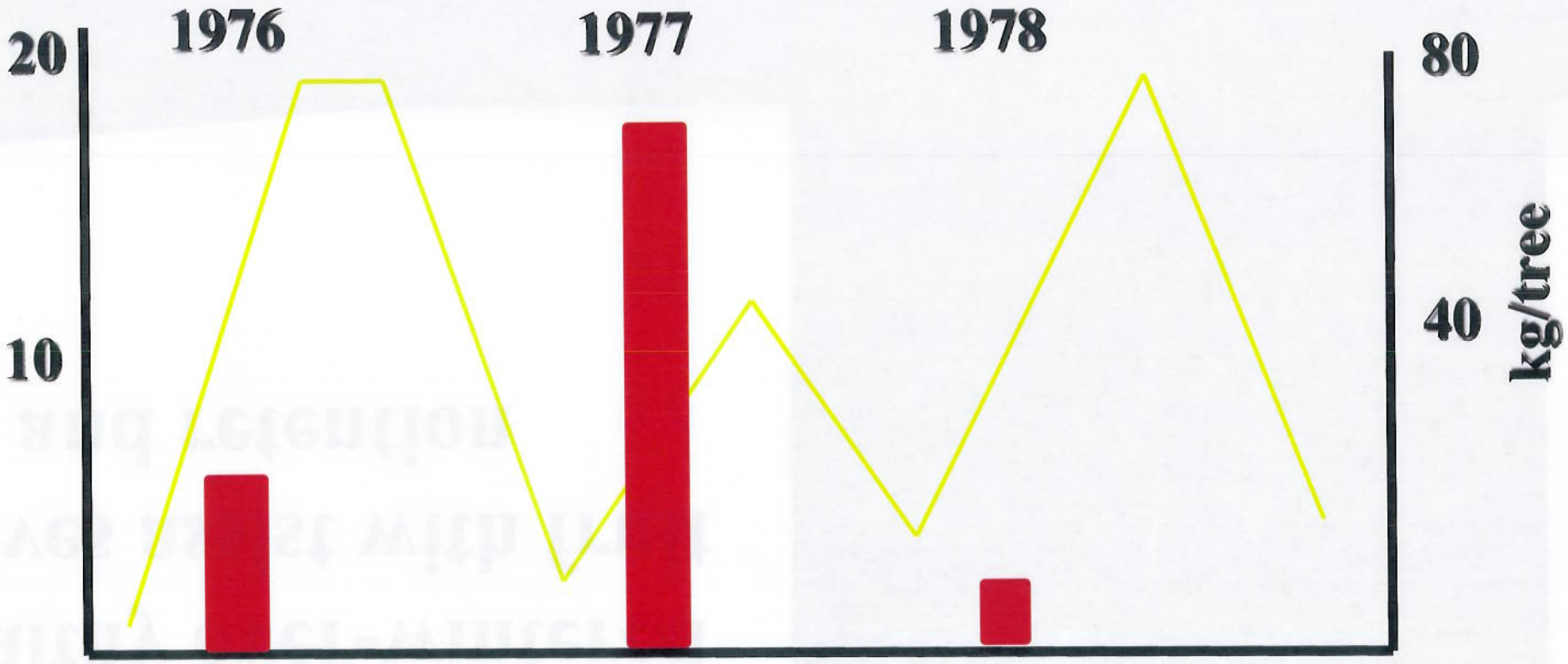
- The best we can hope for is a reduction in the amplitude of annual variation while maintaining viable yields. (Testing of elite rootstocks)?

- Some of our better growers are already there.

Orchard Composition

	2007	2008	2009	2010	2011	2012
1	16.9	31.5	57.8	112.8	104.6	171.4
2	0.0	38.3	28.8	115.5	113.3	240.9
3	4.6	24.3	42.9	156.4	139.4	207.9
4	0.4	0.7	15.7	58.3	75.0	112.0
5	5.4	29.0	32.0	114.1	117.7	162.9
6	0.0	1.2	16.0	19.8	61.2	110.2
7	0.0	15.5	10.8	50.3	82.4	133.9
8	0.3	12.9	13.7	83.4	101.8	176.5
9	10.4	33.9	46.5	45.6	93.3	155.8
10	5.8	18.0	6.1	76.2	75.9	110.8
Mean	4.4	20.5	27.0	83.2	96.5	158.2

Effect of Carbohydrate Accumulation on Avocado Yield



Source: Scholefield *et al.*, 1985

CHO and Flowering in Subtropical Climates

In subtropical climates healthy over-wintered leaves assist with fruit set and retention

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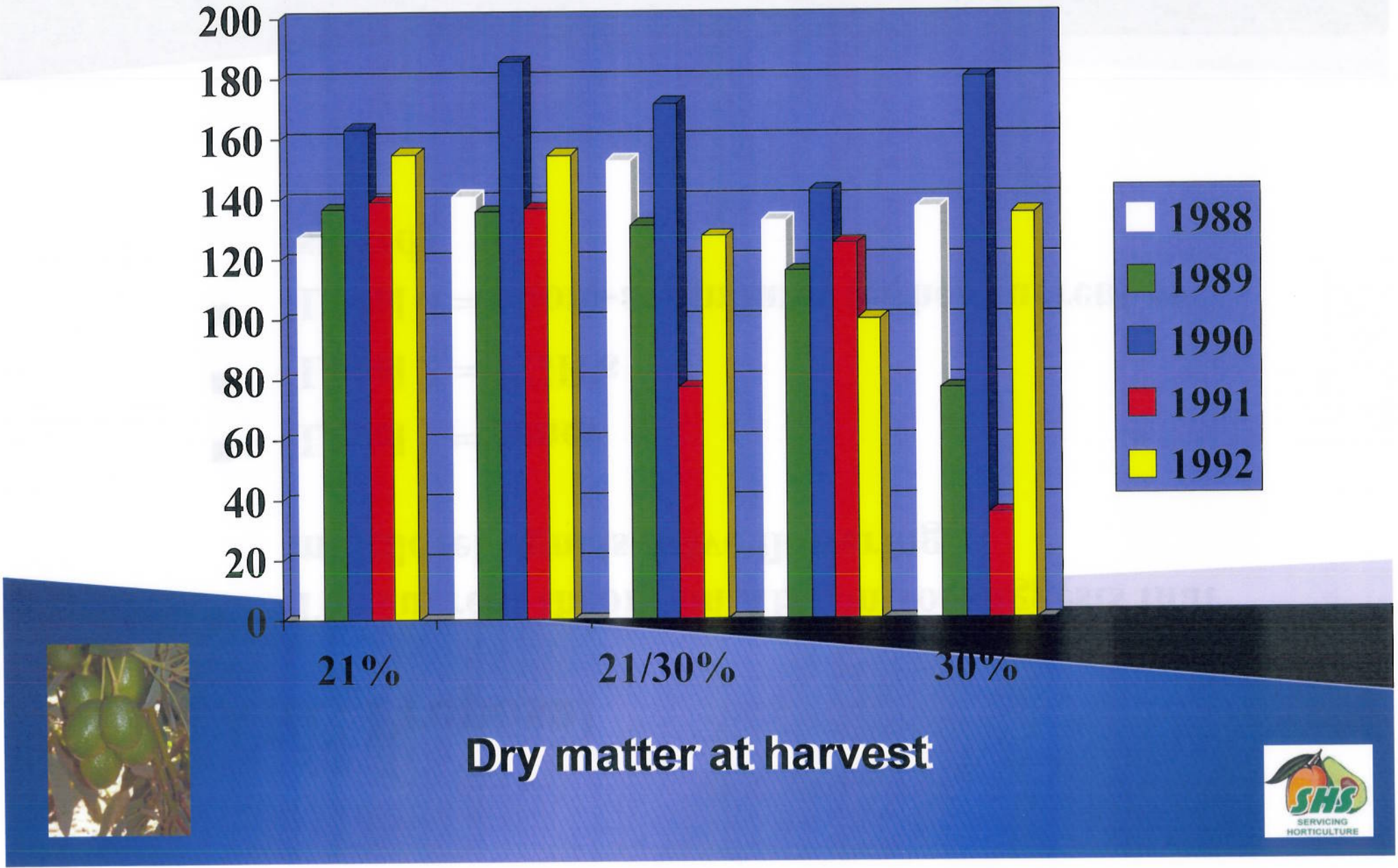
Effect of Harvest Time on Yield



The ARC Proposal

- The current theory on AB control suggests that multilevel signals drive flowering.

- Level 1 = genes
- Level 2 = PGR's
- Level 4 = photo-assimilates (either current or stored)

The ARC Proposal

- The Lovatt (UCR) proposal is based on previous research and new hypotheses to develop further understanding of multilevel signals and their staged control of flowering
- The original proposal (presented at the WAC 7) is well referenced and the science base is sound. The original budget is modest.
- The practical outcome appears to rely on a "silver bullet" – high risk for grower levy money!

The ARC Proposal

- The revised PFR submission remains unimpressive.
- It ignores a large body of AB research already published and gives no indication of where the gaps are in knowledge that they are proposing to fill.
- There appears to be no holistic understanding of whole-tree physiology and the inter-relationship between events that lead to reliable cropping.

The ARC Proposal

- Ultimately yield is a function of energy (in the form of light) into the crop minus the investment into plant structures and respiration.

- G x E plus on-farm management provide the commercial result.

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The ARC Proposal

	Commercial Presence of AB
Australia	No
California	Yes
Mexico	???
New Zealand	Maybe (IB?)

Department of **Agriculture, Fisheries and Forestry**

Avocado alternate bearing survey summary

Simon Newett, DAFF Qld

Queensland Government

Summary of data collection sites

REGIONS	FARMS	BLOCKS	VARIETIES
NQ	6	16	Hass & Shepard
CQ	6	15	Hass, Shepard & Lamb Hass
SEQ	4	5	Mainly Hass
W Moreton	8	11	Mainly Hass
NSW	8	11	Mainly Hass
Tristate	7	8	Hass
WA	12	19	Hass
TOTAL	**51 farms**	**85 blocks**	

- Great cooperation from the whole industry – thank you
- Limitations to survey
- Survey results layout
- Management rating
- AB index = (Yield year 1 – Yield year 2) (Yield year 1 + Yield year 2)
  - A high value e.g. 0.8 means high degree of AB
- Same farm number means same farm, i.e. 2a and 2b are different blocks on same orchard
- Impossible to tell (in the survey process) if there has been sufficient overlap of male and female flowers each year
- AB issue complicated by the fact that all trees in a block are not always synchronised in say an "on" year
- Please respect confidentiality of data

What is Alternate Bearing?

- Alternate bearing AB is initiated by 'one-off' climatic or management factors that negatively impact production over one year through poor flowering or excessive fruit loss, e.g. freeze damage, extreme temperatures during flowering and fruit set, water deficits, nutritional disorders, poor pruning practices. The resultant poor crop load ('off' year) is typically followed by very high production ('on' year) and once the alternate cycle begins it becomes entrenched through endogenous tree factors that ultimately affect the intensity of annual flowering.

2nd Edition (unpublished) "The Avocado – botany production and uses" Whiley et al.

What is Irregular Bearing?

- Irregular bearing (IB) is driven by climatic events that impact negatively on crop loading irrespective of flowering intensity. Irregular bearing is more common in areas that are climatically marginal for avocado production and is usually due to low temperatures at flowering, sometimes combined with consistent wet weather during anthesis that disrupt the dichogamous cycle and/or restrict pollination and ovule fertilization for most of the flowering event. Poor crops can occur several years in succession prior to favourable conditions prevailing that result in a heavy fruit set. The year following heavy fruit set is normally an 'off' year due to the establishment of an AB cycle, but a succession of poor crops can reoccur due to inclement climatic conditions.

2nd Edition (unpublished) "The Avocado – Botany production and uses" Whiley et al.

Alternate bearing and Irregular bearing (continued)

- The "off" year associated with AB is coupled with poor flowering, but …..
- trees with Irregular bearing (IB) generally have an average to good flowering every year.
- AB is unlikely to occur until yield reaches 15t/ha and above

The three main times when yield is determined

- Flower initiation
  - doesn't appear to be a major issue in Australia
- Pollination and fruitset
  - the biggest issue in Australia
- Fruit retention
  - the next biggest issue but good managers report that the second fruit shedding event in particular (large fruit) can be minimised through better management especially irrigation

Observations from survey

- In Australia the predominant issue is Irregular Bearing (IB), not Alternate Bearing (AB)
- Where AB is present, it is invariably associated with late harvest
- Growers are learning to minimise AB through better management practices
- More yield variation in cooler areas
- More yield variation in Shepard

(cont.)

Observations from survey (cont.)

- In cooler production areas variation in pollinator activity (e.g. honey bees) appears to be an important factor and is influenced by:
  - Competition from other flowering plants
  - Apparent variation in nectar content of flowers from year to year (related to carbohydrate levels in trees?)
  - Weather conditions at flowering e.g. too windy, cool, cloudy, wet
- Some varieties e.g. Lamb Hass, are more prone to AB
- Rootstock also influences susceptibility of the tree to AB

Note: Small hive beetle appears to be impacting bee numbers

Main factors contributing to IR in Australia appear to be (in order of occurrence) . . . .

- Cold nights at flowering (refer to 'Pollination events' sheet)
- Extended wet conditions at flowering
- Hot dry desiccating conditions at flowering and during the two main fruit shedding events

Practices growers are using to minimise yield fluctuations

- Harvesting earlier
- Applying higher rates of nitrogen as soon as it is apparent that a big crop has been set – this is not only to feed the big crop but to generate leaf growth to drive the leaf growth to produce carbohydrates for the next flowering and crop. Ensuring boron levels are OK.
- Closer monitoring of soil moisture and being more responsive with irrigation applications, using more mulch, o'head misting in Tristate

(cont.)

Practices growers are using to minimise yield fluctuations (cont.) . . .

- Improving canopy management – timing, individual limbs, every year, cincturing limbs to be pruned off after harvest
- Using PGRs
- Introducing more bees and in a more timely manner
- Interplanting with pollinizer varieties (e.g. Ettinger for Hass)
- More careful with rootstock selection
- General tree health (includes *Phytophthora* management of course)

- Your comments please?

Horticulture Australia

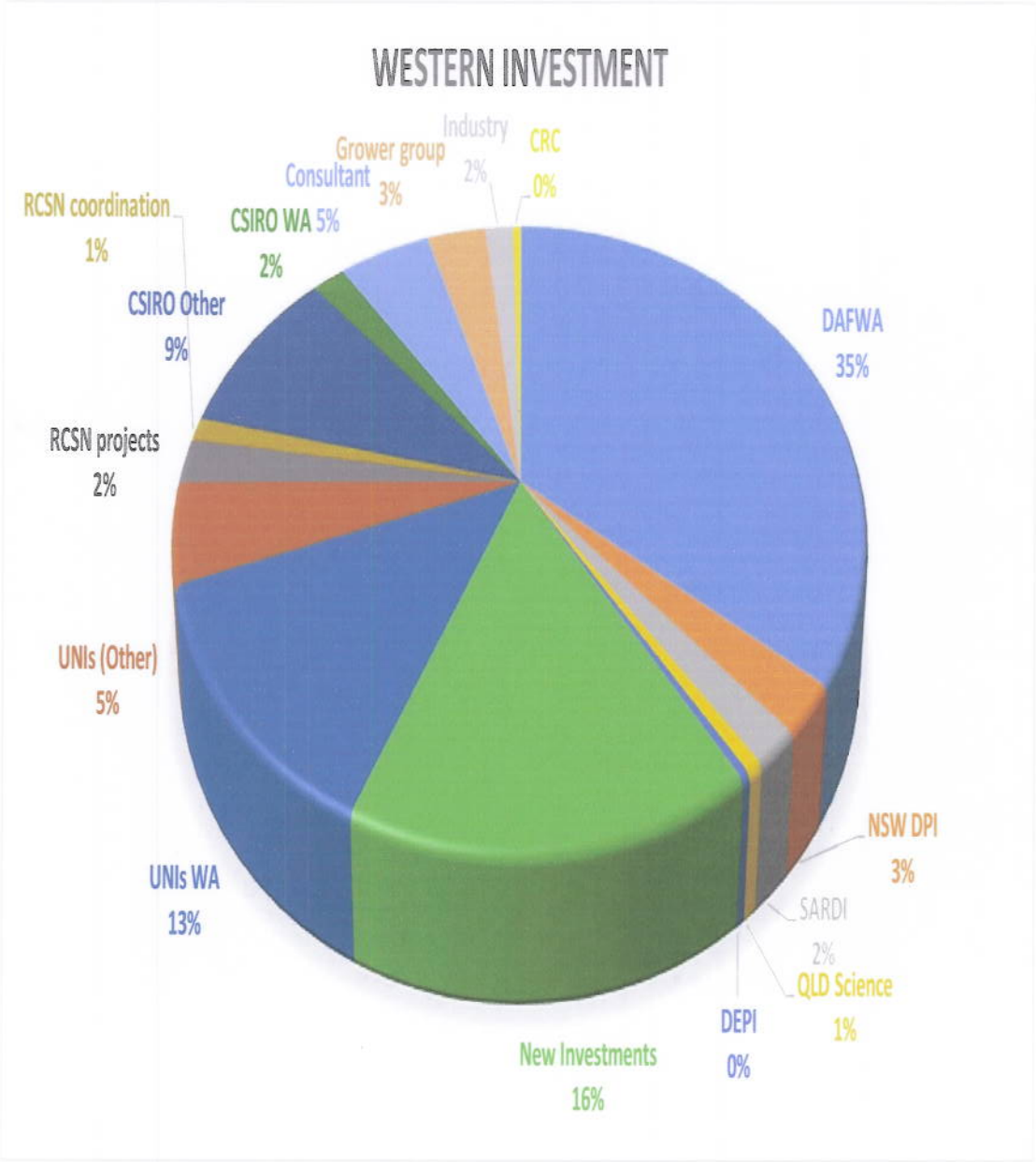
Queensland Government

Your comments please:

Consultancy
Organising
Training

Points for consideration: WAFF Appearance at Levies Inquiry Committee Hearing

Friday, 20 February 2015



Notes on Presentation to Senate enquiry held on 20 Feb 2015

Inquiry into the industry structures and systems governing the imposition and disbursement of marketing and research and development (R&D) levies in the agricultural sector

Julian Krieg Profile

Currently

- **Board Chair Rural Financial Counselling Service of WA,**
- **President Australian Men's Health Forum,**
- **Director Keystart Home loans.**

Julian has worked since 2002 developing and delivering innovative men's wellbeing, health and suicide prevention programs in rural and regional WA. He has developed a successful range of programs and strategies for men, their families and communities to counteract some of the negative effects of drought and declining terms of trade in agriculture, as well as other "Situational Distressors" impacting on individual and community wellbeing.

His approach to these issues comes from his 30 plus years experience in the field of education, specifically Agricultural Education. (In 2001 he retired from his position as Director of Agricultural Education for the department of Education in WA) This experience underpins his philosophy that communities and individuals need to be empowered to deal with emerging social and health issues to keep them "Alive and Well"(the umbrella name for his programs) rather than the medical approach of fixing things after they are broken.

Between 2002 and 2005 he worked closely with the Central Wheatbelt Division of GP's developing and delivering programs on suicide prevention and caring for those bereaved by suicide.

Background Notes

- All progressive farmers believe in R & D that will progress their production and **profitability**.
- When first established the R & D levy system, based on a % of gross income (Eg GRDC 1%) was acceptable given that farming enterprises were returning about 15% net and R & D was increasing productivity in the vicinity of 2% per annum.
- Currently net returns on most agricultural incomes have dropped to less than 5% and increased productivity through R & D has declined to 0.2%.
- In simple mathematical terms every R & D 02 other levies equate to about 20% of a farmers net income for very questionable return on investment. (most rural enterprises have at least two "compulsory" levies)

Most farmers believe changing the current system is beyond their power or control. They feel shut out of the process of determining R & D projects with researchers and academics ***"telling farmers what they need"*** rather than listening to ***"what farmers <u>know</u> they need."***

This is a significant problem for farmers as they feel disempowered at all levels once they realise the facts.

R & D levies should be primarily to support the farming industries, it has been overtaken by "technocrats" supporting the research and academic industries and the core function has become a secondary consideration.

In my letter to the press and this enquiry on this matter I state

"*Mental health is seriously impacted by situations that any individual perceives to be beyond their control*". **(This applies to every strata of society)** In the case of levies farmers "perceive" it as beyond their control, which it is not.

In considering profitability farmers often experience this, feeling a sense of hopelessness believing that organisations outside their sphere of influence control their destiny. The flow on negative distress effect has a dramatic impact on the mental capacity of the farmer to manage all the issues of life generally. This almost certainly impacts personal relationships leading to family dysfunction and in extreme cases suicide."

This is my primary concern "Reducing a significant "Distressor creating Mental Anguish" for farming families.

There are a number of things that fit into this category (markets banks etc) but Levies, in their current state is one of the biggest, and in my opinion most resolvable by considering alternative options.

Two things that specifically cause the "situational distress" for the farmer are;

1. The financial problems outlined
2. The frustration with the technocrat system of project selection. I have been informed of situations where projects get funded because of who is on the selection panel rather than the merit of some of the proposals.

Suggestions?

- Abolish the current system based on Gross turnover to something linked to units of production. (per ton rate that is realistic)
- Reengage farmers in determining R & D projects, and the assessment of potential gains.
- Build in Profitability gains as well as production gains.
- Allow the use of R & D funds to improve overall Business Management Skills. We have high quality producers who often lack business and marketing skills.
- All levies should be separately invoiced or documented so farmers are fully aware of their contributions and have transparent access to the expenditure of their contributions.
- All projects must be funded on the merit of the project, not the links to the selection panel.

I wish you well in your deliberations and hope that a more appropriate and transparent method of funding can be recommended as soon as possible.

Julian Krieg
Chair RFCSWA.