Improving spraying and management of spotting bugs in avocados

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Growing Greener Growers

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by

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This report is published by Horticulture Australia Ltd to pass on information about a series of eleven air-assisted sprayer workshops for avocado growers held in the major growing regions in Western Australia, New South Wales and Queensland in 2007 and 2008.

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Media summary

Spotting bugs are major native pests of avocados along the east coast of Australia.

Spotting bugs have many alternate hosts from which they migrate into crops during spring and summer. Monitoring for the presence of spotting bugs in the crop allows growers to apply targeted sprays to eliminate the pest and reduce fruit damage. However most growers continue to apply sprays on a calendar or ad-hoc basis because of the perceived need to apply protective fungicides.

This series of eleven workshops in New South Wales, Queensland and Western Australia aims to give growers the knowledge and skills to monitor pests like spotting bug and make decisions on the appropriate actions for their individual situation. Currently the management of spotting bugs still often relies on effective spraying with broad-spectrum insecticides.

Spraying large canopies, such as avocados, is a complex process. In the past extension efforts have highlighted the importance of canopy air displacement to transport droplets to their target. The workshops focused instead on the importance of droplet kinetic energy and drift as major processes for spraying tall trees and on the appropriate calculation of Concentrate chemical rates.

The practical on-farm workshops demonstrated the effects of tractor speed, air volume and spray volume on coverage within the canopy. The flexible demonstrations, using an innovative system of placement of water-sensitive papers within the canopy, highlighted the ease of spraying the bottom of the canopy and difficulty in spraying the tops with hollow cone jets. The successful use of solid cone and solid stream jets to increase recovery in the tops was confirmed.

The steps involved in calculation of Concentrate rates based on an estimate of the Dilute spray volume and Dilute rate were presented and worked through. All participating growers were offered a free desktop assessment of their own sprayer’s calibration and received a comprehensive sprayer calibration manual to complement the field program.

The workshops were designed to give growers greater confidence in the calibration of their own sprayers and this should result in improved coverage and control with reduced off-target impacts.

Introduction

The problem

The native coreid fruit spotting bugs (FSB), *Amblypelta lutescens* and *A. nitida*, can cause high levels of immature fruit drop and shoot damage in many fruits, including avocados, in New South Wales (NSW) and Queensland (Qld). Spotting bugs are not known to be a problem in Western Australia (WA). For all practical purposes the two species are near identical and can be considered together.

Spotting bugs have been the subject of considerable research in Qld (Waite *et al*., 2000; Waite, 2004) and NSW (Huwer *et al*., 2006). A survey of avocado grower's practices by Drew (2005) identified several factors determining the importance of spotting bugs in individual avocado orchards. The first was strong regional differences. Overlying this were strong local hotspot differences, between blocks and varieties, the presence of which can be exploited by decision-making based on monitoring.

The survey by Drew (2005) was carried out in all avocado growing regions affected by spotting bug to quantify the impact of the pest across the industry. The survey found that the majority of growers were still spraying regularly with broad-spectrum insecticides like Endosulfan. However there appeared to be a generally poor understanding of sprayer calibration and particularly the new concepts of "Dilute" and "Concentrate" spraying now found on product labels. The likely results of this knowledge gap are poor coverage in tall canopies and under-dosing leading to incomplete control and increased frequency of sprays.

The survey found that overall 31% of respondents had combined losses and control costs of below $1000/hectare, while 38% had costs of $1000-4000, and only 11% had costs over $4000. This latter group represent two scenarios, low spray users with high losses and very high spray users with low losses.

The pest and the damage

Spotting bugs feed on a very wide range of plants and are often worse in areas adjoining natural bushland, particularly wet forest along creeks and waterways. An unknown number of ornamentals and native trees and shrubs can be hosts. They invariably attack only green immature fruit or lush new growth in all crops. While feeding spotting bugs secrete an enzyme which causes extensive breakdown of cells and this is why damage has a deep stained appearance. The adults and nymphs pierce fruit and shoots repeatedly and young fruit usually drop within a 5-10 days. Surface scars or depressions are usually present on small fruits of mango, persimmon or avocado but may be very difficult to notice in mature fruit. Older fruit may not drop but internal fruit quality is impaired and diseases and infestation by other insects such as Queensland fruit fly are more likely.

Eggs, which are oval, pale green and laid singly on fruit or leaves, hatch in 6-7 days in summer. Nymphs then pass through 5 stages taking about 5 weeks. They and the adults are very alert, often hiding from an observer. Nymphs do not travel far from their feeding site - damage is consequently often concentrated in individual trees or parts of trees. Adults are green, winged, slender and about 15mm long. They may live for more than 6 months. Females lay only a few eggs per day but more than 100 in their lifetime. There are usually 3-4 generations per year (one in spring, 1-2 in summer and one in autumn) and adults of the autumn generation overwinter to lay eggs in spring.

Management options

Improved management of spotting bugs needs to be based on a systematic on-farm monitoring program. Currently very few avocado growers do this because of perceptions of risk and low cost-effectiveness. Monitoring is feasible but time-consuming. Current control strategies could be improved by monitoring to determine pest activity and by improved timing in response to pest levels. There are number of control strategies in use or under consideration:

1. Qld DPI has been working on identifying FSB pheromones (sex attractants) to use in traps or baits, or in a breeding disruption strategy. NSW DPI has been following similar research based on attractants using host volatiles. Traps would greatly improve the cost-effectiveness of monitoring.

2. Native parasites and predators appear to be relatively unimportant in controlling FSB in the orchard. General predators such as spiders, assassin bugs and ants have been seen feeding on FSB, and a parasitic tachinid fly (*Pentatomophaga bicincta*) does parasitise nymphs and adults, but they are not effective in controlling their numbers. FSB are "stink bugs" and are well adapted to protecting themselves by releasing noxious allomones to deter natural enemies. Research into an egg parasitoid (*Centrodora darwini*) is continuing in both North Qld and Northern NSW (Huwer *et al*., 2006). Monitoring might improve the effectiveness of augmentative releases of beneficials.

3. Registered chemical controls in avocados include:
Endosulfan. Endosulfan is registered for use in avocados as a Dilute or Concentrate spray up to 5X concentration. It is still widely used as it is relatively soft on "beneficial insects" and compatible with most fungicides. It can only be purchased and used by persons with ChemCert accreditation. There is currently no restriction on the number of sprays in orchard crops.
β-Cyfluthrin. β-Cyfluthrin is registered in avocados as a Dilute or Concentrate spray up to 5X concentration. It should be used with great care as it may cause flare-ups of scale and mites.
Methidathion and Trichlorfon. Both products are registered in avocados as a Dilute or Concentrate spray up to 5X concentration. It appears that successful control is strongly rate-dependant in both cases. Methidathion has good scale control activity.
Chlorpyrifos and Methomyl. Spotting bug may be partly controlled by these chemicals applied for other pests. Methomyl is of very short persistence.

Spray application

Sprayer calibration is a critical issue in the safe and effective application of pesticides in avocados. However many growers have a poor understanding of the link between sprayer setup and chemical concentration. A series of spray technology workshops was carried out in avocado and macadamia orchards in Qld, NSW and WA in 1997-98 (Battaglia, 1999). The workshops and manuals, funded by HAL Project No. HG97011, focused on the canopy air-displacement model of spraying and did not cover issues of appropriate spray volume or pesticide concentration because they were, at that time, inconsistent with pesticide product labelling. Approximately 500 copies of the workshop manual "Efficient Pesticide Use in Tree Crops" were distributed (Battaglia, Woods, & Hughes, 1997).

The concept of low volume Concentrate spraying has been recommended by Qld DPI for nearly 20 years (Banks *et al*., 1990). However it was not until 2000 that doctoral research by Drew (2000) stimulated a regulator/chemical industry review leading to labelling changes permitting the use of Concentrate sprays.

With funding from the AMS and HAL research into optimum performance of sprayers in very large macadamia canopies was carried out under HAL Project MC00041 (Drew *et al*., 2004). This project recommended a macadamia industry standard Dilute spray volume of 6.0 L/100m^3 of canopy on which to base Concentrate spray concentrations (Drew, Betts & Geitz, 2002).

The project identified constraints and opportunities for improvement in the main technologies used in large canopies such as macadamias, avocados and mangoes. It particularly emphasised the importance of kinetic energy of droplets as an alternative to canopy air displacement and drift as the optimum process for spraying the tops of tall canopies like avocados.

The workshops

The aim of the current project was to hold intensive, practical, hands-on one-day spotting bug management/spraying workshops in the main avocado growing regions in WA, Qld and NSW. The workshops followed a similar format to those successfully presented for the macadamia industry (Drew, 2004).

The spotting bug component focused on spotting bug identification, monitoring and decision-making. The spraying component was designed to complement the ChemCert accredited courses but with greater focus on air-assisted sprayer setup to suit the full range of crop scenarios and individual grower needs. Key aspects were on preparation of the sprayer including jet selection, observation of spray application, spray assessment using water sensitive papers and Dilute and Concentrate calibration calculations.

The workshops should result in better calibration of sprayers resulting in fewer sprays applied, lower off-target impacts, better fruit quality and improved returns to growers. Improved calibration may also reduce direct costs of spraying, reduce risk and increase the value of the crop. The workshops will give the participating growers the skills to continually adapt their practices to new pest challenges, changes in pesticide product labelling or changes to agronomic practices, such as pruning regimes.

Technology transfer strategy and activities

Workshop venues

The planned program of workshops was advertised in the AAL magazine "Talking Avocados" and by direct mail-out to AAL members. Venues were determined by AAL on the basis of demand and equity.

Eleven one-day workshops were held at Carabooda WA, Pemberton WA, Alstonville NSW, Stuarts Point NSW, Comboyne NSW, Peats Ridge NSW, Glasshouse Mountains Qld, Childers Qld, Blackbutt Qld, Walkamin Qld and Mareeba Qld (TABLE 1).

The workshops were open to growers and farm managers on a first-come first-served basis with any free spaces available to consultants and DPI extension staff. Workshops bookings and payment of a nominal fee were handled by AAL and were restricted to approximately 20 participants per workshop. The small numbers at each workshop gave all participants a very good opportunity to participate and interact. Workshops began at 9.00 am and finished at 4.00 pm on each date. Morning smoko and lunch were provided by AAL at all workshops. Workshop hosts were reimbursed for machinery use expenses but gave their time freely. All the venues and demonstration areas were excellent and many thanks to the workshop hosts.

TABLE 1. Workshop hosts, venues and participants

NO.	DATE	HOSTS	VENUE	STATE	No. Growers attending.	No. Sprayer, Chemical Co & DPI attending.
1	01/05/07	Alan Blight	Carabooda	WA	**7**	0
2	03/05/07	Wayne Francheschi	Pemberton	WA	20	0
3	09/05/07	Des & Bev McCulloch	Blackbutt	QLD	23	0
4	16/05/07	Gordon Burch	Comboyne	NSW	12	3
5	17/05/07	Tim Kemp	Peats Ridge	NSW	6	2
6	24/05/07	Jim Carney	Childers	QLD	13	3
7	18/07/07	Dennis Howe	Walkamin	QLD	22	0
8	01/05/08	Malcolm Heather	Stuarts Point	NSW	6	0
9	14/05/08	House With No Steps	Alstonville	NSW	15	1
10	19/05/08	Kerry Smerdon	Glasshouse Mountains	QLD	10	1
11	26/06/08	Bob Waterman	Mareeba	QLD	8	2

A total of 154 participants attended - 27 from WA, 45 from NSW and 82 from Qld. The great majority of these were growers (142) with 12 representatives of local DPI, spray machinery or chemical resellers. Local DPI officers attended 3 workshops at Peats Ridge, Alstonville and Mareeba.

Of the growers attending 19% were from WA, 27% from NSW and 54% from Qld. AAL estimates that while only 14% of the total number of growers attended, these represented nearly two thirds (62%) of total avocado production in Australia.

The largest groups (>20) were from Pemberton WA, Blackbutt Qld and Walkamin Qld. The smallest groups (<10) were from Carabooda WA, Peats Ridge NSW and Stuarts Point NSW. In some ways these reflected the size of the local industries but also the cohesiveness of local subgroups. They may also reflect previous levels of service delivery by local DPI and resellers.

Workshop format

The format for each workshop was flexible. Participants were encouraged to raise their own specific concerns and to query the information presented. Questions were addressed at any time.

The key components of each workshop were as follows:

- Welcome by host and introduction to the issues
- Distribution of workshop manuals (Drew, 2007)
- Results of surveys and research into spotting bugs
- Results of spray trials and research in large tree crops
- Discussion of sprayers, nozzle types, droplet size and kinetic energy
- Discussion of routes by which droplets reach their target
- PRACTICAL DEMONSTRATIONS
  Systematic focused monitoring techniques
  Spray coverage assessment using water sensitive papers
  Measuring speed, pressure / flow rates, canopy volumes
  Effects of changes in speed / air volume, spray volume and droplet types on coverage
  Effects of different equipment type (where available) on coverage
- Discussion of legislative issues relating to spray volumes, chemical rates and product labels
- PRACTICAL Calculation of Dilute and Concentrate volumes and chemical rates for different canopies and sprayers
- Distribution of evaluation forms

While the initial sprayer setup was pre-determined (the host's current practice) subsequent setups (eg. speeds, volumes, jets, etc.) for demonstrations were selected by the participants. The strong focus was on understanding the full calibration process for each type of spray technology so that participants could confidently modify, or adjust, and calibrate their own sprayer after the workshop to suit their own crop and pest priorities. Each participant received a Workshop Manual containing step-by-step calibration sheets.

Workshop follow-up

Since the workshops a number of growers have sent in their calibration details for a desktop analysis. This free service is on-going for 12 months.

Local issues

Discussion during the workshops showed that there was wide variation between regions and individual growers in both insect and disease management strategies. Wetter areas, such as Pemberton, Comboyne/Peats Ridge, Alstonville and Glasshouse Mountains, were generally applying calendar fungicide sprays. Drier areas, such as Bundaberg, Blackbutt and Walkamin had some growers doing no fungicide sprays at all.

Differences in insecticide use and efficacy are harder to interpret. Certainly wetter coastal areas (except WA) reported bigger spotting bug problems. However these areas also tend to have smaller orchards and blocks, and would be subject to bigger "edge-effects". Given that a number of growers have been applying Concentrate spray volumes (low volume below runoff) with Dilute spray rates it is difficult to determine if poor spotting bug control is attributable to high pest pressure or ineffective spraying. In worst cases I suspect both.

Evaluation

At the end of each workshop all participants were given or emailed an anonymous evaluation sheet to complete and return. Eighty four out of 154 participants returned their evaluations.

The questions, number of responses to each question and an average percentage response are outlined below. Not all respondents answered all the questions. The responses were generally very positive but it was apparent that some individuals were overawed by the complexity of the spraying process.

- 80% of respondents rated the workshop as very relevant to their farm.
- 97% of respondents said the workshop had made them quite confident or very confident in managing spotting bugs.
- 99% of respondents said the workshop had made them quite confident or very confident in setting up their own sprayer.
- 74% of respondents said the information was presented in a very clear way, with 24% saying quite clear.
- 76% of respondents rated the venue and demonstrations as very good.
- 10% of respondents said any particular subjects were confusing or poorly presented.
- 17% of respondents said some subjects should have been covered in more detail.

The individual questions and the number of responses to each were:

Q1. How would you rate the relevance of the workshop to your farm operation?

Very relevant	66 (80%)
Quite relevant	16 (20%)
Undecided	0
Not very relevant	0
Irrelevant	0

Q2. Has the workshop made you more confident in managing spotting bugs?

Very confident	20 (27%)
Quite confident	52 (70%)
Undecided	2 (3%)
Less confident	0
No way!	0

Note: WA does not have spotting bugs. All other areas visited had significant problems.

Q3. Has the workshop made you more confident in setting up and calibrating your own sprayer?

Very confident	25 (33%)
Quite confident	48 (63%)
Undecided	3 (4%)
Less confident	0
No way!	0

Q4. Was the information generally presented in a clear way

Very clear	62 (74%)
Quite clear	22 (26%)
Undecided	0
Not very clear	0
Confusing	0

Q5. How would you rate the venue and demonstrations?

Very good	63 (76%)
Quite good	20 (24%)
Undecided	0
Quite poor	0
Very poor	0

Q6. Were any particular subjects confusing or poorly presented?

No	75 (90%)
Yes	8 (10%)

Q7. Should any particular subjects have been covered in MORE detail?

No	66 (83%)
Yes	13 (17%)

"Yes" responses included:

- Spraying. (?)
- Probably differences in sizes of sprayers – 3-point linkage units, but spray time was curtailed due to spotting bug basics (not needed).
- Identification of FSB & parasites, IPM of FSB.
- Probably the per hectare calculation for total tree volume.
- Different types of air delivery.
- Calculation record: Actual spray volume per $100m^2$ of canopy.
- Good balance.
- Some more time on different spray options, individual fan options.
- Best options for minimising spraying are important.
- Some people found the calibration sheets confusing.
- Mathematical example could be done in more detail, not all farmers are good at maths, eg. on Powerpoint.

Q7 "Yes" responses continued …

- Concentrate application rates.
- Yes, What sprayer is best and how should it be set up.
- Key factors in calibration - this seems to me to be the crux of the matter but with so many variables (eight in total) understanding their relationships in more detail would have been helpful.

Q8. Should any particular subjects have been covered in LESS detail?

No	77 (98%)
Yes	1 (2%)

Q9. How else could the workshops have been improved? All comments welcome …

Comments included:

- Very good – I now know more about spotting bug lifecycle than has been explained before.
- Enjoyed the presentation, especially variations in chemical rates above or below dilution rates.
- If possible more examples of spray equipment.
- Achieved what I expected.
- The hands-on with the sprayer and canopy management was excellent.
- Terrific field day – I got a lot out of everything.
- Over two days with more farmer input.
- Very good day.
- Great workshop – No changes needed.
- Excellent presentation by Henry – clear and logical.
- Might have been useful to compare different sprayer configurations eg. plain axial flow versus c/w conveyor versus quantum etc.
- Level of economic damage and cost benefit to spray versus not spray.
- Not much chance of fitting in more, but felt like another ½ day would have been good.
- Could include more types of different sprayers to demo.
- Would be keen to note any difference in spray coverage.
- Maybe sprayer manufacturers could supply machines not available in local area.
- It was pretty good.
- Excellent workshop manual – Arrows and scale bars on insect photos would be helpful.
- Possibly more practical on calculating flow rates of nozzles.
- More sun would have been nice.
- Actual specimens of spotting bugs.
- My wife and myself found the day very informative – Excellent.
- All good.
- Excellent day.
- Found the workshop very worthwhile and informative.
- Most of our spraying here would relate to dieback (*Phytophthora*) control – Would have like to look at this application more closely.
- Overall very good.
- Some parts I found confusing because it's all new to me. It would have been helpful to use whiteboard/overhead or data projector for the theory parts.
- For me (a novice) it was a very good investment in time.
- I wish I could only have a clearer picture of where to go from here. I hope you can help me when I send through my details for assessment. In the meantime I'm going to buy a packet of water sensitive papers!!
- Thanks for bringing some science to what I thought was an art!!!

Discussion

The workshops were very well received by participants. Many growers put positive comments on their evaluation forms. Most negative comments related to a shortness of time or to the balance in time spent between spotting bugs and spraying issues. At most workshops there were still places available for participants. The booking system worked well but not all those who booked turned up on the day. Making growers book through AAL may have reduced the numbers attending by eliminating "spur of the moment" growers.

Comments at the workshops suggested that there was still confusion on a few issues, namely:

- **The calculation of Concentrate mixing rates for different blocks on one farm**.
  Hectare rates have the same problems. Some growers feel that spraying all blocks to, or beyond, runoff with Dilute sprays overcomes this complexity. Of course it does, but the cost is in higher water volumes and increased runoff to the soil.

- **The frequency of copper sprays required for anthracnose control in different districts**.
  This is a key issue hindering the adoption of insect pest monitoring in avocados. This is because many growers feel that the addition of insecticides to a calendar fungicide program is highly cost-effective. What is not clear is whether the calendar fungicide programs (and their frequency) are necessary to produce quality fruit in all areas. This is despite on-going research on this issue (Anderson *et al*., 2005; Willingham *et al*., undated). If the number of fungicide sprays can be reduced then the cost-benefit of applications of insecticide based on pest monitoring is improved. There were extremely divergent positions on this issue amongst growers with some applying no fungicides and others applying up to 16 sprays per season. While there is no evidence of fungicide applications affecting parasites or predators of spotting bug the damaging effects on soil microfauna are well known.

- **The coverage required with copper sprays to achieve acceptable anthracnose control**.
  The mode of action of protective copper sprays suggests that 100% coverage of fruit is not necessary to achieve protection from anthracnose. This is because the copper ions that kill spores are only released when there is surface moisture. This moisture redistributes copper residues on each occasion. However many growers are unconvinced that lower water volumes combined with Concentrate mixing rates of copper fungicides will achieve equal control to Dilute sprays to, or beyond, runoff. There was no consistent position amongst growers on the advantages of different brands and formulations of copper fungicides.

Other issues arising out of the delivery of the workshops were:

- **The consistency of advice from "experts".**
  There is currently no training program on Dilute vs Concentrate spraying issues for consultants, spray machinery or chemical resellers, or DPI officers – all of whom could be considered "experts" under the label guidelines. The ChemCert program for growers also does not have a specific tree crops module dealing with these issues. There have been some attempts to standardise recommendations based on tree area (rather than canopy volume) and to include guidelines on labels (Furness, 2006) but these have been opposed by many independent consultants, chemical companies and the APVMA. There is a need for a national approach to training under ChemCert or Agsafe.

- Systematic monitoring will only be adopted by growers if it is reliable and cost-effective. Currently there is very little avocado monitoring experience amongst crop consultants because there is no demand from growers. Field monitoring is currently time consuming, and therefore expensive, and in high pest pressure areas may not result in lower costs or higher quality fruit. In low pest pressure areas, particularly on bigger farms with lesser edge-effects, monitoring for spotting bugs and other pests can have significant benefits. However the development of spotting bug traps would greatly reduce monitoring costs, improve reliability, and probably swing the balance away from calendar spraying to strategic applications even in high pest pressure areas.

  The other drivers for a move away from calendar sprays to strategic application would be:
  1) Failure of the current system due to pest resistance – Low probability.
  2) The emergence of secondary pests (such as scale and mites) due to suppression of natural enemies – Medium probability if Endosulfan is withdrawn.
  3) Big increases in pesticides costs (either copper fungicides or insecticides), tipping the balance in favour of monitoring – Medium probability. With the current very high price of copper fungicides both avocado and mango growers are exploring the possible use of 2-3 applications of Amistar alone instead of calendar copper.

Recommendations

The following recommendations are made:

1. That on-going research into spotting bug trap crops, host volatiles and pheromones be supported.

2. That further research be carried out on the required frequency and coverage of copper and Amistar fungicide sprays required to control anthracnose. An economic assessment needs to be carried out to compare a proven calendar program with strategic application based on monitoring. This may be possible through data collected under the Avoman program.

3. That research be carried out into developing a quick field test (swipe test) for copper residues to determine actual levels and better manage the frequency of sprays.

4. That AAL survey its members in coming seasons to see if changes in sprayer setup arising out of the workshops can be linked to improved quality or reduced costs.

5. That AAL publish information each year in Talking Avocados on labelling issues, including the Dilute versus Concentrate concepts.

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Bibliography

- ANDERSON, J.M. *et al*. (2005). New strategies for the integrated control of avocado fruit diseases. New Zealand & Australian Avocado Growers Conference, Tauranga, New Zealand, 20-22 Sept. 2005.

- BANKS, A. *et al*. (1990). Pesticide application manual (2nd ed.). Brisbane, Australia: Queensland Department of Primary Industries.

- BATTAGLIA, R., WOODS, N & HUGHES, P (1997). Workshop Manual on Efficient Pesticide Use in Tree Crops. UQ Gatton College / HRDC / QDPI, Gatton, Australia.

- BATTAGLIA, R. (1999). Macadamia and avocado spray technology workshops. Final report, Project HG97011. Gatton, Australia: Queensland Department of Primary Industries / HRDC.

- DREW, H. (2000). The management of pesticide application dose in Australian orchards: One glug or two? Doctoral Thesis, November 2000. University of Queensland, Brisbane, Australia.

- DREW, H., BETTS, G. & GEITZ, G. (2002). So what is the appropriate Dilute spray volume in macadamias? Australian Macadamia Society News Bulletin. July 2002, Vol. 29, No. 4, 58-62.

- DREW, H. *et al*. (2004). Spray technology for optimum pesticide application in macadamias. Final report, Project no. MC00041. Horticulture Australia Ltd, Sydney, Australia.

- DREW, H. (2004). Sprayer setup to suit your needs and orchard. Final report, Project no. MC03002. Horticulture Australia Ltd, Sydney, Australia.

- DREW, H. (2005). Spotting bug management in avocados – A review. Paper presented at New Zealand & Australian Avocado Growers Conference 05, Tauranga, New Zealand, 20-22 September 2005.

- DREW, H. (2007). Improving the management of spotting bugs in avocados. Grower workshop manual. Project no. AVO6001. Horticulture Australia Ltd, Sydney, Australia.

- FURNESS. G. (2006). Orchard and vineyard spraying handbook for Australia and New Zealand. SARDI, Adelaide, Australia

- HUWER, R.K. *et al*. (2006). Advancing Integrated Pest Management in macadamias. Final Report, Project Nos. MCO2048 and MCO5005. Horticulture Australia Ltd, Sydney, Australia.

- WAITE, G. *et al*. (2000). Ecology and behaviour of fruitspotting bugs. Final report, Project no. HG97010. Horticulture Australia Ltd, Sydney, Australia.

- WAITE, G. (2004). Fruitspotting bug management using hotspots for targeted monitoring and control. Final report, Project no. AVO2002. Horticulture Australia Ltd, Sydney, Australia.

- WILLINGHAM, S. *et al*. (undated). Which Copper Fungicide Should I Use? From HAL Project No. AV97001 – Field Management of Avocado Postharvest Diseases. Horticulture Australia Ltd, Sydney, Australia.