Australian Sweet Persimmon Industry Development - Phase 3

Grant Bignell
The Department of Agriculture, Fisheries and Forestry, Qld

Project Number: PR12000

PR12000

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FINAL REPORT FOR HAL PROJECT PR12000

(May 2014)

AUSTRALIAN SWEET PERSIMMON INDUSTRY DEVELOPMENT PROJECT (Phase 3)

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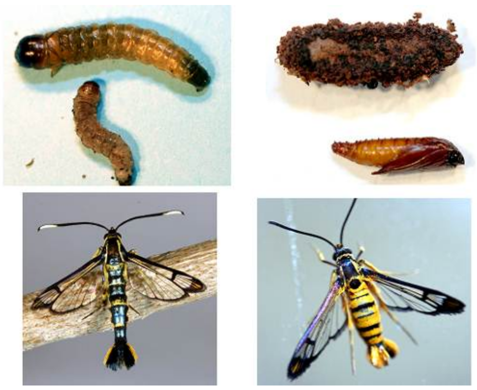

HAL Project Number: PR12000

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This is the final report for RD and E work conducted for the Australian Persimmon Industry from 2012-2014.

This project was funded by Horticulture Australia Limited (HAL) using the persimmon levy and matched funds from the Australian Government.
This is an integrated research, development and extension project where the following team members all contributed significantly to successful project outcomes.

Grant Bignell	**Research Scientist, DAFF**
David Bruun	**Field Operations Manager, DAFF**
Lara Senior	**Entomologist, DAFF**
Alan George	**Horticulturalist, APAC**

Date of report: May 2014

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SUMMARY

MEDIA SUMMARY

The Persimmon industry is established from the semi-tropical far north of Queensland to the cool temperate zones of Victoria, South Australia and Western Australia, with no single centre of production. Fruit from warmer regions mature four months earlier than southern States, giving the industry a harvest spread from February to July inclusive. The majority of the Australian industry is based on sweet (non-astringent) cultivars with the major varieties including Jiro, Fuyu and Izu. Yield and fruit size vary within and between regions. There are approximately 250 growers producing 700,000 (4kg) trays from approximately 130,000 producing trees. Currently the Persimmon Industry Association has approximately 150 members and the Australian industry is estimated to be worth approximately $12 million. Significant new plantings have taken place in Victoria and South Australia. Improving fruit quality, minimising pest and disease and increasing post-harvest storage life are critical to increasing market penetration for both domestic and export markets.

The objective of this two year project was to improve fruit quality of Australian persimmons through varietal selection, pest and disease control, post-harvest handling methods and dissemination of R&D findings to growers in major production regions.

We have evaluated several mealybug monitoring techniques and have identified systemic insecticides which are effective in controlling mealybug populations in persimmon orchards. We have evaluated the efficacy of clearwing moth mating disruption pheromones and identified potential insecticides for their control. We have produced and released an extension video to educate growers on control options for clearwing moth. Trials on disease have been inconclusive due to dry conditions throughout this project. Australian persimmon growers have been informed of the latest R&D findings through series of field days and workshops in Queensland and Victoria.

Through a series of postharvest trials incorporating the ethylene inhibitor 1-MCP and modified atmosphere bag technologies we have developed storage recommendations for varieties Fuyu and Jiro from different growing regions. Postharvest strategies have been presented in the Persimmon Postharvest Manual which has been distributed to all levy contributing growers.

TECHNICAL SUMMARY

The objective of this two year project was to improve fruit quality of Australian persimmons and to develop improved post-harvest handling methods. The project focussed on evaluating key pre- and post-harvest management factors affecting fruit quality.

A range of scientific methodologies were used including statistical and observational trials to evaluate key management factors affecting fruit quality and post-harvest storage life.

The project involved research, extension and industry development officers from Queensland Department of Agriculture, Fisheries and Forestry (DAFF) and commercial growers from Persimmons Australia Inc. (PAI).

The project has produced important results for the Australian persimmon industry, as listed below.

- We have identified soil and foliar applied systemic insecticides that can potentially reduce the level of clearwing moth infestation in persimmon orchards. We showed that Altacor® (chlorantraniliprole) when sprayed in November reduced clearwing larvae damage significantly. However more research is required to establish the best timing of application.

- We found that systemic insecticides can reduce mealybug infestations. The use of Samurai® as a soil drench applied in October can significantly reduce the levels of infestations of mealybug under the calyx of persimmon.

- We found that the efficacy of clearwing moth mating disruption pheromone dispensers can be variable between orchards and will not control this moth alone. Removal of background populations through mechanical methods such as water blasting and the use of insecticides need to be part of an integrated management approach for this pest.

- We have found significant borer damage in Fuyu trees in South Australia. Most samples recovered from these trees have failed to pupate and allow a positive identification of this pest. Monitoring traps have also failed to catch any moths that could potentially be causing this damage.

- A postharvest manual has been written containing 27 chapters describing pre and postharvest factors that can influence the quality of persimmon. The manual has chapters on:

    - Fruit development and ripening
    - Maturity standards and harvesting
    - Packhouse procedures and grade standards
    - Cool storage
    - Cool chain handling
    - Quality assurance and food safety
    - Exporting and disinfestation

  The manual has been distributed to all levy contributing growers in USB flashdrive format.

- Pest and disease strategies have been developed for Australian growers. These strategies have been presented in an Integrated Pest and Disease Manual which has been updated to include new minor use permits.

- We have found that Jiro from coastal and inland regions can be stored for two weeks at 15ºC and up to six weeks at 0ºC when treated with 1-MCP.

- We have found that Fuyu from coastal and inland regions can be stored for two at 15ºC using 1-MCP and up to 10 weeks at 0ºC when using a combination of 1-MCP and modified atmosphere bags.

- We have found Jiro is sensitive to internal flesh blackening when treated with 1-MCP and stored in modified atmosphere bags for longer than two weeks at 0ºC.

- We have identified a successful clonal propagation technique for cuttings of Jiro, Fuyu and Rojo Brillante.

- The introduction of Rojo Brillante has been delayed due to imported budwood containing a mixture of cultivars. Trees of the correct cultivar have been propagated and will be distributed in spring 2014. Due to the small numbers of mature trees, evaluation of this cultivar will need to continue before recommendations can be made for different growing regions.

INTRODUCTION

The Persimmon Australia Inc. (PAI) instigated a grower levy to support RD and E activities in 2005. The industry has funded three R&D projects which were conducted between 2006 and 2014 (HAL Projects PR 6000, PR09000 and PR12000 "Australian Sweet Persimmon Industry Development – Phase 1, 2 and 3). These projects have been highly successful in developing new technologies for industry.

The major objective of this project was to investigate control options for mealybug and clearwing moth, assess new persimmon cultivars, identify leaf and fruit diseases and finalise post-harvest management protocols. This report will present results from mealybug, clearwing moth and postharvest trials and report on extension activities carried out during 2012-2014.

RESULTS AND DISCUSSION

THE EFFECTIVENESS OF SYSTEMIC INSECTICIDES FOR CONTROLLING MEALYBUG IN NON-ASTRINGENT PERSIMMON

INTRODUCTION

Mealybugs are a major pest of persimmon in Australia. Export shipments can be condemned or downgraded if mealybugs are found beneath the calyces of fruit. Therefore, fruit need to be regularly inspected for the pest.

Citrus mealybug occurs throughout Australia but is much more common in coastal districts and in the areas north of Sydney in the eastern states. Longtail mealybugs are more prevalent in Victoria and South Australia. Mealybugs are normally found from mid-November with reasonable populations tending to build up by mid-December. Higher populations seem to be building up earlier in recent years. If left untreated, very high populations will be present by mid-January on most persimmon blocks. Extensive sooty mould will develop in many trees. The mealybug infestation becomes economically serious when 25% or more of the fruit has one or more adult female mealybugs present.

There are about 6 generations of the mealybug per season. The mature females lay some 500 eggs in a loose cottony mass; these hatch into yellow crawlers, which settle under the calyx of the fruit and pass through three moults before reaching the female adult stage (Figure 1). The male mealybug goes through 4 moults before emerging as a fragile winged adult.

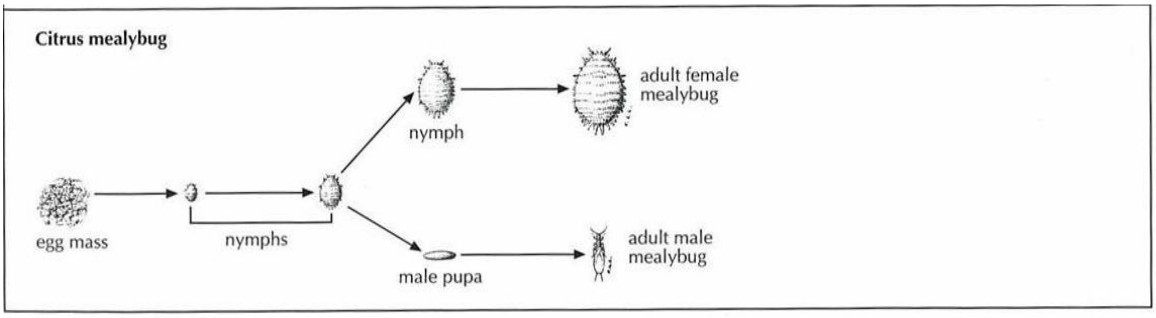

Figure 1- Life cycle of the citrus mealybug (*Plannococcus citri)*

Current chemical control of mealybug in Australian persimmon consists of high grade petroleum and parafinnic oils, methidathion *(Supracide®)* and Buprofezin *(Applaud®).* These current methods of chemical control depend greatly on good spray coverage in densely foliaged trees. Mealybug predominantly infest under the calyx of persimmon which often results in contact prays being ineffective. Systemic insecticides allow suppression of phloem-feeding insects as the systemic activity directly exploits their feeding behaviour (Cloyd et al., 2012). Systemic insecticides are commonly applied as a soil drench for uptake or absorption through the roots, and then translocated to the rest of the plant through the vascular system (Norris 1967). The use of five different systemic insecticides to control actively feeding mealybugs was trialled on the non-astringent variety 'Jiro'.

Imidacloprid (Confidor®)

Imidacloprid is used in New Zealand to control mealybugs in grapes. Similar to persimmon, controlling mealybug in hard to treat areas of grapevines such as the underside of leaves, inside bunches and under bark and roots has posed a challenge (Lo et al., 2011). Imidacloprid is taken up by the roots of plants and travels within the sap flow. It works slowly on the nervous systems of insects and directly influences insect behaviour, resulting in an "anti-feeding" effect. Imidacloprid has long-lasting residual efficacy and has a 20 week withholding period when used on citrus. Confidor was shown to control mealybug and scale insects in mango (La Lagadec and Brewer, 2002).

Clothianidin- (Samurai®)

Clothianidin is registered for control of mealybug in apples, pears and grapes and can give effective control of woolly apple aphid in large trees. Clothianidin has systemic and residual activity while also having contact efficacy and can be used with IPM as it has low mortality rates on predators and parasatoids (Cloyd 2006).

Thiamethoxam- Actara®

Thiamethoxam is a unique systemic insecticide that claims to provide excellent, fast-acting and long-lasting elimination of a broad range of foliar and soil pests.
When Thiamethoxam is applied to the soil, it is readily taken up by the roots and rapidly translocated throughout the plant. Once inside the plant, thiamethoxam is slowly metabolized, resulting in extended residual control. Trials on mangoes proved that thiamethoxam applied at 1.44 g ai (6ml) per tree was the most cost effective dosage for controlling scale insects and mealybugs (Le Lagadec, 2003).

Spirotetramat (Movento®)

Spirotetramat is effective in controlling juvenile stages of many sucking insects including mealybugs, soft and armoured scales, aphids, psyllids, and whiteflies. It exhibits excellent translaminar efficacy against targeted pests and has limited contact efficacy ((Nauen et al., 2008). Once penetrated into the plant spirotetramat is hydrolysed to its enol form. As a weak acid this compound is mobile within the phloem of the plant. Hence it can move acropetally and basipetally and control hidden pests (Nauen 2008). This insecticide is very well suited to IPM as it has a limited effect on predatory insects.

Sulfoxaflor- Transform®

Sulfoxaflor is systemic, with translaminar activity in the plant on a broad range of sap-feeding insects and has extended residual control. It has a unique mode of action (a unique interaction with the nicotinic acetylcholine receptor) and will therefore have a new IRAC classification (4C). It is claimed to have no cross resistance with any other insecticide group. Sulfoxaflor is effective against aphids, mirids and whiteflies and has activity on mealybugs, some thrips and other bugs (http://www.dowagro.com/au/prod/transform.htm).

MATERIALS AND METHODS

Experiment 1

A commercial block of the cultivar Jiro was selected on an orchard in Woombye which had traditionally experienced large populations of mealybug. This trial was established using a randomised block design. Six replicates of three tree plots were used for each treatment, using the middle tree for data collection. A normal commercial spray regime of contact kill insecticides methidathion *(Supracide®)* and Buprofezin *(Applaud®)* was used by the grower in combination with these treatments; therefore these treatments including the control were supported by these sprays. Populations of longtailed mealybug, (*Pseudococcus longispinus)* were observed in high numbers throughout the block.

Five different systemic insecticides were trialled:

Soil applied (drench)

- Imidacloprid- Confidor® 200g/L
- Clothianidin- Samurai® 500g/kg
- Thiamethoxam- Actara® 240g/kg

Foliar sprayed

- Spirotetramat- Movento® 240g/kg
- Sulfoxaflor- Transform® 240g/L

Soil applied insecticides were diluted in 2L water and applied as a soil drench on 12th October 2012 at the following rates;

- Imidacloprid- Confidor® 6ml per tree
- Clothianidin- Samurai® 5g per tree
- Thiamethoxam- Actara® 6g per tree

A light irrigation was applied following application of soil drench treatments to allow good penetration of each chemical to the root zone.

Foliar applied insecticides were sprayed to the point of run-off on 16th October 2012 at the following rates;

- Spirotetramat- Movento® (plus Maxx® surfactant) 40ml/100L
- Sulfoxaflor- Transform® (plus Maxx® surfactant) 40ml/100L

20 fruit from each data tree were randomly selected and inspected under the calyx for mealybug. This process was repeated throughout the fruit development period in January 2013, early March 2013 and just before harvest in late March 2013.

Experiment 2

The persimmon trial block on Maroochy Research Facility (MRF) was used to trial the same chemicals and rates as experiment one, however soil drench treatments were applied on the 18th October 2012 and foliar applied treatments were applied on the 6th October 2012. No additional insecticide sprays were used in this trial so the effectiveness of the treatment alone could be observed.

Populations of longtailed mealybug, (*Pseudococcus longispinus)* were observed in high numbers throughout the block. Treatments were applied in a randomised block design using six individual tree replicates of each treatment.

Data analysis was performed using a generalised linear regression model (glm) in GenStat. The total number of mealy bugs was analysed using a log-linear regression model assuming a Poisson distribution (and a log link). The proportion of fruit with mealy bug was analysed using logistic regression (assuming a binomial distribution with logit link – as each of the 20 fruit either had mealy bugs or did not (presence or absence).

RESULTS AND DISCUSSION

Experiment 1

All treatments reduced the percentage of fruit infested by mealybug in January compared to the control treatment. Samurai® was the most effective treatment with 6.7% of fruit having some level of infestation under the calyx and an average of 1.7 total mealybug, which indicates when there was mealybug under the calyx it was usually in very low numbers (Figure2). There was no significant treatment effect on total mealy bug number (P=0.335) or on proportion of fruit with mealybugs (P=0.292) at the January assessment.

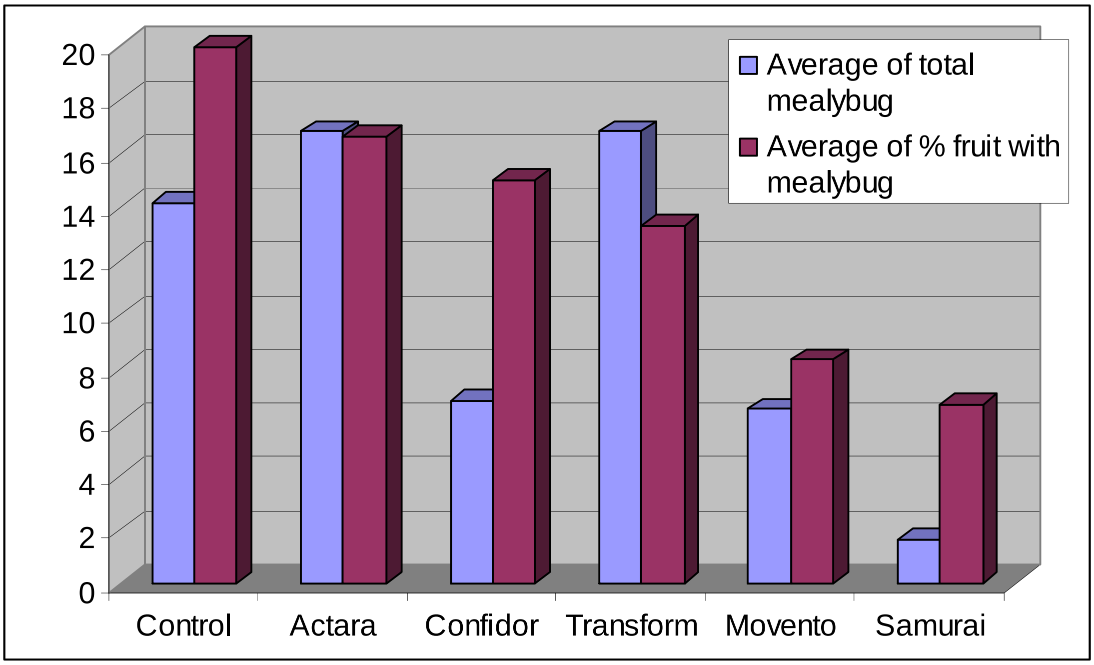

Figure 2- Difference in average total mealybug and average percentage of fruit with mealybug infestations between chemical treatments in January 2013 at Woombye.

Mealybug counts in early March showed similar levels of mealybug with Samurai® again being the best treatment with 5.8% of fruit having mealybug under the calyx (Figure 3). All treatments had less percentage of fruit with mealybug compared to the control; however Actara and Transform had higher total numbers of mealybug than the control. There was no significant treatment effect on total mealy bug number (P=0.990) or on percentage of fruit with mealybugs (P=0.491) on the early March assessment.

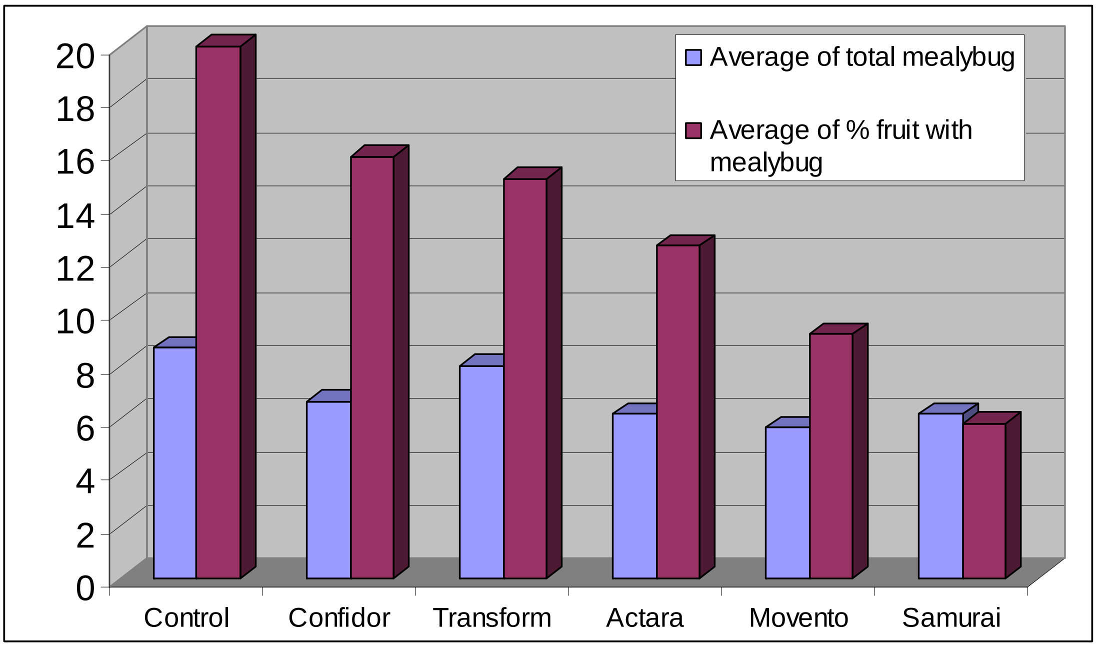

Figure 3- Difference in average total mealybug and average percentage of fruit with mealybug infestations between chemical treatments in early March 2013 at Woombye.

Mealybug counts taken just before commercial harvest in late March showed Samurai® was the most effective treatment with 6.7% of fruit infested with mealybug and an average total mealybug count of 4.2 (Figure 4). There was a significant treatment effect (P=0.017) on the percentage of fruit with mealybug (Table 1) and almost a significant treatment effect (P=0.058) on the total number of mealy bugs (Table 2).

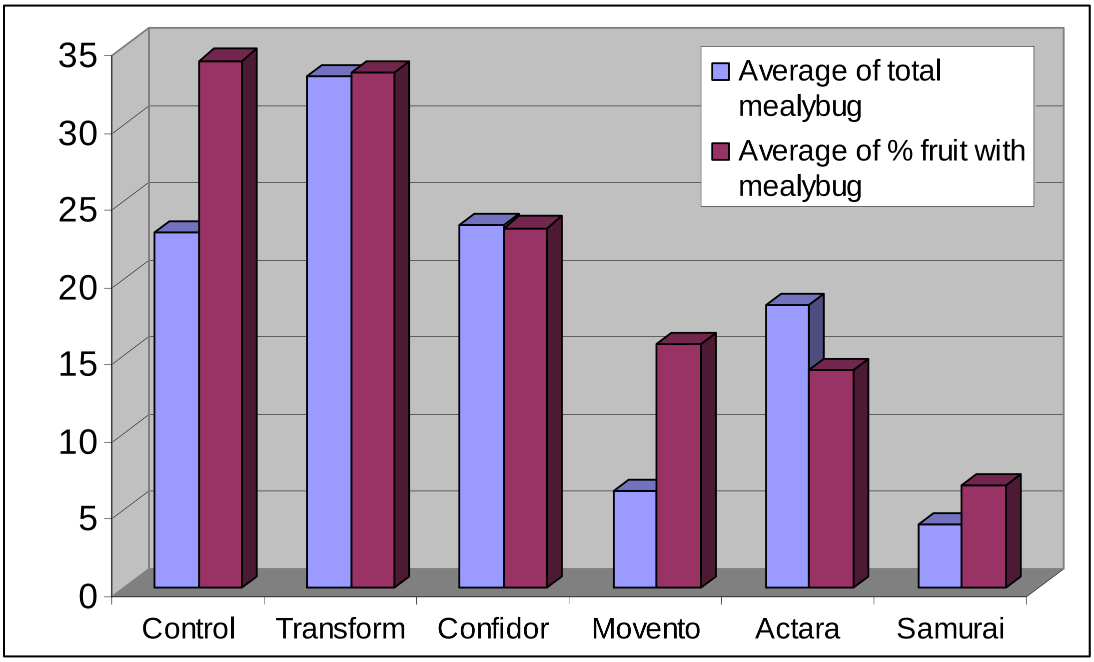

Figure 4- Difference in average total mealybug and average percentage of fruit with mealybug infestations between chemical treatments in late March 2013 at Woombye.

Treatment	Prediction	s.e.	
Samurai	0.0667	0.03442	a
Actara	0.1417	0.04805	ab
Movento	0.1583	0.05028	abc
Confidor	0.2333	0.05818	bcd
Transform	0.3333	0.06476	cd
Control	0.3417	0.06514	d

Table 1- Proportion of fruit with mealybug predictions for each treatment in late March at Woombye (predictions followed by the same letter are not significantly different).

Treatment	Prediction	s.e.	
Samurai	4.17	3.038	a
Movento	6.33	3.751	ab
Actara	18.33	6.382	abc
Control	23	7.148	bc
Confidor	23.5	7.225	bc
Transform	33.17	8.584	c

Table 2- Total mealybug predictions for each treatment and pair-wise comparisons in late March in Woombye (predictions followed by the same letter are not significantly different).

Experiment 2

Data collected in late March at MRF showed all treatments greatly reduced the number (percentage) of fruit infested with mealybug and the average total number of mealybug. Samurai® was the most effective with only 3.3% of fruit having mealybug infestations (Figure 5 and Appendix 2- Table 8). Actara also achieved a good level of control with only 5% of fruit infested with mealybug. There was a significant treatment effect (P<0.001) on the proportion of fruit with mealybug (Table 3) and the total number of mealybug Table 4).

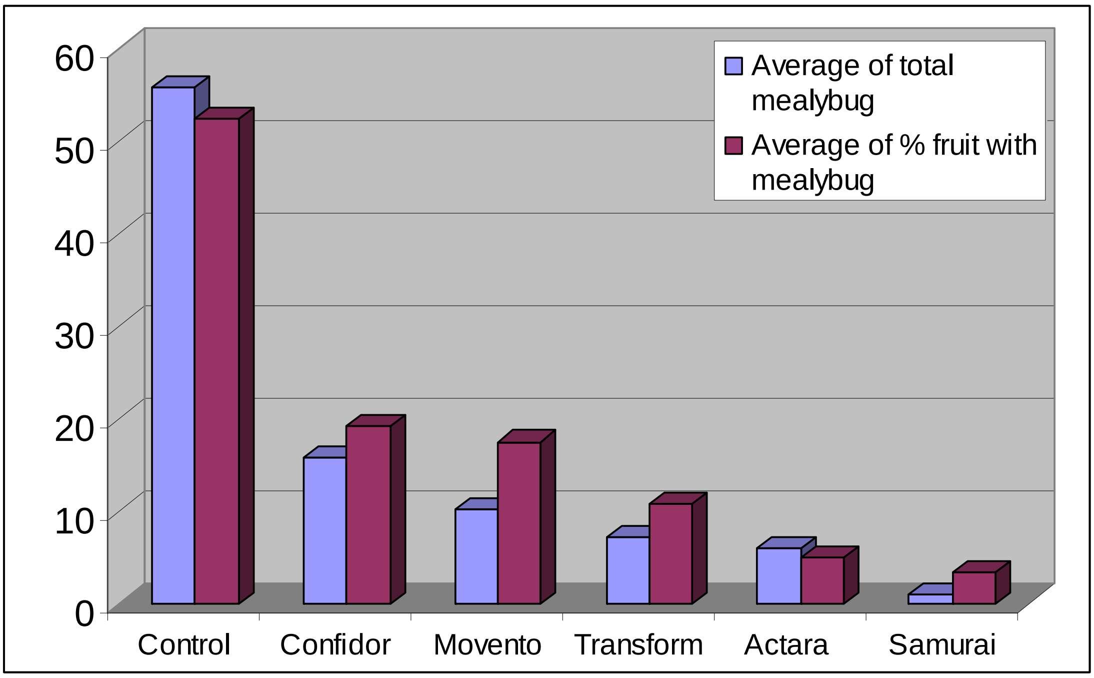

Figure 5- Difference in average total mealybug and average percentage of fruit with mealybug infestations between chemical treatments in late March at MRF.

Treatment	Prediction	s.e.	
Samurai	0.0333	0.02799	a
Actara	0.05	0.03394	a
Transform	0.1083	0.04807	a
Movento	0.175	0.05832	a
Confidor	0.1917	0.06031	a
Control	0.525	0.07471	b

Table 3- Proportion of fruit with mealybug predictions for each treatment in late March at MRF (predictions followed by the same letter are not significantly different).

Treatment	Prediction	s.e.	
Samurai	1.00	1.461	a
Actara	6.00	3.578	a
Transform	7.17	3.911	a
Movento	10.17	4.659	a
Confidor	15.83	5.815	a
Control	55.83	10.919	b

Table 4- Total number of mealybugs predictions for each treatment in late March at MRF (predictions followed by the same letter are not significantly different).

After three fruit inspections throughout the growing period for 'Jiro' at Woombye, Samurai® reliably achieved the highest level of control of longtail mealybug. Samurai® treated trees have shown a consistent level of control over these three inspection dates whereas other chemical treatments have fluctuated.

Samurai® and Actara® have shown to be effective in controlling populations of longtail mealybug in "Jiro' at Maroochy Research Facility with no additional broad spectrum insecticide cover sprays.

It appears that the application of Samurai (clothianidin) around flowering time (mid October) as a soil drench at a rate of 5 grams per tree is the most effective treatment for longtail mealybug in the cultivar 'Jiro'.

THE EFFECTIVENESS OF SAMURAI® (CLOTHIANIDIN) FOR CONTROLLING MEALYBUG IN PERSIMMON

INTRODUCTION

Previous studies at Maroochy Research Facility and on a commercial orchard in Woombye have shown that Samurai® (clothianidin) can be effective for controlling mealybug in persimmon when applied as a soil drench at 5g/tree in mid-October. Although Samurai® was effective when compared to other neonicotinoids different application rates need to be tested to determine the optimum soil drench treatment. This experiment investigated the efficacy of different application rates of Samurai® for controlling mealybug in persimmon orchards.

MATERIALS AND METHODS

The persimmon trial block on Maroochy Research Facility (MRF) Nambour was used to trial different rates of soil applied Samurai on the variety "Jiro". This trial was established using a randomised block design. Treatments were applied in a randomised block design using four individual tree replicates of each treatment.
Samurai was diluted in 2L water and applied as a soil drench on 22nd October 2013 at the following rates;

- 2.5g/tree
- 2.5g/tree in October + 2.5g/tree in December
- 3.5g/tree
- 5g/tree

A light irrigation was applied prior to and following application to allow good penetration of the chemical to the root zone.

No additional insecticide sprays were used in this trial so the effectiveness of the treatment alone could be observed.

Populations of longtailed mealybug, (*Pseudococcus longispinus)* were observed in high numbers throughout the block in 2012/13.

10 fruit from each data tree were randomly selected and inspected under the calyx for mealybug on the 26th February 2014, approximately one week from harvest.
Data analysis was performed using a generalised linear regression model (glm) in GenStat. The total number of mealy bugs was analysed using a log-linear regression model assuming a Poisson distribution (and a log link). The proportion of fruit with mealy bug was analysed using logistic regression (assuming a binomial distribution with logit link – as each of the 10 fruit either had mealy bugs or did not (presence or absence).

RESULTS AND DISCUSSION

All treatments reduced total mealybug and percentage of fruit with mealybug infestations when compared to the untreated control (Figure 1). The lowest rate of 2.5g/tree achieved the lowest level of control of all treatments with 37.5% of fruit having some level of mealybug infestation. Applying two consecutive treatments of 2.5g/tree in October and December gave better control than a single treatment October with only 25% of fruit having mealybug, however populations (total mealybug) under the calyx were higher than the single treatment. Treatment with 3.5g/tree gave similar control with 22.5% of fruit having mealybug. The best control was achieved by applying 5g/tree with only 10% of fruit having mealybug under the calyx and an average population of one mealybug per infestation. There was a significant treatment effect on the total number of mealy bugs ($P<0.001$) (Table 1) and on the proportion of fruit with mealybug ($P=0.020$) (Table 2).

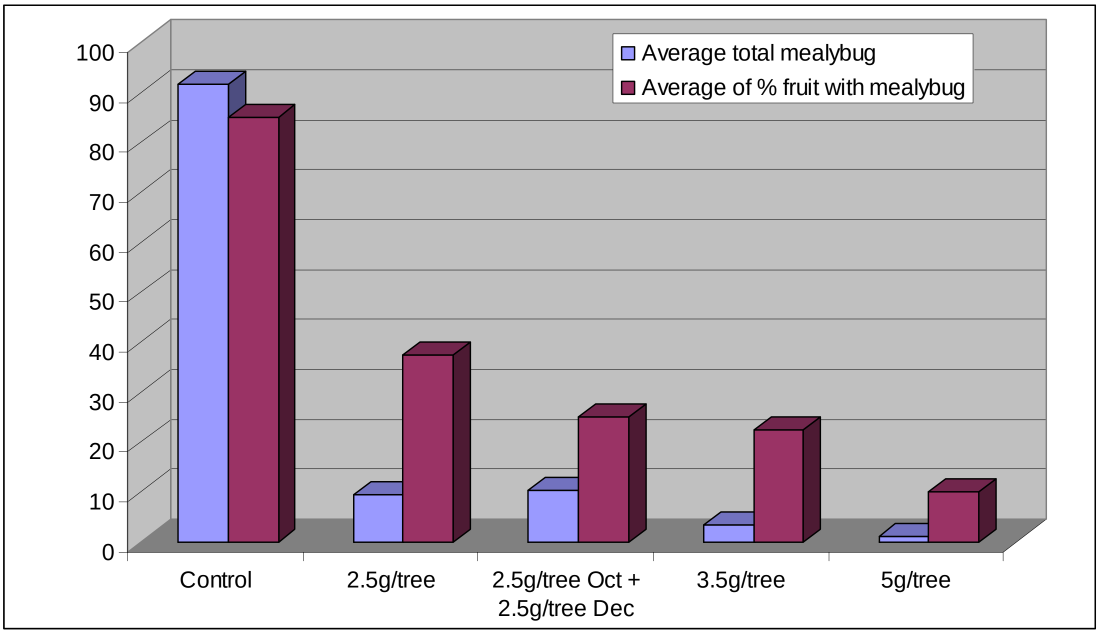

Figure 1- Difference in average total mealybug and average percentage of fruit with mealybug infestations between treatment rates of Samurai in Late February 2014.

Treatment	Prediction	s.e.	
5g/tree	0.1	0.07315	a
3.5g/tree	0.225	0.10179	a
2.5g/tree Oct +2.5g/tree Dec	0.25	0.10555	a
2.5g/tree	0.375	0.11798	a
Control	0.85	0.08689	b

Table 1- Proportion of fruit with mealybug predictions for each treatment and pair-wise comparisons (predictions followed by the same letter are not significantly different).

Treatment	Prediction	s.e.	
5g/tree	1	1.2	a
3.5g/tree	3.5	2.241	a
2.5g/tree	9.5	3.7	a
2.5g/tree Oct +2.5g/tree Dec	10.25	3.837	a
Control	91.75	11.497	b

Table 2- Total mealybug predictions for each treatment and pair-wise comparisons (predictions followed by the same letter are not significantly different).

Longtail mealybug was observed in the previous season in large numbers, however the species identified this season in the same block was citrus mealybug (*Planococcus citri*) (Plate 1) which shows Samurai® has efficacy on both species. This trial has shown that a treatment range between 2.5g and 5g per tree can reduce mealybug infestations in persimmon. There appears to be no benefit in using multiple applications of the lower rate. Lower rates may be effective in orchards with smaller populations, however for orchards with heavy pressure from mealybug the higher rates may give better control.

Plate 1- Citrus mealybug on non-treated control fruit.

EVALUATION OF TOOLS FOR MONITORING MEALYBUG POPULATIONS IN PERSIMMON ORHARDS

INTRODUCTION

A number of different mealybug species can infest persimmon in Australia. In the southern states and inland, the more important pests are citrophilous mealybug, *Pseudococcus calceolariae* and longtailed mealybug, *Pseudococcus longispinus*. These two species can be distinguished by the presence of distinctive long, anal filaments (at least as long as the body) in the longtailed mealybug. In Queensland, the dominant pest species is the citrus mealybug, *Plannococcus citri*.

Most species of mealybug have several generations per year, often overlapping so that immature and adult stages are present at the same time. Optimum conditions for development are temperatures of about 25°C, with high relative humidity, so populations often peak in spring and autumn.

Citrophilous and citrus mealybugs produce eggs in an egg sac, whereas in longtailed mealybugs the eggs are laid directly beneath the female’s body, often hatching very quickly. Females can produce several hundred eggs in their lifetime. After hatching, the juveniles (termed crawlers) move away to look for a sheltered feeding site. Soon after beginning to feed they develop the distinctive white, waxy/mealy coating that gives them their name. The crawlers moult several times before becoming adult.

Male and female mealybug adults look very different (Plate 1). In the case of males, the last crawler stage pupates in a silk cocoon, emerging as a small, winged adult male. The males are short-lived, their only purpose being to mate with the females. In comparison, adult females change little as they develop, resembling larger versions of the crawlers.

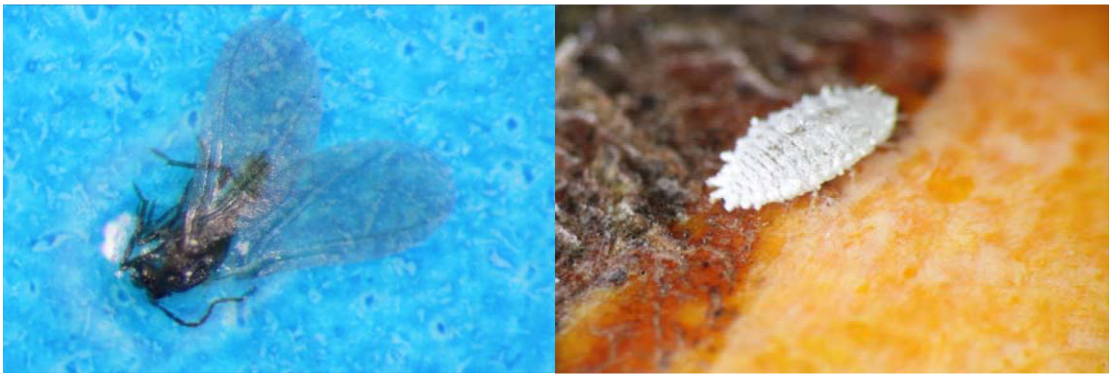

Plate 1. Male (left) and female (right) citrus mealybug (*Plannococcus citri*)

Current guidelines for monitoring mealybug in persimmon are based on recording presence or absence of mealybugs on randomly selected fruit (George *et al*, 2011). Action thresholds are based on the percentage of infested fruit and natural enemy activity. However, this method is not effective for detecting low infestations, or for early detection of mealybugs. An improved monitoring method, based on an understanding of the seasonal dynamics of mealybug populations, is necessary in order to apply insecticides and other controls in a targeted manner.

Pheromone trapping can provide a simple and sensitive method for early detection of infestations, and for monitoring changes in mealybug populations throughout the year. As pheromones are species specific, they can be used to confirm which mealybug species are present: this can be important for selection of appropriate management strategies. However, pheromone trapping should be combined with conventional monitoring techniques in order to determine when treatment is required. Walton *et al* (2003) recommended the use of pheromone traps as early warning tools to detect vine mealybug in vineyards: a threshold trap catch then triggers the use of visual monitoring to determine control action. Research would be required before pheromone traps could be usefully deployed in persimmon orchards, in order to understand the relationship between trap catch, infestation and damage levels, and therefore determine action thresholds for treatment.

A better understanding of the seasonal movement and distribution of mealybugs on persimmon would also help to target visual inspections. For example, Franco (1992) described the movement of mealybugs on citrus from overwintering sites to young shoots in the spring, and then to developing fruit. Likewise Kerns *et al* (2004) suggested that early season monitoring for overwintering mealybug in citrus should be directed to the trunks and lower branches; as the season progresses, upper branches, twigs and fruit should be inspected. Nissen *et al* (2012), working on persimmon in Vietnam, described the movement of overwintering citrus mealybug from the soil around the trunk base to developing shoots in spring.

Geiger & Daane (2001) compared a number of sampling methods for grape mealybug (*P. maritimus*) in Californian vineyards: sticky tape barriers on canes, excised spur counts, non-destructive spur counts, standard-sized bark sample counts and timed counts. They concluded that timed three or five minute counts resulted in the strongest correlation with absolute counts as determined through destructive sampling. This method employed experienced samplers, familiar with mealybug habits, who were flexible in the locations sampled and relied on cues such as presence of ants and honeydew. The authors also found that midseason counts were better predictors of damage at harvest than early season counts. Although these particular sampling strategies may not translate directly to persimmon orchards, the premise holds that strategies should vary according to the season and should also take advantage of periods when the pest is more easily found. Sticky bands, placed around branches, have also been used successfully to monitor Comstock mealybug (*Pseudococcus comstocki*) on pear trees (Agnello *et al*, 1992).

MATERIALS AND METHODS

Monitoring techniques were tested in persimmon orchards in SE Queensland between 2012 and 2013. Citrus mealybug pheromone traps were trialled on orchards in Grantham and Woombye. Trece Pherocon monitoring traps were placed in orchards in early September at a density of approximately 4 traps per hectare. Sticky bases were placed at the bottom of the traps with the pheromone lure. Traps were placed approximately 1.5 meters from ground level in the canopy of Jiro trees and monitored weekly for male mealybug. Monitoring was focussed between September and December.

A range of sticky bands were trialled using adhesive film and paint-on stickers. Sticky band treatments were applied to the base of trunks and individual branches in early September. Six replicates of each sticker treatment were placed on trees with evidence of sooty mould from the previous cropping season. Sticky bands were monitored weekly for movement of overwintering mealybug from the soil and root zone to vegetative areas.

Visual inspections under the bark and soil at the base of trees were carried out on several orchards.

All monitoring techniques were compared to the traditional method of visual inspections under the calyx of randomly selected fruit.

RESULTS AND DISCUSSION

Monitoring of pheromone traps between September and December at both sites only resulted in one citrus mealybug male being trapped at Woombye in early October. Visual inspections of fruit at the Woombye site at the time a male was trapped resulted in no females being identified under the calyx. This result may indicate that mealybug were present in the orchard but had not reached the fruit after overwintering.

The use of monitoring traps had limitations. As the lure only attracts males, which is a very small winged insect, in-field identification is almost impossible without high magnification. Another limitation is cross contamination with other small winged insects that are caught which resemble the male mealybug.

No males were captured at the Grantham site, however after visually inspecting a large proportion of the crop limited numbers of females were present. Visual inspections of the Woombye site in December indicated that citrus and longtail mealybug were both present. Larger proportions of longtail mealybug were observed which would have influenced monitoring trap counts as the lure was specifically formulated for citrus mealybug.

Citrus mealybug lures were tested in sealed cages with large populations of citrus mealybugs being raised on pumpkins. Large amounts of males where trapped in these cages which indicated that the lures were effective (Plate 2); however traps were only a short distance from large infestations which isn't representative of an orchard situation.

Plate2. Male mealybugs trapped in cages using pheromone lures with (left) and without (right) magnification.

Monitoring of sticky band treatments between September and December failed to identify any mealybugs. Visual monitoring of fruit in December identified mealybug under the calyx of fruit in trees treated with sticky bands. This result indicates that mealybug may not be overwintering in the soil and root zone at the base of trees. It's likely those mealybugs are overwintering under the bark which has been observed in South Australia, where longtail mealybugs have been found under bark and borer frass in Fuyu trees. This was a surprising result given that the grower employs water blasting as a method to control clearwing moth which removes a large quantity of loose bark from the trees. A limitation of sticky bands was also cross contamination from other insects and grass clippings that covered the trapping area as a result of orchard mowing (Plate 3). Mealybug were found under sticky bands in late May (Plate 4) which indicates movement from the tree canopy to lowers sections of the tree.

The current system for monitoring mealybug in persimmon is a visual inspection of fruit. This method is time consuming and ineffective for early detection. Mealybugs are particularly hard to spot early in the season, when insecticide applications may have the most impact on developing mealybug populations. An effective monitoring system would therefore allow pesticides to be applied in a more targeted manner. Sex pheromones show great potential as monitoring tools, providing early warning of an increase in mealybug numbers. However, only the citrus mealybug pheromone is currently commercially available in Australia. The longtailed mealybug pheromone (available from the USA) would require further research to determine its effectiveness for use against Australian mealybug populations; the citrophilous mealybug pheromone should be available from New Zealand in the near future. For all three pheromones, research would be required to determine the optimum application method (e.g. application rate and dosage) and action thresholds for use in different persimmon growing areas in Australia. In order to accurately monitor mealybug populations, trapping should be combined with other techniques such as targeted visual monitoring and sticky bands, based on a better understanding of the seasonal

activity of the pest. Sticky bands will need further evaluation as this trial failed to identify any mealybug emerging from the base of trees after overwintering.
A monitoring system for mealybug will be developed in the next phase of this project and will evaluate pheromone traps, sticky bands (trunks and branches), and visual inspections under bark strips, destructive sampling of roots, bark and shoots and monitoring of ants.

Plate 3. Sticky bands at the base of Jiro trees. Note the contamination of traps by grass clippings.

Plate 4. Mealybug found under sticky traps in May 2014.

THE EFFECTIVENESS OF MATING DISRUPTION PHEROMONES FOR CONTROLLING CLEARWING MOTH Ichneumenoptera chrysophanes

INTRODUCTION

Mating disruption relies upon the release of large quantities of synthetic sex pheromones to prevent males from finding females, resulting in unmated females either laying infertile eggs or none at all. Clearwing moths have been shown to be quite susceptible to mating disruption using pheromone dispensers. Significant reductions in both male moths and larvae were demonstrated in treated orchards with pheromone dispensers compared with the untreated (Vickers, 1997-2000). There are many benefits of using mating disruption pheromones which include improved biological control, slower development of pesticide resistance, less exposure to insecticides and a reduction in chemical residues (Brunner and Knight, 1993).

The effectiveness of controlling a pest using mating disruption can depend on factors such as the size and location of the orchard, pest levels, monitoring, costs and other environmental factors like wind and temperature.

Although uptake of the dispensers by growers in southeast Queensland was initially quite promising, it appears that few growers are currently using pheromone mating disruption as a means of control. Efficacy of pheromones on borer species present in South Australia and Victoria is not known as further studies are needed to correctly identify the species of these regions.

Many growers have found that a single application of pheromone was ineffective in reducing infestations of clearwing moth compared with no applications. In contrast, growers who applied the pheromones twice during the season achieved near 100% control.

MATERIALS AND METHODS

A mating disruption pheromone efficacy trial was established at an orchard in Amamoor, Queensland in August 2012. Pheromones were applied to in late August at a rate of 1100 dispensers per hectare in two hectares of Fuyu with significant clearwing borer damage. One hectare of Fuyu was used as a control in a separate block on the same orchard. Treated and untreated blocks were separated by a native vegetation strip greater than 50 meters (Plate 1). Nine Trece Pherocon monitoring traps were placed in the untreated block and 12 in the treated block Plate 2. Traps were monitored fortnightly in early August to establish flight patterns and presence of moth in treated and untreated blocks. Traps were monitored between August 2012 and May 2013 to establish flight patterns (Figure 1). Assessment of borer damage was carried out in January and July 2013 by counting 2000 new shoots per hectare with a maximum of 30 shoot per tree. Borer damage was classified as presence of frass at the base of new shoots (Plate 3).

Plate 1. Control (left) and treated (right) blocks. Note the exposed slope of the treated block.

Plate 2. Traps used to monitor male clearwing moth flight.

Plate 3. Fresh frass caused by clearwing larvae.

RESULTS AND DISCUSSION

In previous phases of this project we have found that seasonal flight patterns of clearwing moth have about four major peaks in south-east Queensland. These periods are:

- Mid-spring (mid-September – mid October)
- Mid-summer (early January – late January)
- Early autumn (mid-February-early March)
- Late autumn-early winter (mid-May to early June)

Data from monitoring traps placed in the untreated block on 15th August 2012 show similar peaks in moth activity, with the major peak occurring in mid-spring. Another peak occurred in late January with an additional peak in mid-April. Monitoring of moth numbers in the treated and untreated block for two weeks prior to application of pheromones resulted in only two moths captured in the untreated block and one in the treated block. This indicated that the peak flight had yet to occur and the timing of pheromone application was suitable.

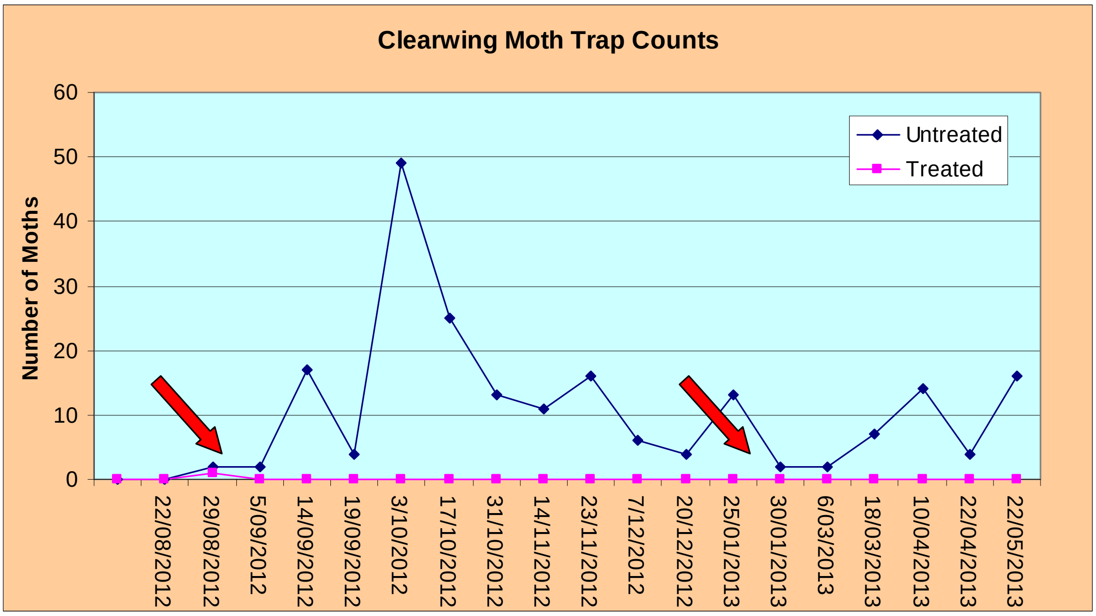

Figure 1. Moth counts from monitoring traps in treated and untreated blocks between August and May. Arrows indicate the timing of application of pheromones to the treated block.

Assessment of borer damage in both January and July showed a reduction in damage to new shoots (Figure 2). In January an average of 6.8% of new shoots were damaged compared to 7.3% in the untreated block. Similar results were obtained in July with the treated block recording and average of 8.1% of new shoots damaged compared to 10.9% in the untreated control block.

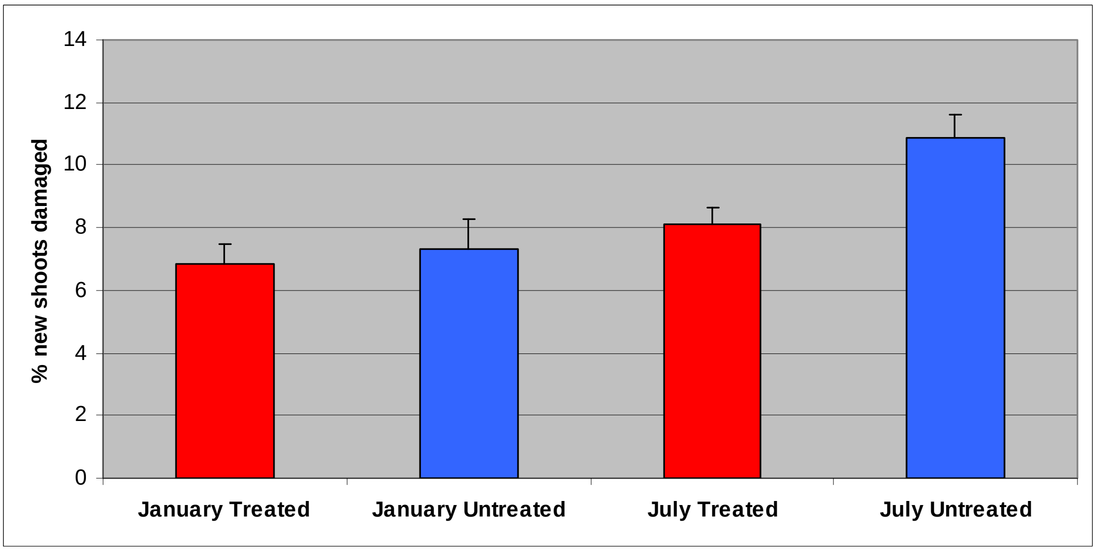

Figure 2. Percentage of new shoots damaged by clearwing moth larvae in treated and untreated blocks in January and July 2013 with error bars indicating the standard error of means.

While this result indicates a reduction in borer damage it would not justify the cost and labour associated with pheromone application. Infestation levels in the treated block were still at a high level even though no adult male moths were trapped while pheromones were applied in the block. Monitoring traps in the treated block may not have captured any males due to large quantities of pheromone from the dispensers making it impossible to find the lure within the trap.

Several factors including the size and location of the orchard, prior pest levels, wind, slope and uniformity of tree canopies may have influenced the results in this trial. The treated block was in close proximity to natural vegetation which may have provided an area where mated females could fly into the treated block and lay eggs. Spraying insecticides in these bordering areas may reduce populations of clearwing in the treated block. Levels of clearwing moth damage in the treated and untreated block high prior to pheromone application. Mating disruption pheromones alone may not be adequate to control large populations, especially in the first year of use. Additional insecticidal sprays may be required to reduce populations to a level where pheromones can be effective. The orchard on which this trial was carried out applied minimal insecticides which may have allowed a build-up of clearwing. Additionally this was the first year of application which has been shown to be less effective than pheromone treatment over consecutive years.

The treated block was located on an exposed steep hill and was subjected to a large amount of wind. This may have affected results as pheromone may not have been evenly distributed or at a high enough level to provide control. A large amount of replanted trees were present in the treated block which impacted the uniformity of canopies. This may have also affected the concentration of pheromones as smaller trees would provide less protection to wind.

Pheromones can flow down steep slopes and leave the upper areas of the orchard unprotected (Carter and Fraser, 2003). Data was separated into the top and bottom of the block to identify if there was a better result achieved in the lower half. Average damage to the bottom half of the block was less than the top of the block at both assessment dates, indicating that pheromone may have been at a higher concentration in the lower half. In January the top half of the treated block had an average of 7.8% of new shoots damaged compared to the bottom half that had 5.9%. In July 9% of new shoots were damaged in the top half which was higher than 7.4% in the bottom half of the orchard (Figure 3).

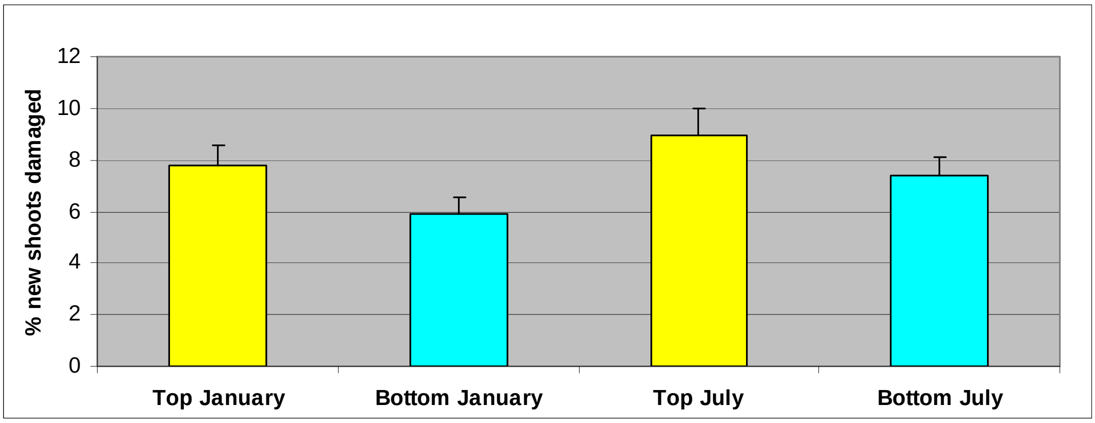

Figure 3. Average new shoots damaged in the top and bottom half of the treated block in January and July 2013 with error bars indicating the standard error of means.
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A sub-sample of dispensers that were placed in the treated block between late-August to late-January was evaluated for pheromone loss. On average 58% of pheromone and stabiliser was still remaining. While over 50% of pheromone is still present after this duration it may not be in sufficient quantity to provide an adequate concentration to be effective. In previous studies we have shown that six and nine month old dispensers can attract male moths to monitoring traps; however the effect on mating disruption of older dispensers is still unknown.

Growers currently using mating disruption pheromones for controlling clearwing moth have generally achieved good levels of control after consecutive years of application. However, the use of pheromones is regarded as part of an integrated approach for the control of this pest, which also includes a program of insecticides and mechanical removal.

It seems site selection has influenced the results of this trial and has identified limitations to the use of mating disruption. With many factors that can influence the success of mating disruption growers should be aware of these different aspects when using this technique for control of clearwing moth.

EFFICACY OF INSECTICIDES FOR CONTROLLING CLEARWING MOTH (Ichneumonoptera chrysophanes)

INTRODUCTION

The persimmon clearwing moth causes significant damage to persimmon orchards, particularly in south-east Queensland and northern New South Wales. Growers rely on mating disruption pheromones, broad-spectrum insecticides and mechanical removal methods such as water blasting for control of this pest. Selective insecticides with systemic and residual activity would be an effect tool in the management of persimmon clearwing moth *(Ichneumonoptera chrysophanes)*.

Sesiidae or clearwing moths are a family of Lepidoptera in which the wings have hardly any of the normal lepidopteran scales, leaving them transparent. The bodies are generally striped with yellow, sometimes very brightly, and they have simple antennae (Plate 1). The general appearance is similar to a wasp or hornet to make it likely that the moths gain a reduction in predation by Batesian mimicry. This enables them to be active in daylight. They are commonly collected using pheromone lures. The larvae bore into the stems, bark or roots of trees and pupate in the larval tunnels (Common, 1990).

Ichneumonoptera chrysophanes has a larger distribution when compared to other native clearwing species and range from north Queensland to the ACT. Alternative host plants include the bark of red ash (Alphitonia excelsa RHAMNACEAE), gum trees (*Eucalyptus* spp. MYRTACEAE), branches of figs (Ficus MORACEAE) and galls of native cherry (*Exocarpus cupressiformis* SANTALACEAE) (Common, 1990). Orchards surrounded by native vegetation are more susceptible to infestations.

The larvae of the moth tunnel through the bark, causing severe lesions to develop in the crotches of limbs. In severe cases, branches are girdled at the point of attachment to a larger branch or the trunk and the weight of maturing fruit or strong wind snaps them off. Successive generations of larvae continue to tunnel in old wounds and trees can eventually be killed. The 10-15mm long, creamy white larvae (Plate 1) tunnel under the bark, but do not bore into the wood. Clearwing moth larvae create dark, moist frass under damaged bark (Plate 2). The larvae pupate in the bark tunnels and wasp-like adults mostly emerge in spring. However, adults have also been found emerging in autumn.

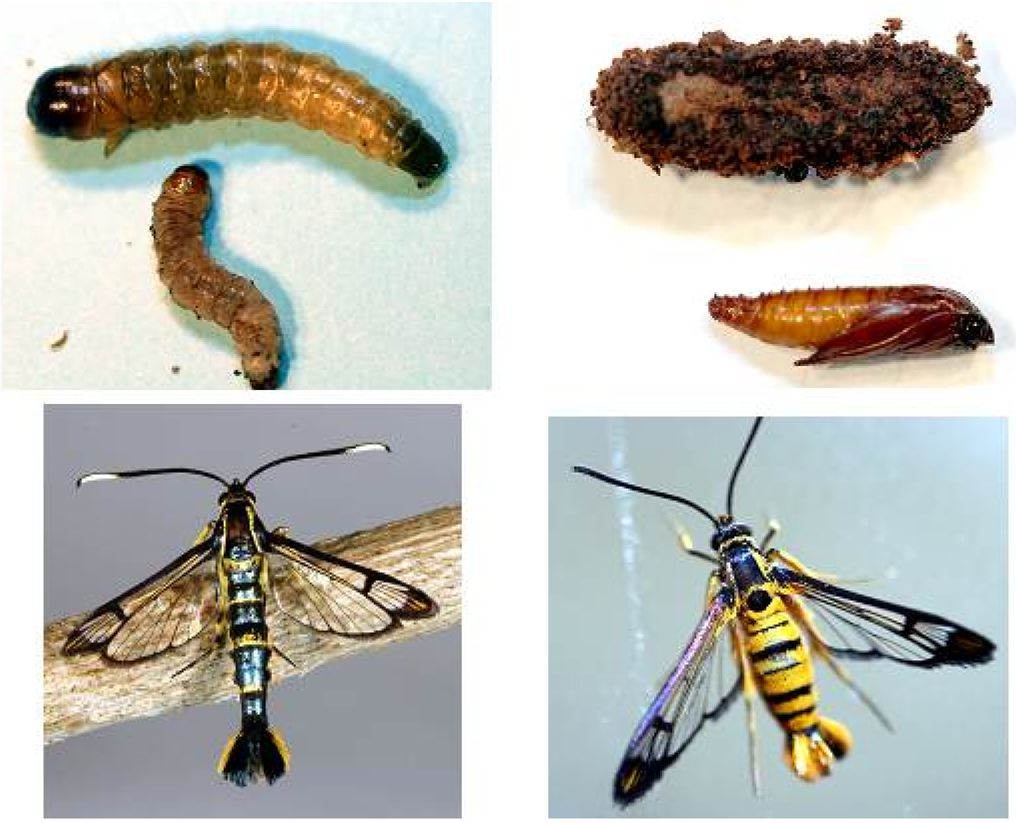


Plate 1. Clearwing moth larvae (top left), pupae (top right), male (bottom left) and female (bottom right)

This trial evaluated the efficacy of five insecticides in controlling damage caused by clearwing larvae in persimmon orchards.

MATERIALS AND METHODS

A trial was established in Grantham, Queensland to assess treatments for the control of clearwing moth in an orchard with high levels of clearwing moth infestations. The orchard was treated with mating disruption pheromones and pressure blasted to remove background populations of clearwing.

Five insecticides were applied to mature ‘Fuyu’ trees. Insecticides tested were:

- imidacloprid
- clothianidin
- thiamethoxam
- spirotetramat
- chlorantraniliprole

Neonicotinoids

Neonicotinoid insecticides are a relatively new class of pesticides that act as agonists at the insect nicotinic acetylcholine receptors, which plays an important role in synaptic transmission in the central nervous system (Nauen *et al*. 2001). This group of compounds include nitenpyram, dinotefuran, clothianidin, thiamethoxam, imidacloprid, acetamiprid, thiacloprid and imidacclothiz (Zhang *et al*. 2012).

Imidacloprid (Confidor®)

Imidacloprid is taken up by the roots of plants and travel within the sap flow. It works slowly on the nervous systems of insects and directly influences insect behaviour, resulting in an “anti-feeding” effect. Imidacloprid has long-lasting residual efficacy and has a 20 week withholding period when used on citrus.

Clothianidin- (Samurai®)

Clothianidin is registered for control of mealybug in apples, pears and grapes and can give effective control of woolly apple aphid in large trees. Clothianidin has systemic and residual activity while also having contact efficacy and can be used with IPM as it has low mortality rates on predators and parasatoids (Cloyd 2006).

Thiamethoxam- (Actara®)

Thiamethoxam is a unique systemic insecticide that claims to provide excellent, fast-acting and long-lasting elimination of a broad range of foliar and soil pests.
When Thiamethoxam is applied to the soil, it is readily taken up by the roots and rapidly translocated throughout the plant. Once inside the plant, thiamethoxam is slowly metabolized, resulting in extended residual control.

Spirotetramat (Movento®)

Spirotetramat is effective in controlling juvenile stages of a many sucking insects including mealybugs, soft and armoured scales, aphids, psyllids, and whiteflies. It exhibits excellent translaminar efficacy against targeted pests and has limited contact efficacy ((Nauen *et al*., 2008). Once penetrated into the plant, spirotetramat is hydrolysed to its enol form. As a weak acid this compound is mobile within the phloem of the plant. Hence it can move acropetally and basipetally and control hidden pests (Nauen *et al*., 2008). This insecticide is very well suited to IPM as it has a limited effect on predatory insects.

Chlorantraniliprole (Altacor®)

Chlorantraniliprole is effective on almost all Lepidoptera species and has strong residual activity. Altacor is compatible with Integrated Pest Management (IPM) programs as it causes limited effect on parasitoids, predators and pollinators.

Chlorantraniliprole controls pests by activating the ryanodine receptors which causes an uncontrolled release of internal calcium preventing muscle contraction (paralysis).

Treatments were applied using the following methods, dates and concentrations:

- Imidacloprid- Confidor® at 6ml/L soil applied at 1 litre per tree (6/09/2012)
- Clothianidin- Samurai® at 5g/L soil applied at 1 litre per tree (6/09/2012)
- Thiamethoxam- Actara® at 6g/L soil applied at 1 litre per tree (6/09/2012)
- Spirotetramat- Movento® at 0.4ml/L foliar applied (9/10/2012)
- Chlorantraniliprole- Altacor® at 0.09g/L foliar applied (15/11/2012)

There were 6 treatments (Altacor, Samurai, Actara, Movento, Confidor and Control) with 6 replicates of each treatment in a randomised complete block design (RCB). There were 3 tree plots with the middle tree used for data. From each tree 30 new shoots were evaluated for clearwing borer damage in February 2013 .

Trials were established using a randomised block design. Six replicates of three tree plots were used for each treatment, using the middle tree for data. In February, 30 new shoots were randomly selected and assessed for the presence of clearwing larvae damage (Plate 2).

Plate 3. Clearwing larvae damage at the base of new shoots.

As the data consisted of proportions that may not be normally distributed, analysis was performed using a generalised linear regression model (glm) in GenStat. The proportion of shoots with clearwing borer damage was analysed using logistic regression (assuming a binomial distribution with logit link – as each of the 30 shoots either had moth borer damage or did not (presence or absence).

RESULTS AND DISCUSSION

There was a significant treatment effect on proportion of shoots with moth borer damage (P=0.014) (Table 1). Altacor, Samurai and Movento had significantly lower damage than the Control (with 4.4%, 7.22% and 10% damage respectively with the control showing 18.89% damage). Confidor and Actara treatments were not significantly different than the control with 12.78% and 11.67% damage respectively.

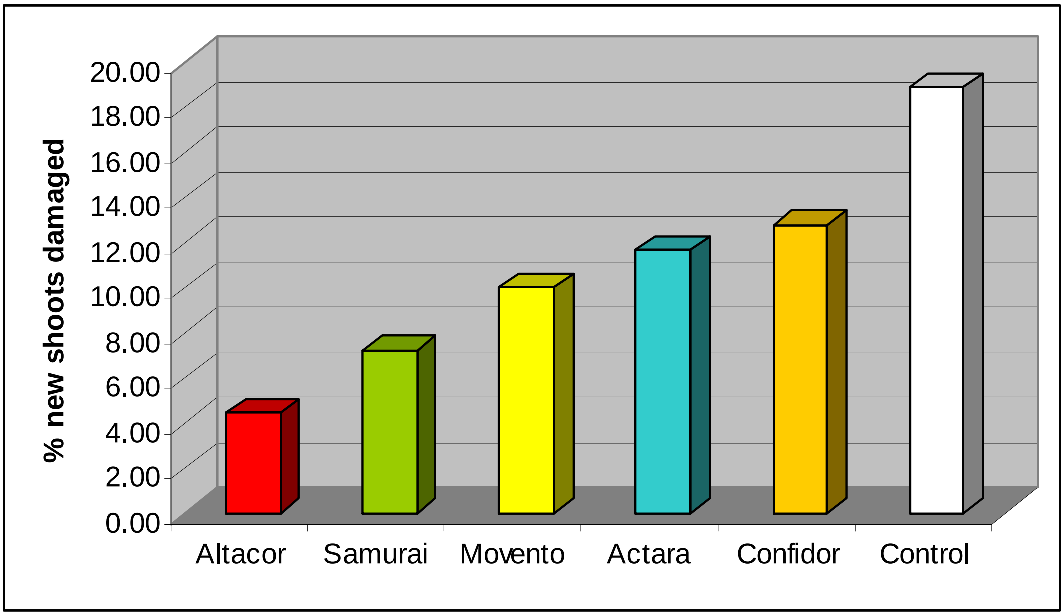


Figure 1. Effects of different soil-applied insecticidal treatments on new shoot damage caused by clearwing moth.

Treatment	Prediction	s.e.	
Altacor	0.0444	0.01686	a
Samurai	0.0722	0.02112	ab
Movento	0.1	0.02445	ab
Actara	0.1167	0.02609	bc
Confidor	0.1278	0.02716	bc
Control	0.1889	0.03174	c

Table 1- Predictions for each treatment and pair-wise comparisons (predictions followed by the same letter are not significantly different).

The use of these systemic insecticides in combination with mating disruption pheromones may be an effective control for clearwing moth in Australian persimmon orchards. Altacor may be an effective insecticide for controlling borer damage as it has larvicidal activity and has shown to be the most effective in this trial. Samurai also may be effective and given the efficacy it has on controlling mealybug and clearwing larvae as a soil drench, may be the best option for the industry to pursue.

COLLECTION OF MEALYBUG AND OTHER INSECTS FROM THE RIVERLAND AREA OF SOUTH AUSTRALIA

INTRODUCTION

A collection of mealybug and suspected borers was made from persimmon orchards with the dual aims of (i) identifying the species of mealybug and borers present and (ii) determining the location and life stage of mealybug present on the persimmon trees during early spring.

MATERIALS AND METHODS

On 17th and 18th October 2013, persimmon trees at two orchards in the Riverland area of South Australia were inspected for the presence of mealybug and borers, and samples collected. At the time of inspection the trees were flowering and still flushing after breaking dormancy. The two locations were in Renmark and Paringa :

A third orchard in Victoria was also inspected but no samples of mealybug or borer were found.

Samples of mealybug, adult moths, moth larvae and pupae were collected into vials. Moth larvae and pupae were incubated in the laboratory until emergence of adults. All samples were identified by taxonomists Desley Tree and Justin Bartlett (DAFF QLD, Ecosciences Precinct, Brisbane).

RESULTS AND DISCUSSION

Mealybug

All samples were identified as longtailed mealybug, *Pseudococcus longispinus*. Previous collections from the Riverland area found both longtailed and citrophilous mealybug, with the latter species dominant but exhibiting a patchy distribution (Baker & Keller 1998; Baker & Huynh 2000).

Inspections of the persimmon trees failed to find any mealybugs on the leaves, shoots or flowers – all samples were found on the trunk or main branches of the trees, predominantly sheltering amongst frass produced by borers in the crotches of the trees (Plate 1). This suggests that at the time of inspection (mid-October) the mealybugs were overwintering in sheltered spots on the trees, with no obvious evidence of the first younger generation on the developing shoots and flowers. Most mealybugs overwinter as slowly-developing juveniles, reaching the adult stage in late winter/early spring. Furness (1976) sampled longtailed mealybug in the Riverland area, finding that most overwintering juveniles were mature by late October and early November, when the first generation of crawlers was produced.

Plate 1. Longtailed mealybug,(*Pseudococcus longispinus*) overwintering in borer frass in mature Fuyu trees.

Borers

Some larvae, pupae and adult moths were collected from areas which appeared to have been damaged by borers, as indicated by the presence of frass and damaged bark. It was noted that the frass produced by borers appeared to provide an over-wintering site for mealybug. Four specimens of moths were identified as 'genus near *Ephestia*', tribe Phycitini, subfamily Phycitinae, family Pyralidae (Plate 3) (http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/Phycitini/checklist). This family is in need of revision, hence the imprecise identification. The genera within the tribe Phycitini include some borers of economic significance such as the American plum borer, *Euzophera semifuneralis*, and the hickory leafstem borer, *Acrobasis angusella*. A small number of other pupae were recovered which appeared different to those of the identified moths, indicating that further borer species may be present. A more intensive collection is required in order to obtain more samples to confirm which borer species are of significance.

Plate 2. Larvae of 'genus near *Ephestia*', tribe Phycitini, subfamily Phycitinae, family Pyralidae, collected from Paringa, South Australia.

Plate 3. Adult moth grown out from collected larvae identified as'genus near *Ephestia*', tribe Phycitini, subfamily Phycitinae, family Pyralidae.

EVALUATION OF CONTROL MEASURES FOR LEAF AND FRUIT DISEASES OF AUSTRALIAN PERSIMMON

INTRODUCTION

All plant diseases result from the interactions between a host (in this case persimmon), a disease causing pathogen (fungi) and the environment. Generally, disease will not occur unless all three of these factors are present and are in favour of the disease. Careful consideration of these points in relation to any crop disease interaction will usually give useful leads for controlling fungal diseases. Disease can be managed by excluding or reducing fungal infecting units (spores), increasing the host's resistance to the disease or modifying the environment so that is unsuitable for the development of disease.

The major diseases found on persimmon in Australia are presented in Table 1 and are classified as high, medium and low priority, which has determined by industry through the Strategic Agrochemical Review Process (SARP). Surveys in previous project phases have found disease pressures were two to three times higher in south-east Queensland and northern NSW compared with Victoria and South Australia. This is probably due to the warmer and wetter climates of the northern States which are more conducive to disease development.

During this project we have responded to growers requests for advice on disease management and have performed disease isolations from several orchards. Extremely dry growing conditions during the two cropping seasons of this project have resulted in very little disease activity in trials and grower visits.

This report will give an overview of the current control measures available for the high priority diseases of Australian persimmon and describe pathogens isolated from orchards.

TABLE 1.
Diseases of persimmon in Australia.

Common name	**Scientific name**	**Organ affected**	**Comments**
High priority			
Angular leaf spot	*Pseudocercospora spp.*	Leaf	Qld - high; WA & NSW - medium - high. Problem in areas with summer rainfall.
Anthracnose	*Colletotrichum spp. (gloeosporioides or kaki)*	Fruit, calyx, leaf	Qld - medium & increasing, low-nil elsewhere.
Twig blight	*Phomopsis spp?.*	Twigs, laterals	Qld & WA - medium, SA - low.
Sooty mould	*Various genera - Capnodium, Fumago, Scorias, Capnodium, Fumago, and Scorias.*	Leaf, calyx, fruit	Problem – all states.
Moderate priority			
Botrytis	*Botrytis cinera*	Leaf, fruit, calyx	Moderate problem in SA and Vic.
Pestalotiopsis spot	*Pestalotiopsis spp. Pestalotiopsis diospyri*	Leaf, calyx, shoots	Disease has been mis-identified as other leaf spots. Problem in Qld and northern NSW.
Low priority			
Rhizopus/Penicillium	*Rhizopus spp. Penicillium spp.*	Fruit (post-harvest rots)	Minor problem - all states.
Bacterial wilt	*Psuedomonas solanacearum*	Roots, trunk, tree	Minor problem - all states.
Armillaria root rot	*Armillaria luteobubalina*	Roots, trunk	Minor problem - all states.
Phytophthora root rots	*Phytophthora cinamomi*	Roots	Minor problem - all states.
Fusarium root rot	*Fusarium solani*	Seedling roots	Minor problem - all states.
Crown gall	*Agrobacterium tumefaciens*	Roots, trunk	Minor problem - all states.

MATERIALS AND METHODS

Pathogens were identified during routine orchard visits and response to grower enquiries. Leaf, shoot and fruit samples were obtained from several nurseries for disease isolation.

A trial was established to test the pathogenic potential of *Pestalotiopsis diospyri. Pestalotiopsis diospyri* was sub-cultured from leaf and calyx samples obtained from the trial block at Maroochy Research Facility. Spores were collected and mixed with water as an inoculum source. Three healthy trees were selected for trialling the following treatments;

- Control
- Control- injured
- Petalotia spray
- Petalotia spray - injured

Shoots in the injured treatments were damaged by scrapping areas of leaves and shoots with a sharp knife to induce an area for potential infection. Shoots were evaluated 14 days after treatment and leaves were assessed for presence of lesions. Lesions were then isolated on PDA media for confirmation as *Pestalotiopsis diospyri.*

A trial was carried out in the Maroochy Research Facility persimmon block to evaluate the use of prochloraz (Octave) for the control of anthracnose (pepper spot). Six replicates of individual Jiro trees were sprayed three times with Octave at a concentration of 1g/L at two week intervals during flowering and early fruit set. Fruit was evaluated at harvest for presence of anthracnose.

RESULTS AND DISCUSSION

ANGULAR (PSEUDOCERCOSPORA) LEAF SPOT

Symptoms consist of an angular leaf spot with distinct margins (Plate 1). The disease affects the leaf only (Plate 1). Spots are small (ranging in size up to 7mm) and brown to grey. Spots often coalesce to form large disfigured areas. Large necrotic spots are commonly seen as the disease progresses. Severe Cercospora infections can cause major fruit drop.

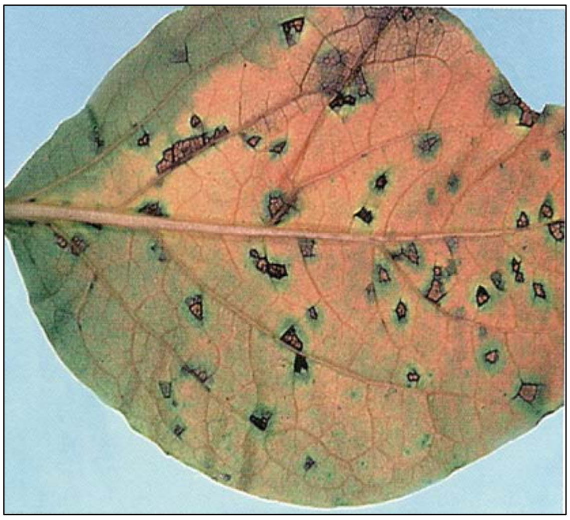


Plate 1. Angular leaf spot showing distinct angular margins.

The casual organism is *Pseudocercospora spp.* possibly *Pseudocercospora kaki.* This disease organism commonly infects persimmon leaves. It is a different *Pseudocercospora* species that causes husk spot in macadamia.

Pseudocercospora leaf spot has been present in Australia for at least fifty years. The disease was probably introduced by immigrants from Italy with the introduction of the older astringent varieties. Pseudocercospora is major problem especially in wet seasons in Queensland and NSW production regions. It does not appear to be a major problem in Victoria, South Australia or Western Australia except in seasons with above average summer rainfall.

There appears to be a varietal difference in the susceptibility to the disease with cv. Izu showing greater susceptibility than other cultivars. The disease can lead to severe loss of photosynthetic capacity and can lead to premature leaf drop in the autumn. Premature leaf drop reduces fruit size in the current season and the build-up of carbohydrate for next seasons flowering and fruit development. Keeping healthy leaf on the tree in the autumn is therefore very important.

The disease overwinters as hyphae in the leaves and leaf bases. Spores of the fungus which cause this disease can survive for 5-6 months in diseased leaves and serve as an inoculum source for next year. The fungus is disseminated chiefly by water. Some growers have reported that the disease is worse under bird netting presumably due to higher humidities and slower leaf drying under netting.

Mancozeb has been shown to be effective against angular leaf spot. We recommend maintaining a regular protectant spray program using mancozeb. Mancozeb is sprayed every 3-4 weeks from flowering until 4 weeks before harvest. Up to 6 sprays per season may be needed in Queensland. Mancozeb can be washed off in high rainfall areas.

As persimmons are harvested over a 1-2 month period, a systemic fungicide is urgently needed with a short with holding period (3-7 days) for Cercospora control during the harvest period. Other non-registered fungicides such as Cabrio® (pyraclostrobin) Tilt® (propiconazole) and Amistar® (azoxystrobin) may be more effective than mancozeb under higher disease pressure situations. These fungicides are not currently registered for use on persimmon.

Although chlorothalonil has a minor use permit for application to persimmon there are some limitations to its use for persimmon. This fungicide should only be used either early (pre-flowering) or after harvesting as it can cause leaf burn and fruit burn. Some growers spray chlorothalonil *Bravo®)* up to 3 times prior to flowering. It can be used again after harvesting is finished to control leaf diseases and to reduce the rate of leaf drop. The advantage of using Bravo® is that it sticks better than mancozeb after rainfall.

Other orchard management strategies for controlling Pseudocercospora leaf spot include;

- When pruning, open up the trees more to improve spray penetration. Dense foliage reduces spray penetration. Prunings which contain carry-over spores and old fruit left on the ground should be removed from the orchard.
- Prune tree skirts to 50 cm above the ground. This will minimise humidity in canopy and ensure optimum spray coverage.
- Remove prunings from the orchard whenever possible, or mulch them quickly to assist natural breakdown. If dead leaves or prunings are left under trees, cover them with straw mulch 50 mm or more in depth to stop spore movement up into the tree. Moisten leaves and mulch to promote leaf breakdown.
- Regularly monitor fruit for infection during the season so that spraying can start before fruit diseases get too severe. Where fruit diseases are an ongoing problem, regular spraying may be required.

ANTHRACNOSE

There can be a variety of symptoms. In the early stages, the disease appears as ‘pepper spots’ which are very small and discrete with well-defined margins (Plate 2). The most likely disease organism producing this symptom is *Colletotrichum gloeosporioides.* Pepper spot also occurs in avocado and custard apple fruit and has been shown to be associated with a stress factor that limits the disease to pepper spots rather than the quite large sunken spots normally characteristic of anthracnose. As the disease progresses, the spots become larger and can merge. Sunken spots may also occur on the leaves and fruit (Plate 3). These symptoms may be caused by a different species, *Colletotrichum kaki*.

Plate 2. Various stages of anthracnose development. Top: Pepper spot caused by *Colletotrichum gloeosporioides.* Bottom: More advanced stage.

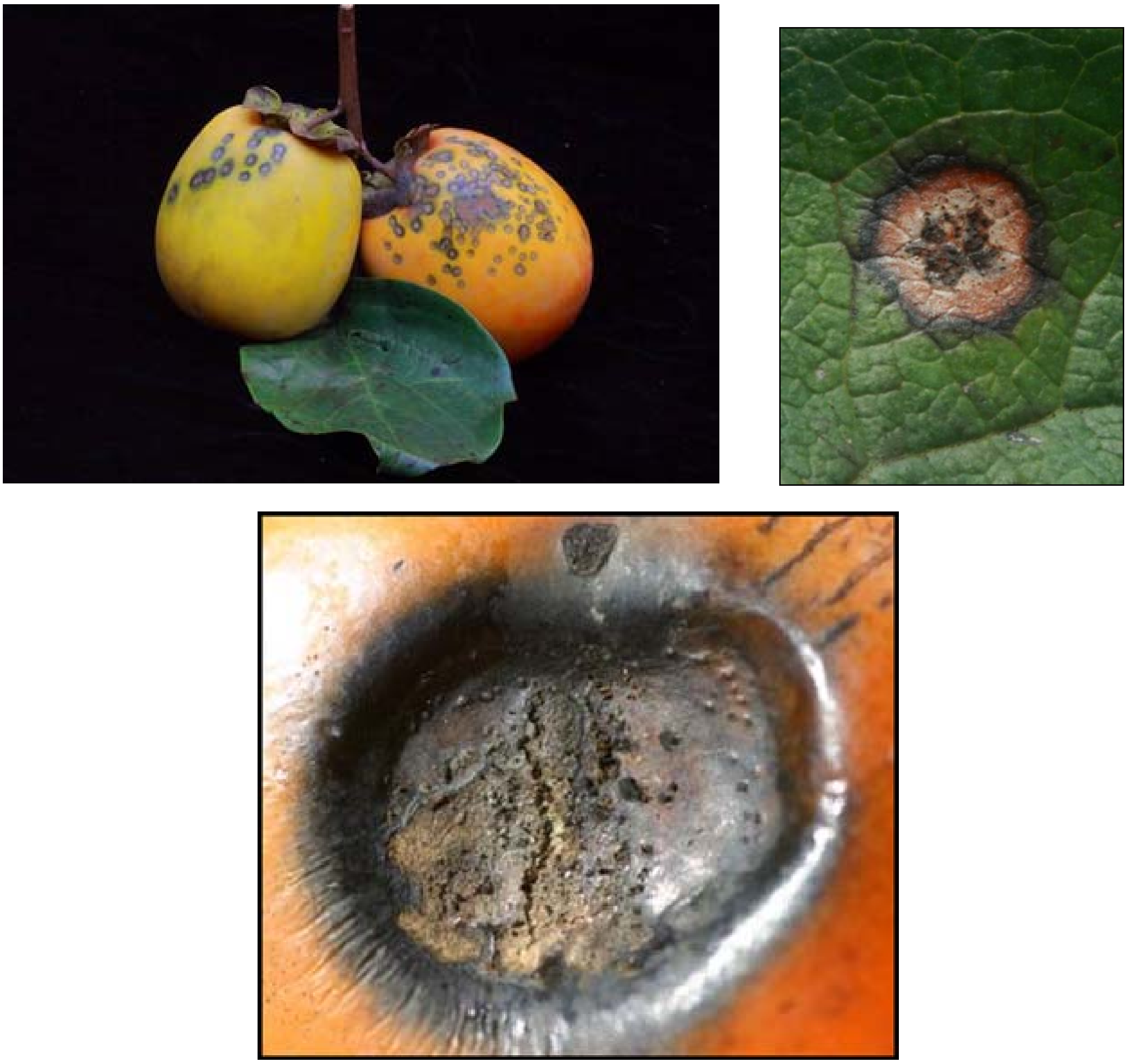


Plate 3. Anthracnose symptoms caused by *Colletotrichum kaki* include sunken spots on the fruit and leaves.

The most likely organism causing damage is *Colletotrichum gloeosporioides* which produces the pepper spot symptom. Symptoms such the sunken spot may also be caused by a different species, *Colletotrichum kaki* which may also be present in Australia. *Colletotrichum* spp. attacks a wide range of fruit, including avocado, custard apple, mango, banana, passionfruit, fig and papaw.

Anthracnose disease has become more significant over the past five years. This fungal disease has been recognised in Queensland since the mid 1950's. It could become an ongoing major disease problem.

Anthracnose is major problem especially in wet seasons in Queensland and NSW production regions. It is a minor problem in Victoria, South Australia and Western Australia presumably due to the drier climate in the production regions of these States. Overseas research indicates that some varieties are more susceptible than others.

Spores of the fungus are produced on dead twigs, leaves and fruit. Given overhead irrigation, heavy dews or warm showery weather, these spores will spread through the orchard. Fruit is susceptible to infection from fruit set to harvest. The fungus penetrates the peel of the fruit where it normally remains dormant until the fruit ripens. The fungus may also start to grow and produce symptoms if the fruit is injured or stressed. Wet conditions increase severity of the disease. There are a number of factors which probably contribute to anthracnose in persimmon:

- Wet and windy conditions favour the disease
- Many orchards in NSW and Queensland are now 20-25 years old, and there is likely to have been a build-up in anthracnose inoculum in these large trees
- Older trees have higher levels of dead/dying tissue on which the fungus proliferates
- Larger older trees are more difficult to spray properly, especially the inner top one third of trees
- Older trees, particularly those which are lightly pruned, retain moisture on the leaves and fruit for longer, and hence favour infection and fungus development
- Fruit that are left to hang on the trees and not picked are sources of fungal spores.
- Fruit hanging on the tree continuously for several months, and it more likely that fungal spores can build up within the tree, and move to uninfected fruit. In contrast, after fruit are harvested in orchards in Queensland, leaves drop from the tree in winter, so that there is a distinct break in the disease cycle.
- Higher levels of infection can occur where orchards are located in close proximity to neglected avocado orchards.
- Prunings may also be a source of inoculum, if they are placed under the tree and tree skirts are kept low or weight of fruit brings branches down to ground level. This inhibits movement of drying air.
- Some growers suggest that the disease is spread by birds/bats but this needs to be verified.

In Queensland and NSW, depending on disease pressure, spray every two - four weeks with a fungicide such as mancozeb. Control with these protectants largely depends on the level of coverage achieved.

Results from Prochloraz (Octave®) trails at Maroochy Research Facilty were inconclusive due to extremely dry conditions during a significant proportion of the fruit development period. No anthracnose was observed in any of the treated or control trees. Prochloraz will be trialled in the next phase of the project during weather conditions more conducive to the occurrence of anthracnose.

Other orchard management strategies for the control of anthracnose are the same as for Pseudocercospora leaf spot.

TWIG BLIGHT (PHOMOPSIS)

The most apparent symptoms are sporadic and delayed budbreak after trees break dormancy in the spring. The new shoots have smaller yellow leaves and etiolated shoots (Plates 4 and 5). New season's laterals dieback from the tip. Sub-leaders may also dieback towards the main leader or trunk with little or no emergence of dormant buds. The one-year old shoots may exhibit ink-dark cankers and the internal wood may be necrotic or stained (Plates 6 and 7).

Plate 4. Symptoms of twig blight at Maroochy Research Facility. Top left: dead laterals. Top right, tree severely affected with dieback. Bottom left: new shoots wilted. Bottom right: total dieback of new season laterals.

DAFF plant pathologist Mr Don Hutton has isolated the disease organisms *Phomopsis* spp. and *Diplodia* spp. from tissue at the margins of shoot necrosis however pathogenicity of these organisms has not been proven. Exact species of *Phomopsis* is still to be determined.

The disease was first observed at Maroochy Research Facility in 2009-10. In the same year, a second orchard at Blackbutt also exhibited similar symptoms. 'Fuyu' trees were more affected than 'Jiro'. Phomopsis has now been observed in orchards in Queensland, NSW and WA. Some nurserymen have also observed this disorder in nursery trees. We suggest that this disorder has been recently introduced into Australia.


Plate 5. Symptoms of twig blight at Blackbutt. Cv. Fuyu severely affected. Leaves of 'Fuyu' are small, yellow and elongated. Note bare sections along sub-leaders.

Twig blight is most often observed in early spring following bud break. Cv. Fuyu is far more susceptible than 'Jiro". Symptoms include wilt and death of leaves on new shoots. Wilt and death of blossoms and young fruit on fruiting wood also occur. A diffuse canker, often with a concentric appearance and exuding gum, can be found on the fruiting wood at the base of the blighted shoots. The canker is usually centred on a dead bud, which is believed to be the infection point for the pathogen.

We believe that most bud infection occurs during the previous fall or winter as the organism can enter fresh leaf scars when the trees are defoliating in late autumn. New infections can also occur in the spring, leading to twig blight during early summer.

Superficially, twig blight can be confused with other causes of twig death (e.g., Cytospora canker), but can be distinguished by close examination of the canker and by laboratory culture. *Cytospora* spp. and *Botrysphaeria* spp. often invade cankers and shoots killed by Phomopsis infection. We would expect that wet weather would exacerbate this problem.

Plate 6. Staining of internal wood on persimmon.

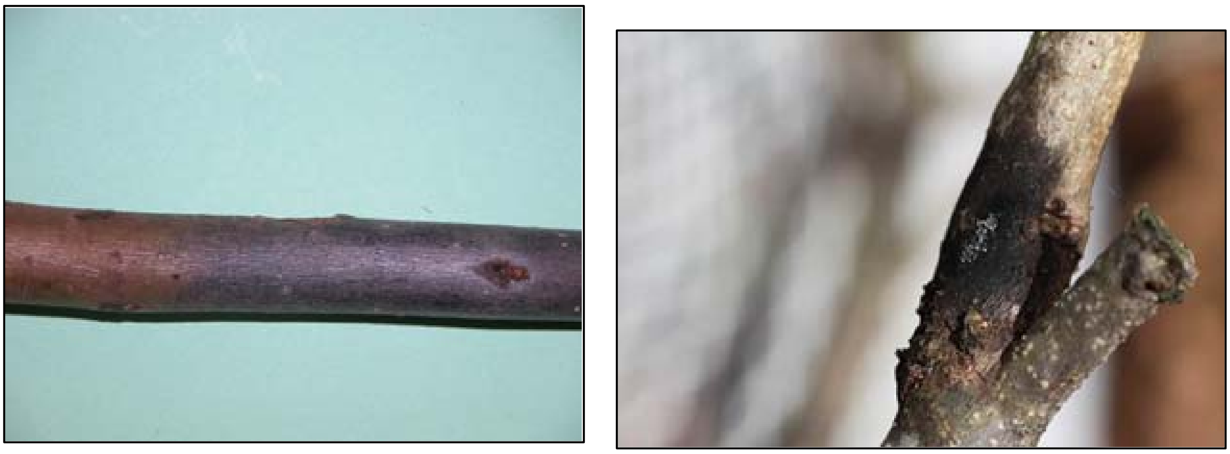


Plate 7. Left: Ink-dark canker of *Phomopsis diospyri* found on persimmon in Greece. Bottom: Canker on persimmon shoot at Nambour.

As chemicals available for the control of *Phomopsis* do not function as eradicants, they must be applied before the spores of the fungus can germinate in order to be effective. If *Phomopsis* has been a problem in any of the previous seasons, spray at 50% budburst (wait until green leaf tissue is becoming evident) and 2 weeks after budburst with mancozeb. This will prevent spores infecting newly develop shoots. If wet conditions persist after budburst, further fungicide applications may be required.
We would recommend that trees also be sprayed in the autumn during mid- and late-leaf drop stages as the fresh leaf scars are a site for entry of the disease organism.

DAFF officers visited a farm in Blackbutt, Queensland in November 2012 in response to a grower request. *Phomopsis* was recovered from an adjacent farm in 2010 and affected trees were displaying the same symptoms (Plate 8). Samples were isolated at Maroochy Research Facility and *Phomopsis* was recovered. This grower now applies regular early sprays of mancozeb and has achieved a good level of control.

Plate 8. Fuyu tree with bare sections along sub-leaders caused by *Phomopsis.*

Growers who have experienced *Phomopsis* in their orchards now take a preventative approach with early applications of fungicides. One grower in Western Australia has experienced an increase in Longicorn beetle larvae damage due to the large quantities of dead wood left after a severe outbreak of *Phomopsis.*

Other orchard management strategies for the control of *Phomopsis* include:

- Treat nursery stock before planting with fungicides.
- Cv. Jiro is much less susceptible
- Prune off and burn infected wood to prevent carry over of spores into the next season
- Disinfect pruning equipment (pruners, loppers, saws) regularly before moving between trees

PESTALOTIOPSIS

Symptoms on leaves are large greyish brown circular ringspots (Plate 9). Usually, they are solitary, but occasionally, two to three spots occur on an affected leaf. In severe cases, lesions develop on more than one-third of the leaf, resulting in defoliation (Yasuda *et al. 2003)*. Small black acervular conidiomata are visible in the surface of spots. Symptoms may also appear on the calyces sepals as brown-to-black necrotic areas; one to four sepals per fruit could be affected. Severe infestations can cause early fruit maturation and premature abscission.

Trials to evaluate the pathogenicity of *Pestalotiopsis diospyri* were successful in recovering this pathogen from inoculated material. All shoots subjected to injury had a higher incidence of *Pestalotiopsis diospyri* (Figure 1). The largest amounts of this pathogen was recovered in treatments that where sprayed with inoculum and subjected to injury. Interestingly *Pestalotiopsis diospyri* was recovered from the injured control treatment and none was recovered from the uninjured spray (inoculated) treatment. This result indicates that *Pestalotiopsis diospyri* infects damaged tissue and has limited pathogenicity on healthy leaves and shoots. The recovery of *Pestalotiopsis diospyri* from 32.5% of leaves in the injured control treatment may be explained by the presence of spores within the tree after treatment.

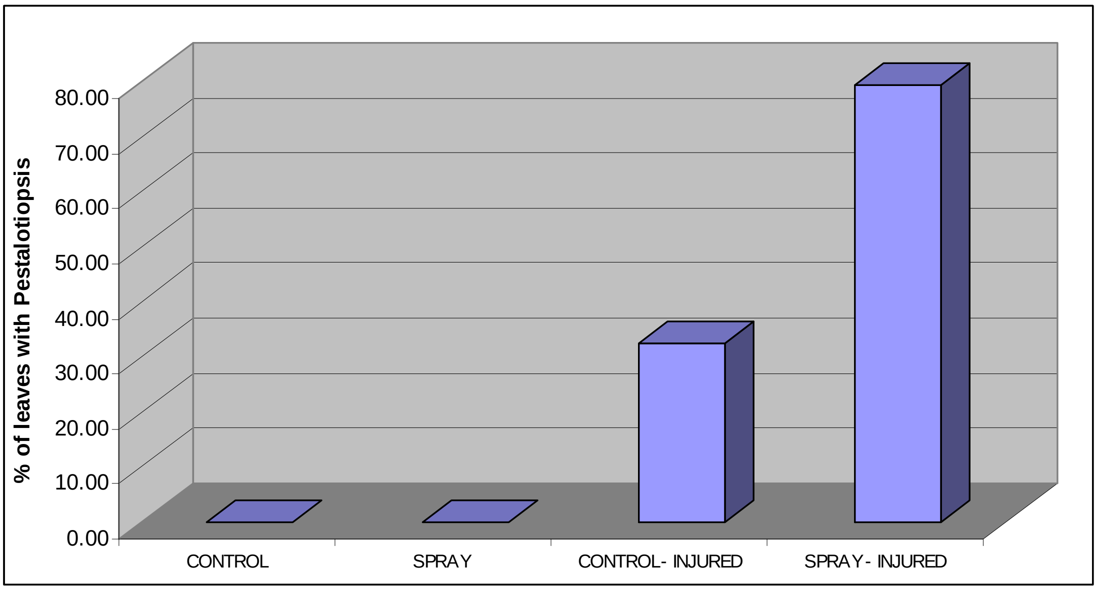


Figure 1. Average percentage of leaves with *Pestalotiopsis diospyri* after treatments.

Plate 9 - Leaf lesions caused by *Pestalotiopsis diospyri.*

ALTERNERIA

Alterneria alternata can cause the development of black spots on fruit usually during the postharvest period. The disease usually infects fruit close to harvesting time and isn't evident until the fruit are stored. *Alterneria* has been reported as a pre-harvest disease in Korea (Lee *et al.*, 2012) and has only been observed locally as a postharvest rot.

Samples from trees displaying black spot symptoms on fruit and leaves were collected from an orchard in Nambour, Queensland (Plate 10). Disease isolations were performed on fruit and leaf tissue. Some *Colletotrichum gloeosporioides* and *Pestalotiopsis diospyri* was observed from fruit lesions. Isolations from leaf samples resulted in 85% of lesions caused by *Alterneria alternate* with the remaining 15% of lesions caused by *Pestalotiopsis diospyri* . This result has not been previously documented in persimmon as fruit are usually the host for this pathogen.

Plate 10. Leaf and fruit spots found on 'Jiro' trees in Nambour.

EFFECTS OF 1-MCP AND MA BAGS ON POSTHARVEST STORAGE AND QUALITY OF 'JIRO' AND 'FUYU' PERSIMMON FROM MAJOR GROWING REGIONS.

INTRODUCTION

Development of postharvest protocols for the Australian sweet persimmon industry is necessary to give growers tools for short, medium and long-term storage. The use of 1-MCP and modified atmosphere bags have proven to be effective in extending the storage life of persimmon while also maintaining quality.

1-MCP reduces ethylene effects in a range of fruits including persimmon (Blankenship and Dole, 2003; Luo, 2007; Oz, 2011). The molecular structure of the gases 1-MCP (C_4H_6) and ethylene (C_2H_4) are very similar (Kim and Lee, 2005). 1-MCP binds to the receptor site for ethylene, thereby blocking its action (Blankenship and Dole, 2003; Sisler *et al*., 1996). The application of 1-MCP delays the ethylene climacteric and reduces the rate of fruit softening even for fruit stored at 20°C. The response may be as dramatic as a doubling of storage life.
1-MCP has also been shown to lower the activity of polygalactonuronase (PG), an enzyme responsible for cell wall softening (Ramin, 2008). Consequently, 1-MCP treated persimmon fruit can maintain their firmness and cell wall integrity for significantly longer periods than non-treated fruit and can also reduce chilling injury, respiration and ethylene production at ambient temperatures (Luo, 2007).

MCP research has been conducted in all the major persimmon growing regions around the world. The bulk of the work has been aimed at reducing rapid fruit softening of the major astringent varieties after removal of astringency (Salvador *et al*., 2004), although there has been considerable research with 'Fuyu' fruit (Kim and Lee, 2005).

The main aim of modified atmosphere (MA) bags is to change the composition of the atmosphere around the product so that the storage life of the product can be extended. Most fruit age less quickly when the level of oxygen ($O_{2)}$ the atmosphere surrounding them is reduced. This is because the reduced oxygen slows down the respiration and metabolic rate of the products and therefore slows down the natural aging process. Raising the level of carbon dioxide (CO_2) to levels of 2 % or more can also be beneficial. Elevated CO_2 levels can reduce the products sensitivity to ethylene. High CO_2 can also slow the growth of many of the postharvest fungi that cause rots. All these effects can help to extend the storage and shelf life of persimmon.

MA storage can be lengthened considerably by combination with 1-MCP, application of which also alleviates most chilling. Inclusion of ethylene absorbents inside the bags can reduce skin browning and maintain flesh firmness but effects are relatively minor compared with applying 1-MCP.

The aim of this trial was to establish storage recommendations for 'Jiro' and 'Fuyu' at a range of temperatures from the major growing regions of Australia which are coastal and inland south-east Queensland, South Australia and Victoria.

MATERIALS AND METHODS

20 trays of class 1 'Jiro' and 'Fuyu' fruit were collected from three quality growers in coastal and inland south-east Queensland and South Australia/Victoria (Fuyu only) and transported to Maroochy Research Facility. Trays were inspected for any soft fruit and removed prior to treatment. All fruit treated with 1-MCP were placed in a completely sealed experimental tent set up within a cold room set at 15°C (Figure 1) and treated at a dose rate of 500ppb for 24 hours. Fruit used as controls were also placed in the same coldroom room outside of the experimental tent. A description of treatments is outlined in Table 1.

After treatment some trays were placed immediately in modified atmosphere bags (Lifespan 296). Trays were then randomised and placed in designated cold rooms at either 15ºC or 0ºC.

TABLE 1.

Description of treatments. Fruit cv. Jiro and Fuyu were sourced from three growers in each major growing region.

Storage Temperature	Duration of Storage	No. of trays treated with 1-MCP	No. of trays treated with 1-MCP and MA bags	Control
0°C	2 weeks	1 tray/grower	1 tray/grower	1 tray/grower
0°C	4 weeks	1 tray/grower	1 tray/grower	1 tray/grower
0°C	6 weeks	1 tray/grower	1 tray/grower	1 tray/grower
0°C	8 weeks	1 tray/grower	1 tray/grower	1 tray/grower
0°C	10 week	1 tray/grower	1 tray/grower	1 tray/grower
0°C	12 weeks	1 tray/grower	1 tray/grower	1 tray/grower
15°C	2 weeks	1 tray/grower	1 tray/grower	1 tray/grower
15°C	4 weeks	1 tray/grower	1 tray/grower	1 tray/grower
15°C	6 weeks	1 tray/grower	1 tray/grower	1 tray/grower

Maturity

Two trays from each grower sampled were initially used to assess fruit maturity and quality (Table 2) before treatment.

Plate 1. Maturity of Jiro from three orchards in coastal (left) and inland (right) growing regions.

Plate 2. Maturity of Fuyu from three orchards in coastal (left), inland (middle (two orchards only)) and SA/Vic (right) growing regions.

Assessments were made on the following fruit quality variables:

- fruit colour
- Brix
- firmness
- dry matter
- calyx quality
- blemish

Destructive sampling measured TSS (Brix) using an Atago refractometer; firmness, using an Effegi penetrometer with an 8mm tip; and dry matter (%), where ~10 grams of fruit flesh was taken from each fruit, cut finely and dried for 48-72 hours at 65°C. Fruit colour was measured three times around the fruit equator using the Japanese persimmon industry colour chart (Plate 1).

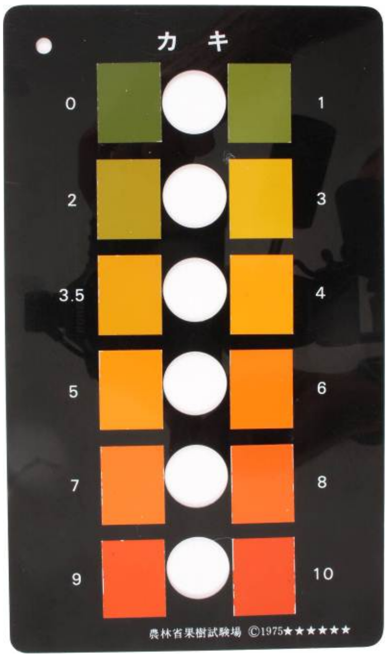


Plate 1. Japanese colour chart. Ratings from 0-10.

After storage, fruit were placed in a cold room (20±1°C) for seven days to simulate retail conditions. After seven days fruit was assessed for fruit quality as above. In addition, the percentage of soft and gelled fruit was also recorded. Gelled fruit are included as soft fruit. The soft fruit count is where the fruit is soft and still looks like a firm persimmon. However, a gelled fruit is still soft but the skin and flesh have taken on a transparent colouring/texture. Symptoms of gelled fruit are shown in Plate 2. Internal blackening was also recorded (Plate 3). Data was analysed using analysis of variance in Genstat (version 11).

Plate 2. Fruit on the right showing signs of severe gelling.

Plate 3. Severe internal blackening of Jiro.

RESULTS AND DISCUSSION

Maturity and fruit quality- Jiro

Maturity and fruit quality indicators for Jiro from coastal and inland south-east Queensland are shown in Figure 1. There was very little difference between growing regions for calyx quality and levels of blemish, however fruit from the coastal region had a slightly higher colour rating of 4.4 compared to 4.1 for inland region fruit. Inland fruit were slightly firmer than coastal fruit with 5.5 kg f/cm^2 compared 5.3 kg f/cm^2. Coastal fruit had a slightly higher dry matter (17.3%) and Brix (14.4%) compared with fruit from the inland region (16.7% and 13.5%).

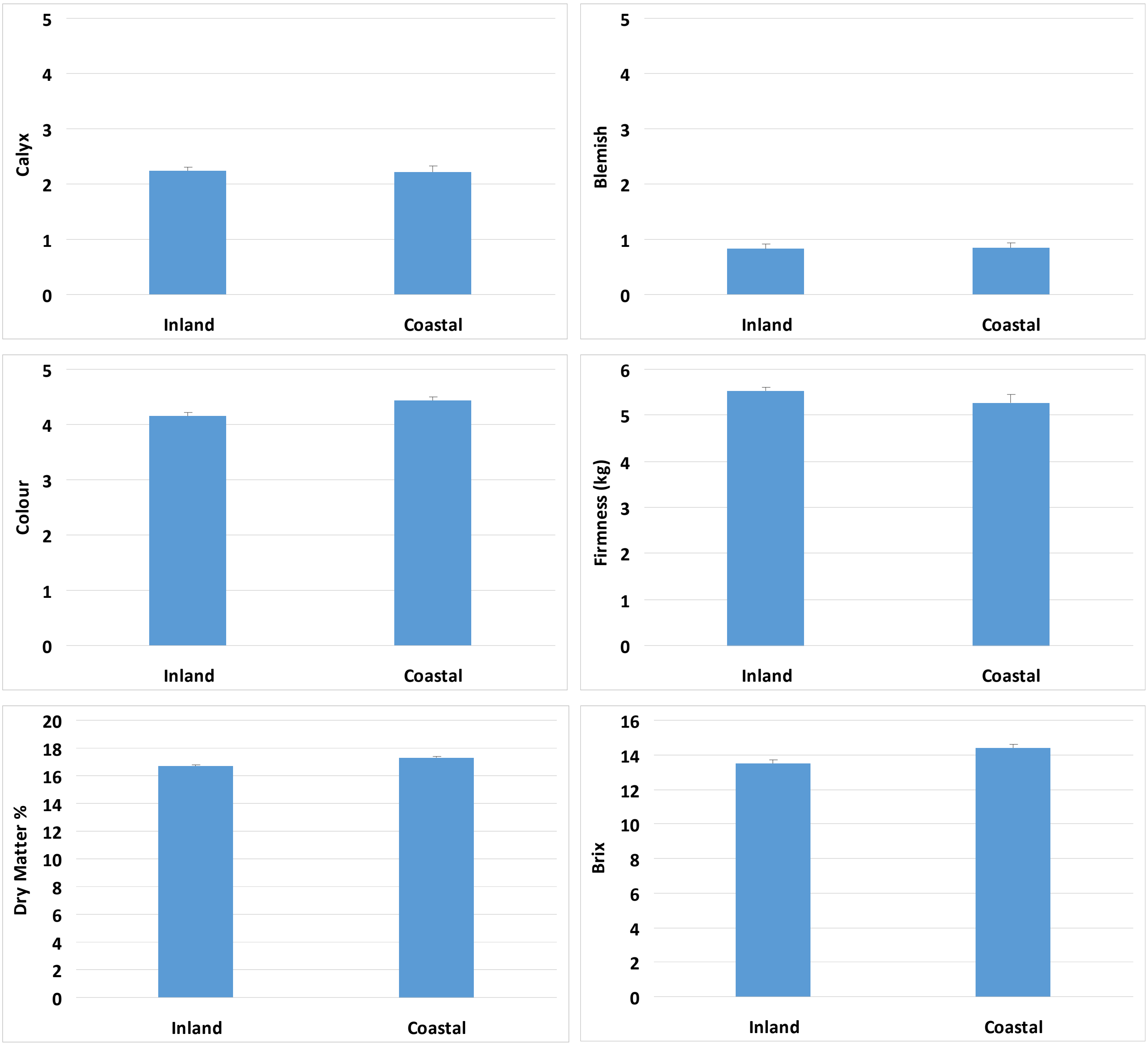


Figure 1. Average Jiro maturity indicators of three growers from each region (inland and coastal south-east Queensland). Calyx health was rated on a scale of 1 to 5, 1=healthy, 5=severely diseased or damaged. Blemishing rated on a scale of 1-5, 1=no blemish, 5=extremely blemished.

Maturity and fruit quality- Fuyu

Maturity and fruit quality indicators for Fuyu from coastal and inland south-east Queensland and South Australia/Victoria are shown in Figure 2. Calyx quality was similar across all growing regions. Fruit from coastal region growers had lower levels of blemish than Inland and SA/Vic growers. Coastal and SA/Vic fruit had a higher colour rating than inland fruit (4.3) with an average of 4.9 and 5.0 respectively. Fruit firmness was similar across growing regions. SA/Vic achieved the highest dry matter content (19.7%) and Brix (17.5%) followed by coastal (18.6% and 16.0%) and inland (17.9% and 14.8%).

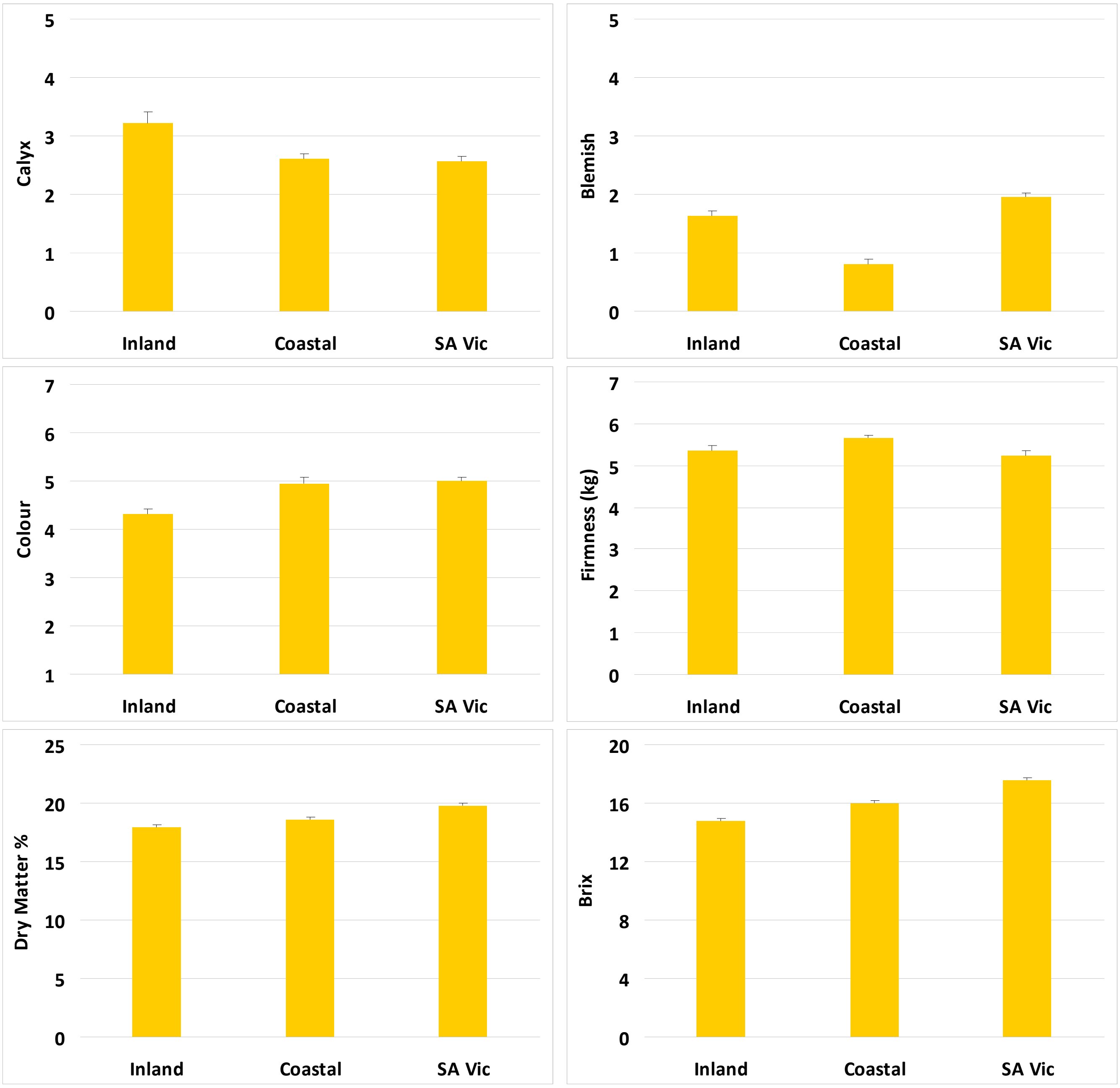


Figure 2. Average Fuyu maturity indicators of three growers from each region (inland and coastal south-east Queensland and South Australia/Victoria). Calyx health was rated on a scale of 1 to 5, 1=healthy, 5=severely diseased or damaged. Blemishing rated on a scale of 1-5, 1=no blemish, 5=extremely blemished.

Jiro from coastal growing regions

Storage at 15ºC

Calyx
There were no differences between treatments at each of the removal stages (two, four and six weeks) with all treatments reaching the maximum rating of 5 by four weeks in storage.

Blemish
Fruit treated with 1-MCP alone or in combination with MA bags slightly reduced blemish at all storage durations. At six weeks storage, fruit treated with 1-MCP had the significantly lower blemish levels with a rating of 2.0 compared to 1-MCP+MA bags (2.5) and the control (2.75).

Colour
Colour at two weeks storage was similar for all treatments; however at four weeks fruit treated with 1-MCP+MA bags achieved a significantly lower colour rating of 5.76 compared with 6.91 for 1-MCP and 7.32 for the control. At six weeks all treatments were of the same colour.

Firmness and % soft
Fruit treated with 1-MCP achieved the best levels of firmness at each of the storage duration. At two weeks fruit treated with 1-MCP and 1-MCP+MA bags had a penetrometer reading greater than 2.0 kg f/cm^2 which is considered marketable and an average softening of 30 and 36% respectively. Control fruit at two weeks had an average firmness of 1.1kg f/cm^2 and average of 72% soft. All treatments achieved an average firmness of less than 2.0 kg f/cm^2 at four and six weeks storage.

Chilling injury (gelling)
The use of modified atmosphere bags increased the levels of chilling injury with 18% and 21% of fruit with internal gelling at two and four weeks storage. No chilling injury was recorded at six weeks due to all fruit becoming extremely soft and impossible to assess.

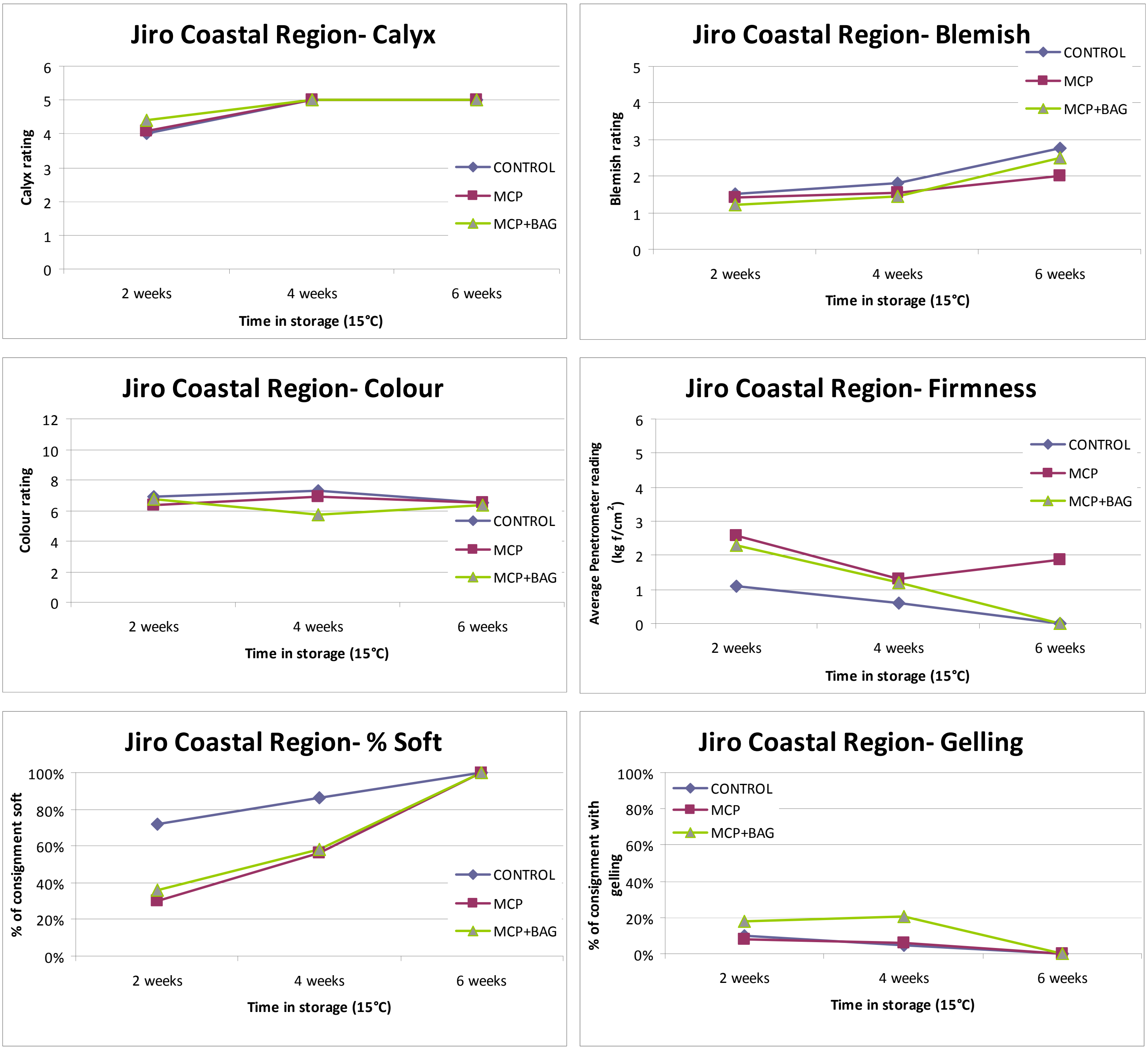


Figure 3. Differences in fruit quality of Jiro from coastal growing regions after treatment with 1-MCP and MA bags and stored for six weeks.

	Treatment	2 weeks		4 weeks		6 weeks	
Calyx	CONTROL	4.03		5.00		5.00	
	MCP	4.10		5.00		5.00	
	MCP+BAG	4.40		5.00		5.00	
	LSD	**0.40**					
Blemish	CONTROL	1.51		1.82		2.75	a
	MCP	1.40		1.56		2.00	b
	MCP+BAG	1.21		1.46		2.50	a
	LSD	**0.43**		**0.30**		**0.33**	
Colour	CONTROL	6.90		7.32	a	6.50	
	MCP	6.38		6.91	a	6.50	
	MCP+BAG	6.72		5.76	b	6.33	
	LSD	**0.66**		**0.65**		**0.59**	
%Penetrometer	CONTROL	1.09	b	0.59	b	0.00	b
	MCP	2.56	a	1.32	a	1.88	a
	MCP+BAG	2.31	a	1.19	a	0.00	b
	LSD	**0.59**		**0.46**		**0.11**	
% Soft	CONTROL	0.72	a	0.86	a	1.00	
	MCP	0.30	b	0.56	b	1.00	
	MCP+BAG	0.36	b	0.58	b	1.00	
	LSD	**0.18**		**0.19**			
% Gelling	CONTROL	0.10		0.05	b	0.00	
	MCP	0.08		0.06	b	0.00	
	MCP+BAG	0.18		0.21	a	0.00	
	LSD	**0.13**		**0.12**			

Table 1. Means and pair-wise comparisons for Jiro from coastal regions stored at 15ºC for six weeks (means followed by the same letter are not significantly different $P<0.05$).

Storage at 0ºC

Calyx
Calyx quality remained similar between treatments for the 12 week duration of storage. Fruit treated with 1-MCP+MA bags achieved a significantly better quality calyx for two and four weeks when compared to 1-MCP and the control.

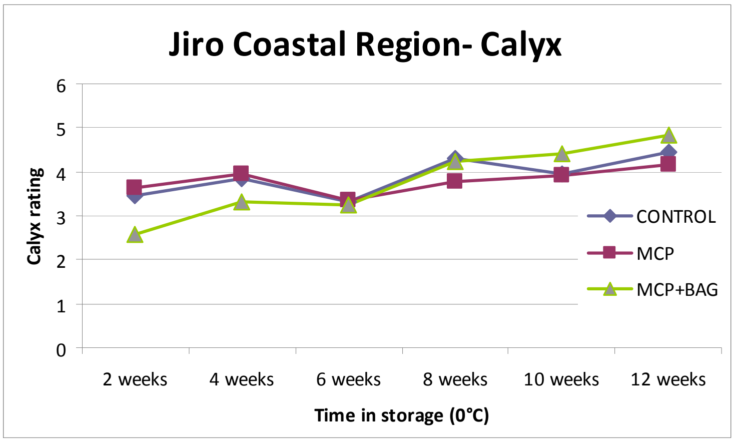
Blemish
At two weeks both 1-MCP and 1-MCP+MA bags treated fruit had lower levels of blemish with a rating of 1.18 compared with 1.54 for the control. Generally fruit treated with 1-MCP+MA bags had lower levels of blemish throughout the 12 week storage duration.

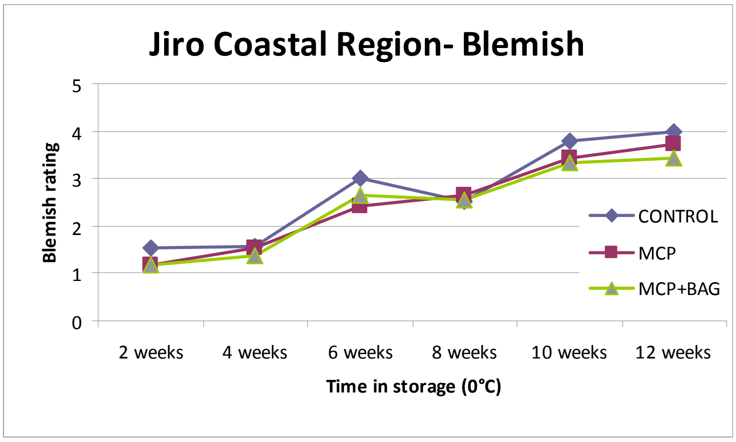
Colour
Average fruit colour was similar for all treatments at two weeks, however from four weeks onwards 1-MCP and 1-MCP+MA bags treated fruit achieved significantly lower colour ratings than the control indicating a reduction in ripening. The use of MA bags in combination with 1-MCP gave the best result by achieving the lowest colour rating at each removal stage.

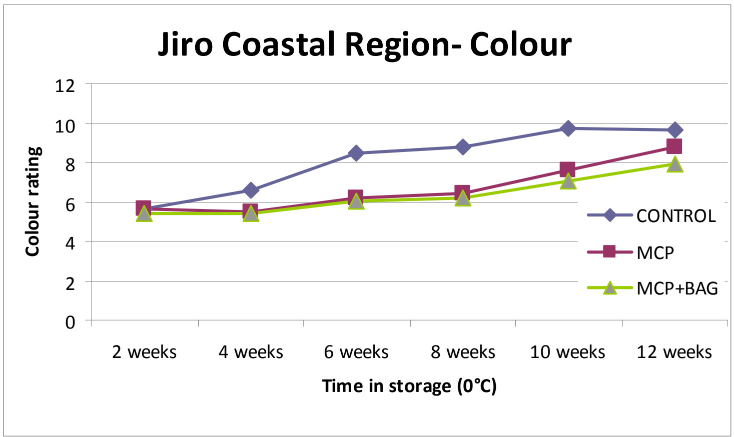
Firmness and % soft
Both 1-MCP treatments (+/- MA bags) maintained an average firmness of over 2.0 kg f/cm^2 for six weeks with an average firmness of 3.8 (1-MCP) and 3.3 (1-MCP + MA bags) kg f/cm^2 at the six week removal stage. The use of 1-MCP alone and with MA bags greatly reduced the amount of soft fruit for six weeks. At two weeks 1-MCP + MA bags treated fruit had no soft fruit. At the same stage 1-MCP treated fruit had only 6% soft compared to the control which recorded 14%. By four weeks 46% of control fruit was soft compared to 4% and 8% in 1-MCP (+/- MA bags) treatments. At six weeks 1-MCP treated fruit had 23% soft fruit which was 60% less than the control. From eight weeks onwards all treatments had over 50% of fruit which had softened.

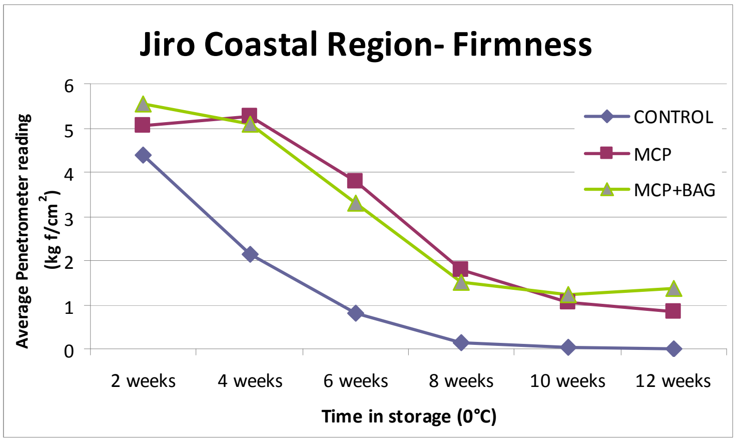
Chilling injury (gelling)
1-MCP treatments significantly reduced the amount of chilling injury at 0ºC at most removal stage when compared to the control. At six weeks both 1-MCP treatments had 19% soft fruit compared with 63% in the control.

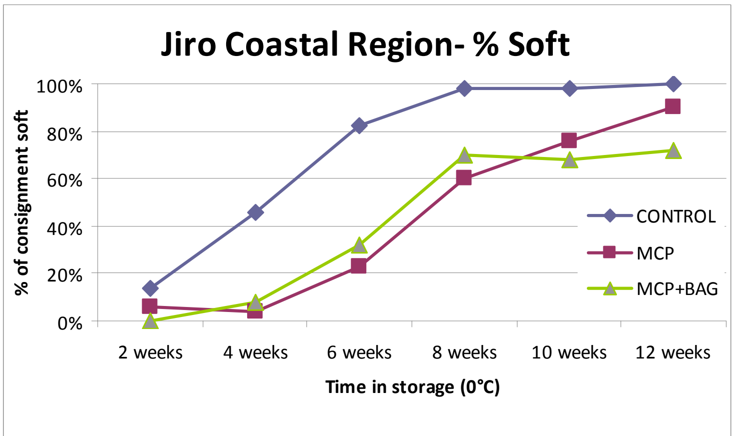
Internal blackening
Internal blackening was evident in the 1-MCP + MA bag treatment, ranging from 13% at four weeks to 59% at twelve weeks. 1-MCP treated fruit experienced lower levels of internal blackening which commenced at six weeks (9%) until twelve weeks (29%). Control fruit experienced no internal blackening until 10 (2%) and 12 (4%) weeks.

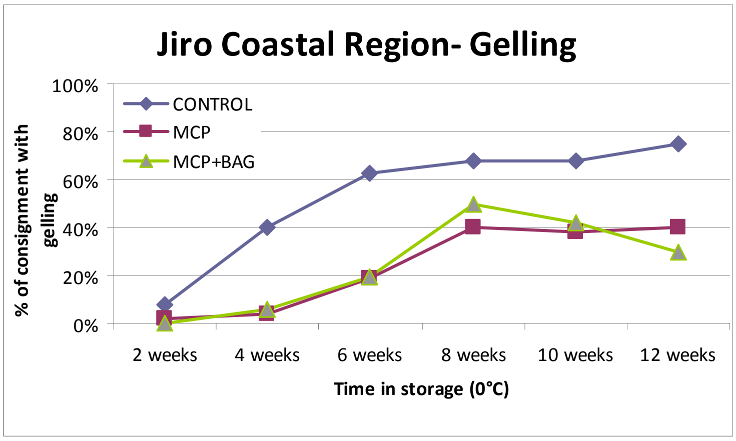












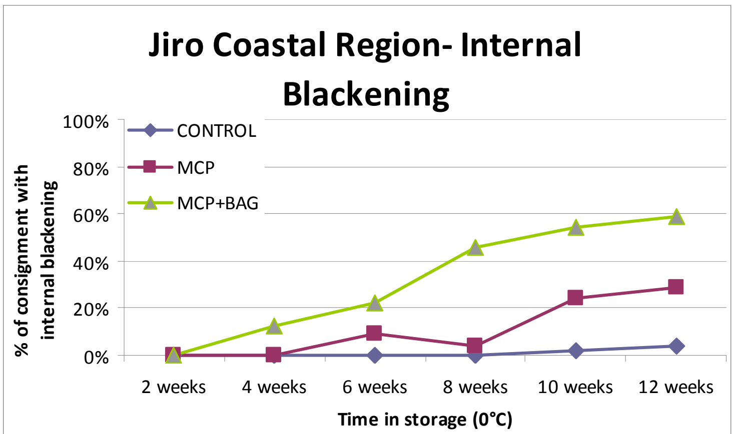


Figure 4. Differences in fruit quality of Jiro from coastal growing regions after treatment with 1-MCP and MA bags and stored for 12 weeks at 0ºC.

	Treatment	2 weeks		4 weeks		6 weeks		8 weeks		10 weeks		12 weeks	
Calyx	CONTROL	3.46	a	3.84	a	3.31		4.32	a	3.96	b	4.46	b
	MCP	3.64	a	3.96	a	3.37		3.78	b	3.92	b	4.16	c
	MCP+BAG	2.56	b	3.32	b	3.26		4.22	a	4.42	a	4.82	a
	LSD	**0.56**		**0.42**		**0.49**		**0.37**		**0.33**		**0.26**	
Blemish	CONTROL	1.54		1.56		3.02	a	2.52		3.78	a	4.00	a
	MCP	1.18		1.53		2.41	b	2.66		3.42	b	3.74	b
	MCP+BAG	1.18		1.38		2.66	ab	2.54		3.32	b	3.42	c
	LSD	**0.37**		**0.26**		**0.44**		**0.41**		**0.32**		**0.21**	
Colour	CONTROL	5.61		6.56	a	8.50	a	8.80	a	9.70	a	9.65	a
	MCP	5.67		5.51	b	6.20	b	6.44	b	7.62	b	8.75	b
	MCP+BAG	5.39		5.42	b	6.07	b	6.22	b	7.09	b	7.89	c
	LSD	**0.40**		**0.52**		**0.60**		**0.73**		**0.63**		**0.58**	
Penetrometer	CONTROL	4.39	b	2.16	b	0.80	b	0.15	b	0.04	b	0.00	c
	MCP	5.06	a	5.28	a	3.79	a	1.79	a	1.07	a	0.84	b
	MCP+BAG	5.56	a	5.09	a	3.31	a	1.52	a	1.24	a	1.38	a
	LSD	**0.59**		**0.65**		**0.74**		**0.57**		**0.39**		**0.37**	
% Soft	CONTROL	0.14	a	0.46	a	0.83	a	0.98	a	0.98	a	1.00	a
	MCP	0.06	ab	0.04	b	0.23	b	0.60	b	0.76	b	0.90	a
	MCP+BAG	0.00	b	0.08	b	0.32	b	0.70	b	0.68	b	0.72	b
	LSD	**0.10**		**0.14**		**0.17**		**0.16**		**0.15**		**0.12**	
% Gelling	CONTROL	0.08		0.40	a	0.63	a	0.68	a	0.68	a	0.75	a
	MCP	0.02		0.04	b	0.19	b	0.40	b	0.38	b	0.40	b
	MCP+BAG	0.00		0.06	b	0.19	b	0.50	ab	0.42	b	0.30	b
	LSD	**0.07**		**0.13**		**0.17**		**0.19**		**0.19**		**0.17**	
% Internal Blackening	CONTROL	0.00		0.00	b	0.00	b	0.00	b	0.02	c	0.04	c
	MCP	0.00		0.00	b	0.09	ab	0.04	b	0.24	b	0.29	b
	MCP+BAG	0.00		0.13	a	0.22	ab	0.46	a	0.54	a	0.59	a
	LSD			**0.08**		**0.13**		**0.12**		**0.15**		**0.16**	

Table 2. Means and pair-wise comparisons for Jiro from coastal regions stored at 0ºC for 12 weeks (means followed by the same letter are not significantly different $P<0.05$).

Jiro from inland growing regions

Storage at 15ºC

Calyx
At two weeks fruit treated with 1-MCP and MA bags had significantly healthier calyx than the 1-MCP treatment and untreated control. All treatment reached the maximum rating by four weeks.

Blemish
The use of modified atmosphere bags increased the levels of blemish at each removal stage. Control fruit achieved the lowest blemish levels of 1.16, 1.29 and 3.5 at two, four and six weeks respectively.

Colour
No differences in colour were observed between treatments.

Firmness and %soft
Both 1-MCP treatments (+/- MA bags) achieved an average firmness of over 2.0 kg f/cm^2 at two weeks which was significantly better than the control which averaged 1.28 kg f/cm^2. All treatments were unmarketable by four weeks. At two weeks 1-MCP treatments achieved 33% (1-MCP + MA bags) and 38% (1-MCP) soft fruit which were significantly lower than the control with 62% soft. By four weeks all treatments had over 80% soft fruit.

Chilling injury (gelling)
Treatment with 1-MCP +MA bags reduced gelling at two (13%) and four (12%) weeks. Treatment with 1-MCP reduced gelling at two weeks but at four weeks achieved the same level of chilling injury as the control.

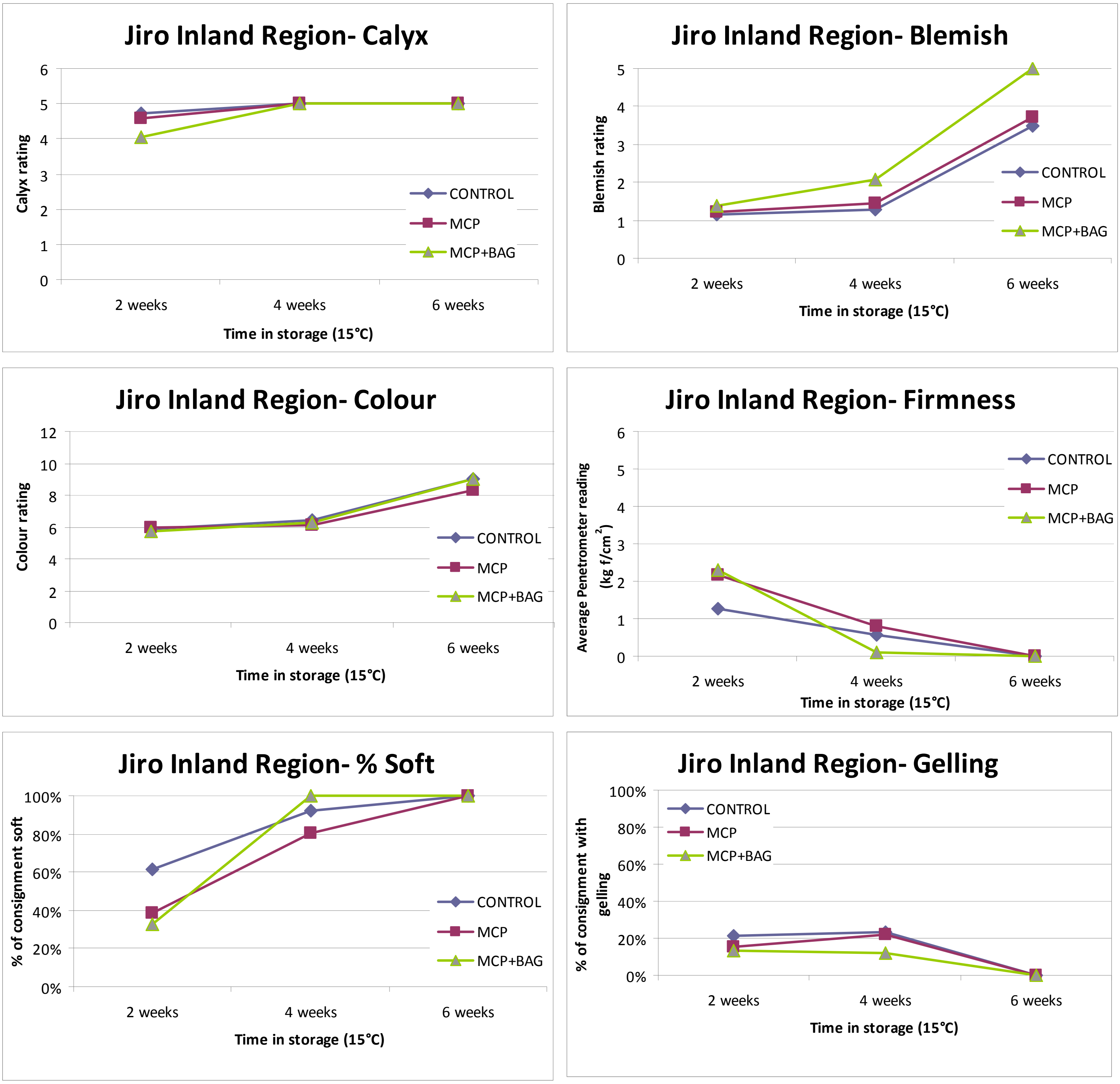


Figure 5. Differences in fruit quality of Jiro from inland growing regions after treatment with 1-MCP and MA bags and stored for 6 weeks at 15ºC.

	Treatment	2 weeks		4 weeks		6 weeks	
Calyx	CONTROL	4.70	a	5.00		5.00	
	MCP	4.60	a	5.00		5.00	
	MCP+BAG	4.04	b	5.00		5.00	
	LSD	**0.36**					
Blemish	CONTROL	1.16		1.29	b	3.50	b
	MCP	1.21		1.46	b	3.71	b
	MCP+BAG	1.38		2.06	a	5.00	a
	LSD	**0.26**		**0.26**		**0.86**	
Colour	CONTROL	5.89		6.45		9.00	
	MCP	5.94		6.11		8.33	
	MCP+BAG	5.70		6.29		9.00	
	LSD	**0.57**		**0.54**		**0.75**	
%Penetrometer	CONTROL	1.28	b	0.56	a	0.00	
	MCP	2.18	a	0.80	a	0.00	
	MCP+BAG	2.30	a	0.09	b	0.00	
	LSD	**0.55**		**0.37**			
% Soft	CONTROL	0.62	a	0.92	a	1.00	
	MCP	0.38	b	0.81	b	1.00	
	MCP+BAG	0.33	b	1.00	a	1.00	
	LSD	**0.19**		**0.11**			
% Gelling	CONTROL	0.21		0.23		0.00	
	MCP	0.15		0.22		0.00	
	MCP+BAG	0.13		0.12		0.00	
	LSD	**0.15**		**0.15**			

Table 3. Means and pair-wise comparisons for Jiro from inland regions stored at 15ºC for six weeks (means followed by the same letter are not significantly different $P<0.05$).

Storage at 0ºC

Calyx
The best calyx quality at two and four weeks was achieved by 1-MCP + MA bags which was significantly lower than other treatments with a rating of 2.54 and 3.22 respectively. From six weeks onwards calyx quality was similar between treatments.

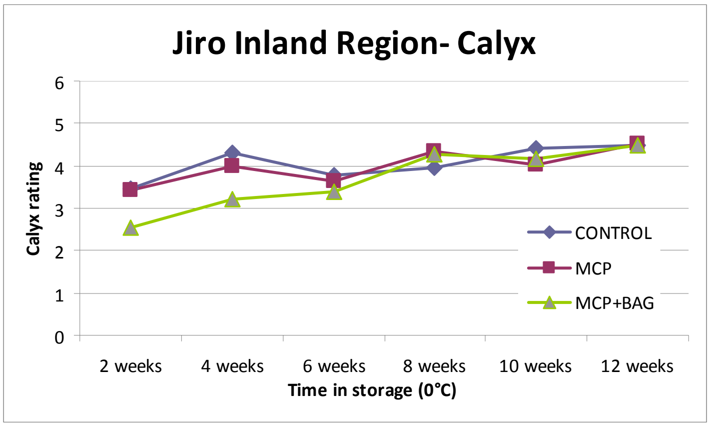
Blemish
Levels of blemish were similar for all treatments across all removal stages. 1-MCP + MA bags treated fruit had significantly lower levels of blemish at four and twelve weeks compared to other treatments.

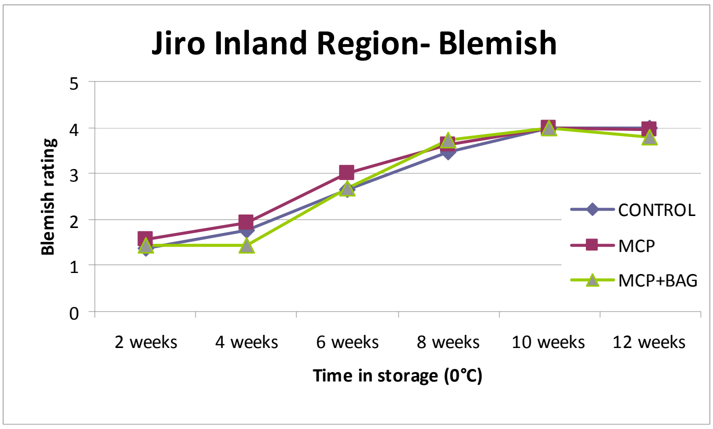
Colour
At two weeks there were no large differences in colour between treatments, however between four and twelve weeks both 1-MCP treatments had significantly lower colour than the untreated control indicating less advanced ripening.

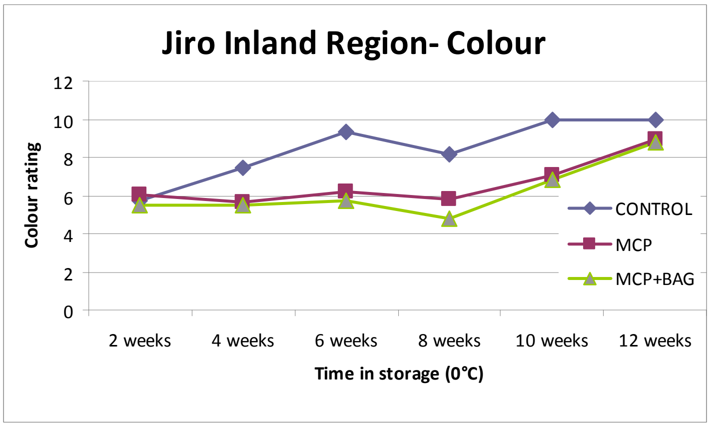
Firmness and % soft
Both 1-MCP treatments had significantly firmer fruit at each removal stage compared to the control. Fruit treated with 1-MCP and MA bags maintained firmness greater than 2.0 kg f/cm^2 for eight weeks and 1-MCP treated fruit remained at a marketable firmness for six weeks. The untreated control was unmarketable by four weeks. 1-MCP treatments had significantly less soft fruit than the control at all removal stages.

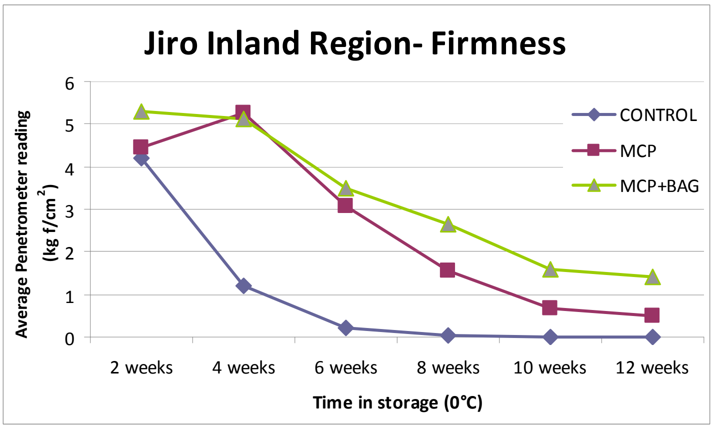
Chilling injury (gelling)
1-MCP treatments (+/- MA bags) reduced the levels of gelling at each removal stage with less than 18% gelling over a six week storage period. 1-MCP + MA bags achieved the lowest levels of gelling for all treatments.

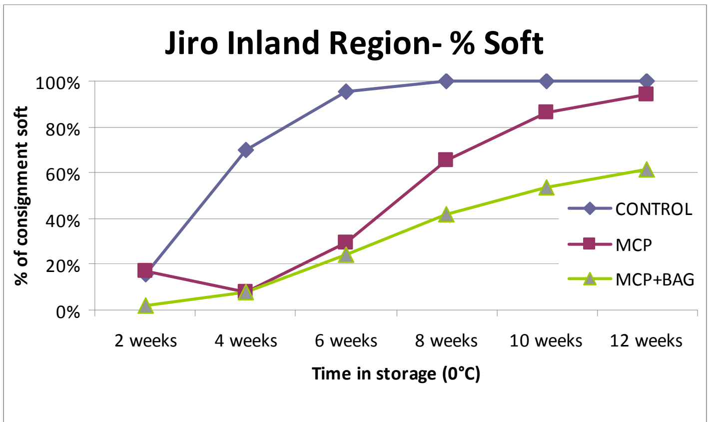
Internal blackening
Minimal internal blackening was observed in all treatments until six weeks when 37% of fruit in the 1-MCP + MA bags treatment had internal blackening. At the same stage the 1-MCP treatment and control recorded 13% and 3% respectively. Internal blackening increased at each removal stage for both 1-MCP treatments. At 12 weeks 45-84% of fruit had internal blackening for 1-MCP and 1-MCP + MA bags respectively.

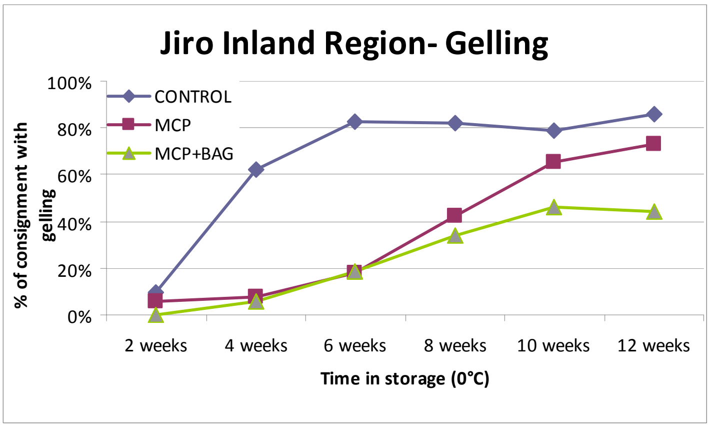












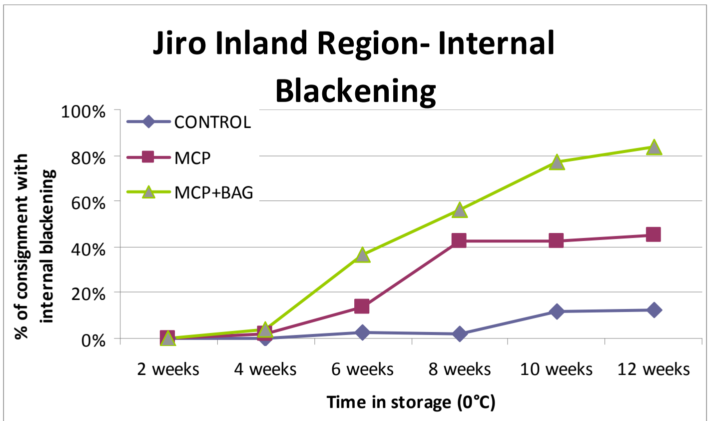


Figure 6. Differences in fruit quality of Jiro from inland growing regions after treatment with 1-MCP and MA bags and stored for 12 weeks at 0ºC.

	Treatment	2 weeks		4 weeks		6 weeks		8 weeks		10 weeks		12 weeks	
Calyx	CONTROL	3.44	a	4.32	a	3.79		3.96		4.40		4.50	
	MCP	3.43	a	3.98	a	3.65		4.33		4.04		4.52	
	MCP+BAG	2.54	b	3.22	b	3.39		4.26		4.15		4.50	
	LSD	**0.60**		**0.48**		**0.51**		**0.37**		**0.35**		**0.26**	
Blemish	CONTROL	1.37		1.78	a	2.64		3.48		4.00		4.00	a
	MCP	1.57		1.94	a	3.00		3.62		3.98		3.96	a
	MCP+BAG	1.42		1.45	b	2.67		3.72		4.00		3.79	b
	LSD	**0.30**		**0.32**		**0.41**		**0.24**		**0.03**		**0.13**	
Colour	CONTROL	5.75		7.43	a	9.33	a	8.15	a	9.95	a	9.96	a
	MCP	6.01		5.65	b	6.21	b	5.79	b	7.04	b	8.93	b
	MCP+BAG	5.50		5.46	b	5.71	b	4.79	c	6.85	b	8.82	b
	LSD	**0.60**		**0.68**		**0.58**		**0.69**		**0.62**		**0.44**	
Penetrometer	CONTROL	4.19	b	1.20	b	0.20	b	0.03	c	0.00	c	0.00	c
	MCP	4.44	b	5.27	a	3.07	a	1.54	b	0.68	b	0.50	b
	MCP+BAG	5.29	a	5.12	a	3.49	a	2.66	a	1.57	a	1.39	a
	LSD	**0.70**		**0.65**		**0.67**		**0.56**		**0.45**		**0.34**	
% Soft	CONTROL	0.15	a	0.70	a	0.96	a	1.00	a	1.00	a	1.00	a
	MCP	0.17	a	0.08	b	0.29	b	0.65	b	0.87	a	0.94	a
	MCP+BAG	0.02	b	0.08	b	0.24	b	0.42	c	0.54	b	0.62	b
	LSD	**0.12**		**0.13**		**0.15**		**0.16**		**0.14**		**0.12**	
% Gelling	CONTROL	0.10		0.62	a	0.83	a	0.82	a	0.79	a	0.86	a
	MCP	0.06		0.08	b	0.18	b	0.42	b	0.65	a	0.73	a
	MCP+BAG	0.00		0.06	b	0.18	b	0.34	b	0.46	b	0.44	b
	LSD	**0.08**		**0.14**		**0.15**		**0.18**		**0.18**		**0.19**	
% Internal Blackening	CONTROL	0.00		0.00		0.03	b	0.02	b	0.12	c	0.12	c
	MCP	0.00		0.02		0.13	b	0.42	a	0.42	b	0.45	b
	MCP+BAG	0.00		0.04		0.37	a	0.56	a	0.77	a	0.84	a
	LSD			**0.05**		**0.14**		**0.16**		**0.16**		**0.17**	

Table 4. Means and pair-wise comparisons for Jiro from inland regions stored at 0ºC for 12 weeks (means followed by the same letter are not significantly different P<0.05).

Fuyu from coastal growing regions

Storage at 15ºC

Calyx
At two weeks fruit treated with 1-MCP + MA bags had a significantly better average calyx rating of 3.74 compared to 1-MCP and control fruit with an average rating of 4.7. From four weeks onwards all treatments recorded the maximum rating of 5.

Blemish
There were no large differences in blemish between treatments until 6 weeks with 1-MCP achieving the lowest average blemish levels of 2.59 compared with a rating of 3.18 for 1-MCP + MA bags and 3.75 for the control.

Colour
Average colour for all treatments was similar at each removal stage. Average colour for all treatments at four weeks exceeded 7 which are unmarketable and overripe.

Firmness and % soft
Average firmness at two weeks was superior for both 1-MCP treatments however at four weeks all treatments averaged less than 2.0 kg f/cm^2. At two weeks the 1-MCP + MA bags treatment had 9% soft fruit compared to 15% for 1-MCP and 25% for the control. Over 70% of fruit was soft in all treatments by four weeks.

Chilling injury (gelling)
Minimal gelling was evident in all treatments at each removal stage.

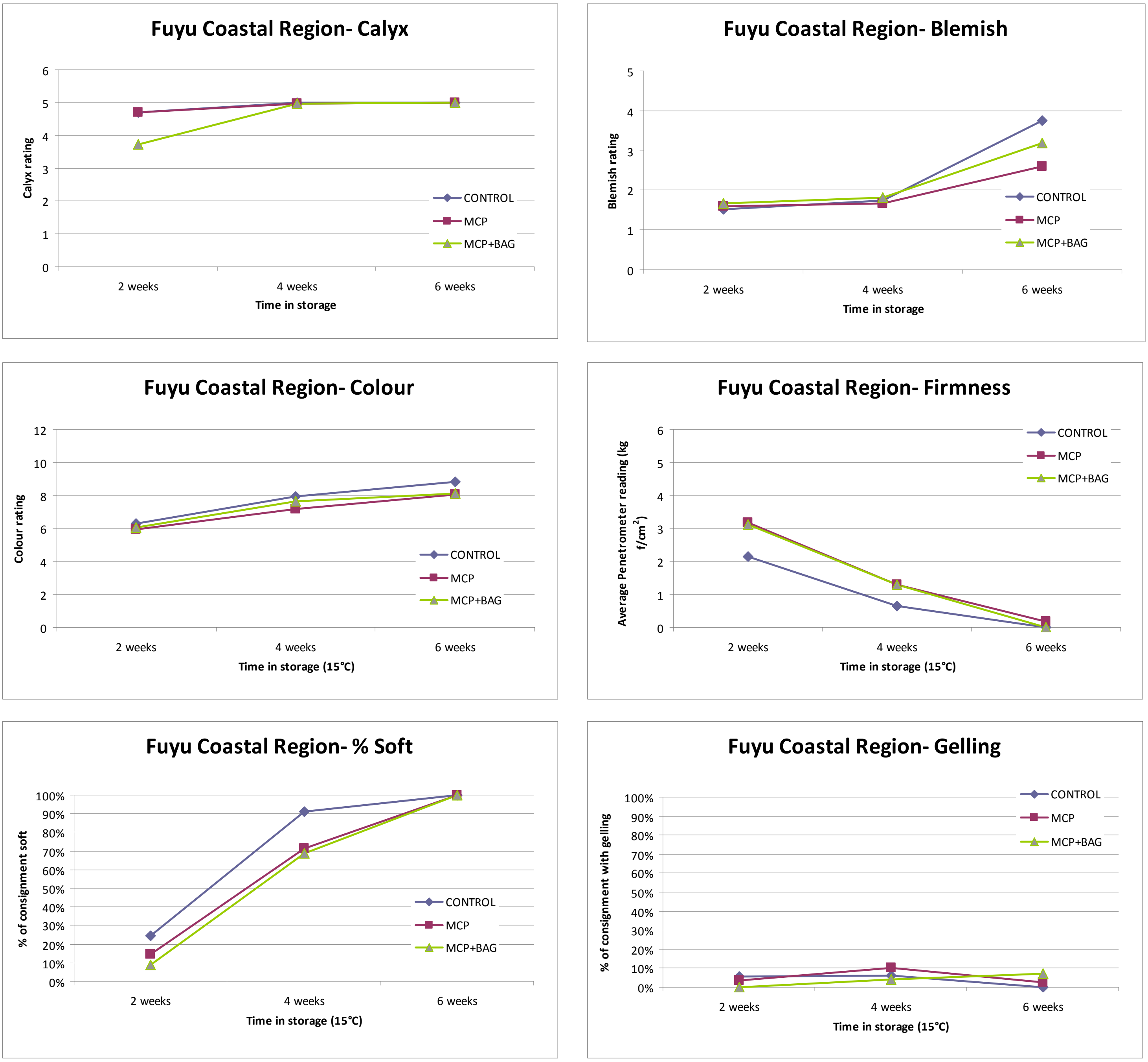


Figure 7. Differences in fruit quality of Fuyu from coastal growing regions after treatment with 1-MCP and MA bags and stored for 6 weeks at 15ºC.

	Treatment	2 weeks		4 weeks		6 weeks	
Calyx	CONTROL	4.70	a	5.00		5.00	
	MCP	4.69	a	4.98		5.00	
	MCP+BAG	3.74	b	4.98		5.00	
	LSD	**0.36**		**0.04**			
Blemish	CONTROL	1.53		1.74		3.75	a
	MCP	1.58		1.67		2.59	c
	MCP+BAG	1.67		1.81		3.18	b
	LSD	**0.35**		**0.27**		**0.32**	
Colour	CONTROL	6.27		7.95	a	8.83	a
	MCP	5.94		7.20	b	8.04	b
	MCP+BAG	6.05		7.66	ab	8.11	b
	LSD	**0.45**		**0.49**		**0.53**	
Penetrometer	CONTROL	2.15	b	0.64	b	0.00	b
	MCP	3.18	a	1.28	a	0.17	a
	MCP+BAG	3.13	a	1.28	a	0.00	b
	LSD	**0.41**		**0.36**			
% Soft	CONTROL	0.25		0.91	a	1.00	
	MCP	0.15		0.71	b	1.00	
	MCP+BAG	0.09		0.69	b	1.00	
	LSD	**0.13**		**0.15**			
% Gelling	CONTROL	0.06		0.06		0.00	
	MCP	0.04		0.10		0.03	
	MCP+BAG	0.00		0.04		0.07	
	LSD	**0.06**		**0.09**		**0.07**	

Table 5. Means and pair-wise comparisons for Fuyu from coastal regions stored at 15ºC for six weeks (means followed by the same letter are not significantly different $P<0.05$).

Storage at 0ºC

Calyx
Calyx quality at two weeks was significantly enhanced by the 1-MCP + MA bag treatment; however ratings at the remaining removal stages showed minimal differences between treatments.

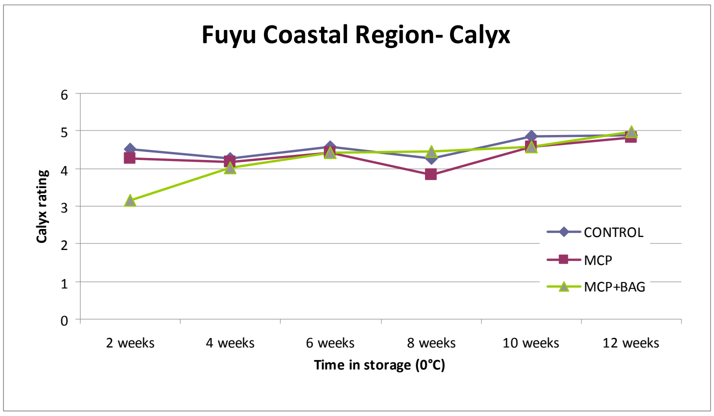
Blemish
Blemish levels remained similar between treatments at two and four weeks. Larger differences where observed from six weeks onwards with fruit treated with 1-MCP + MA bags having a significantly reduced average blemish level between six and twelve weeks.

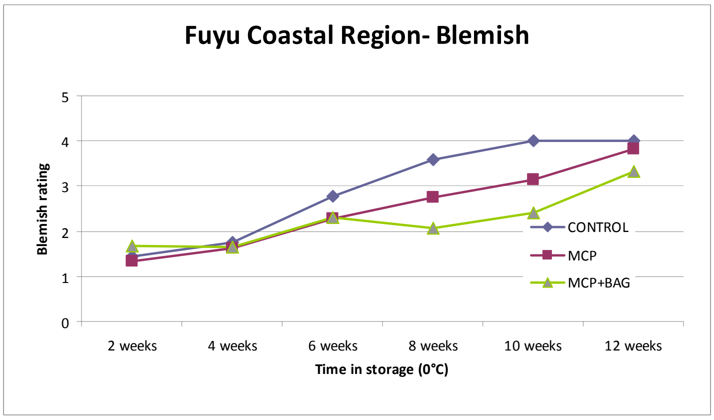
Colour
Fruit colour in the control fruit rapidly increased after the two week storage interval reaching close to the maximum of 10 by six weeks. 1-MCP treatments (+/- MA bags) significantly reduced the level of colour at each removal stage. Fruit treated with 1-MCP + MA bags gave the lowest colour reading reaching a maximum of 7.1 at 12 weeks.

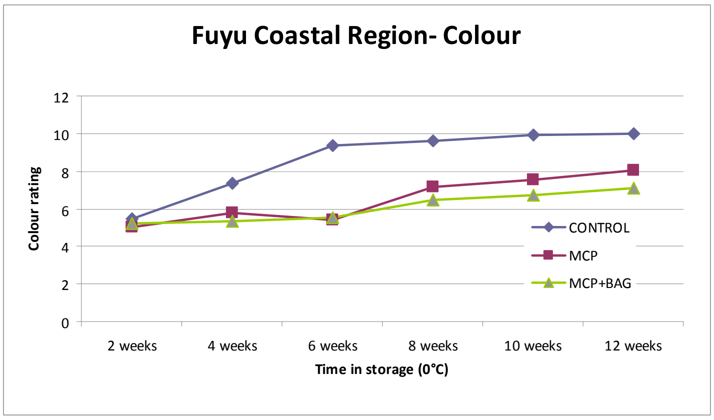
Firmness and % soft
At each removal stage 1-MCP treatments had significantly higher levels of firmness than the control which only achieved an average firmness of above 2.0 kg f/cm^2 for two weeks. 1-MCP treatments maintained fruit firmness in excess of 2.0 kg f/cm^2 for 10 (1-MCP) and 12 weeks (1-MCP + MA bags). 98% of control fruit became soft by the fourth week compared to 8% for 1-MCP and 3% for 1-MCP + MA bags at the same stage. 1-MCP + MA bags gave the best result with only 7% of fruit soft at 10 weeks and 27% at 12 weeks.

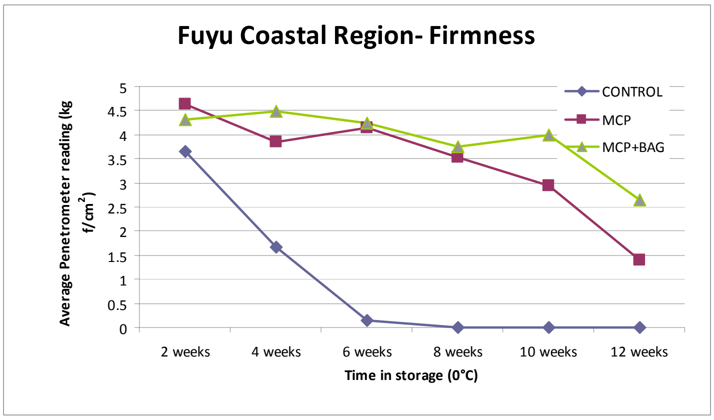
Chilling injury (gelling)
MCP treatments significantly reduced the level of internal gelling at each removal stage after two weeks when compared to the control. After two weeks large amounts of gelling were evident in control fruit with 90% of fruit receiving chilling injury at six weeks. 1-MCP + MA bags was the best treatment for reducing gelling with less than 5% of fruit receiving chilling injury from two to ten weeks and 17% gelled at 12 weeks.

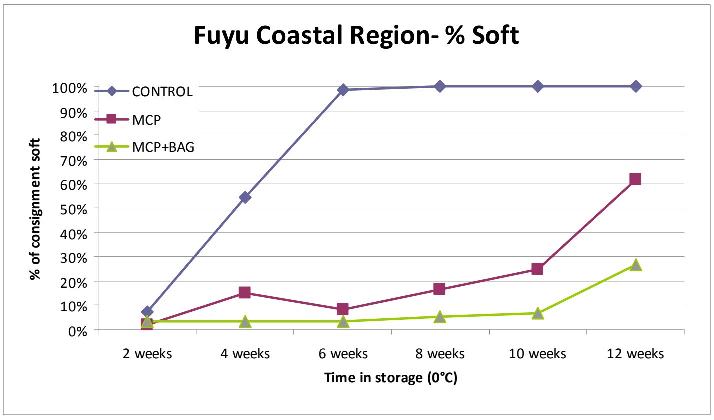
Internal blackening
Very small amounts of internal blackening were observed at various stages for all treatments with the largest levels of 5% at eight weeks in the 1-MCP treatment.

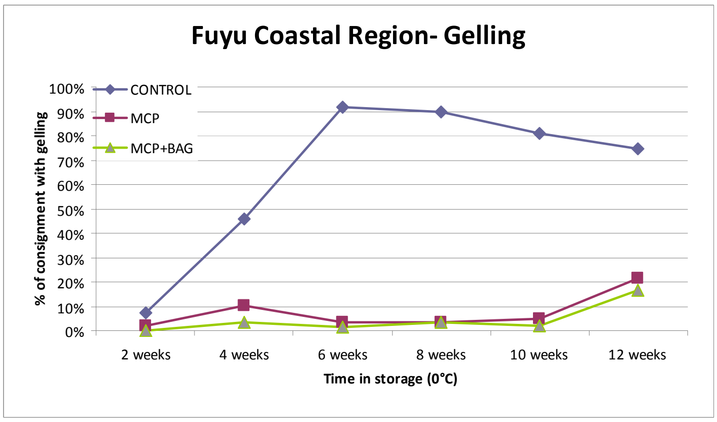












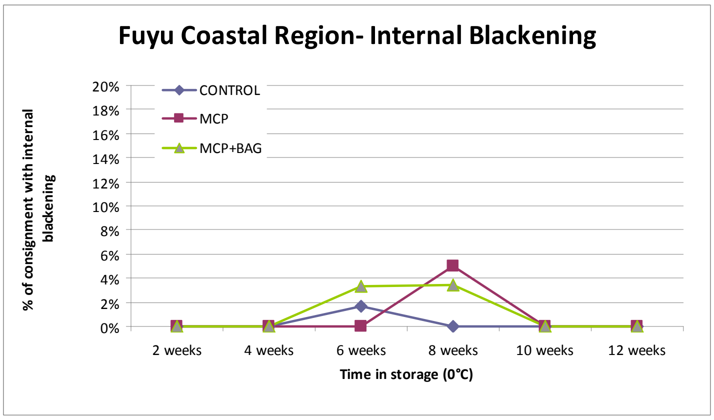


Figure 8. Differences in fruit quality of Fuyu from coastal growing regions after treatment with 1-MCP and MA bags and stored for 12 weeks at 0ºC.

	Treatment	2 weeks		4 weeks		6 weeks		8 weeks		10 weeks		12 weeks	
Calyx	CONTROL	4.52	a	4.25		4.58		4.28	a	4.86	a	4.88	
	MCP	4.28	a	4.17		4.42		3.85	b	4.58	b	4.83	
	MCP+BAG	3.16	b	4.03		4.42		4.45	a	4.57	b	4.98	
	LSD	**0.41**		**0.34**		**0.29**		**0.34**		**0.22**		**0.13**	
Blemish	CONTROL	1.45		1.76		2.76	a	3.58	a	4.00	a	4.00	a
	MCP	1.34		1.63		2.27	b	2.75	b	3.15	b	3.82	a
	MCP+BAG	1.67		1.64		2.32	b	2.07	c	2.40	c	3.32	b
	LSD	**0.31**		**0.20**		**0.34**		**0.32**		**0.24**		**0.23**	
Colour	CONTROL	5.46	a	7.33	a	9.34	a	9.62	a	9.91	a	10.00	a
	MCP	5.00	ab	5.77	b	5.37	b	7.17	b	7.55	b	8.04	b
	MCP+BAG	5.21	b	5.37	b	5.51	b	6.45	c	6.71	c	7.08	c
	LSD	**0.32**		**0.60**		**0.48**		**0.49**		**0.41**		**0.47**	
Penetrometer	CONTROL	3.66	b	1.65	c	0.14	b	0.01	b	0.00	c	0.00	c
	MCP	4.63	a	3.86	b	4.15	a	3.53	a	2.95	b	1.41	b
	MCP+BAG	4.32	a	4.49	a	4.25	a	3.75	a	3.99	a	2.65	a
	LSD	**0.36**		**0.54**		**0.39**		**0.39**		**0.42**		**0.4**	
% Soft	CONTROL	0.07		0.54	a	0.98	a	1.00	a	1.00	a	1.00	a
	MCP	0.02		0.15	b	0.08	b	0.17	b	0.25	b	0.62	b
	MCP+BAG	0.03		0.03	b	0.03	b	0.05	c	0.07	c	0.27	c
	LSD	**0.07**		**0.13**		**0.07**		**0.09**		**0.11**		**0.14**	
% Gelling	CONTROL	0.07		0.46	a	0.92	a	0.90	a	0.81	a	0.75	a
	MCP	0.02		0.10	b	0.03	b	0.03	b	0.05	b	0.22	b
	MCP+BAG	0.00		0.03	b	0.02	b	0.03	b	0.02	b	0.17	b
	LSD	**0.06**		**0.13**		**0.07**		**0.08**		**0.10**		**0.15**	
% Internal Blackening	CONTROL	0.00		0.00		0.02		0.00		0.00		0.00	
	MCP	0.00		0.00		0.00		0.05		0.00		0.00	
	MCP+BAG	0.00		0.00		0.03		0.03		0.00		0.00	
	LSD					**0.05**		**0.06**					

Table 6. Means and pair-wise comparisons for Fuyu from coastal regions stored at 0ºC for 12 weeks (means followed by the same letter are not significantly different P<0.05).

Fuyu from inland growing regions

Storage at 15ºC

Calyx
No large differences in calyx quality were observed between treatments as all received a maximum rating of five by two weeks.

Blemish
No differences in blemish were observed between treatments at two and four weeks, however at six weeks 1-MCP treated fruit had 25% less blemish than the control.

Colour
At two and four weeks 1-MCP treated fruit maintained a lower colour than the other treatments. Control fruit had the highest average colour at each storage removal stage. 1-MCP + MA bags had a slightly lower colour than the control at two and four weeks however fruit was unable to be assessed at six weeks due to fruit becoming too perished to evaluate.

Firmness and % soft
MCP treated fruit (+/- MA bags) had a significantly higher average firmness at two weeks. Both 1-MCP treatments had an significantly higher average penetrometer reading of over 3.0 kg f/cm^2 at two weeks compared to the control which had an average of 2.07 kg f/cm^2 which was at the limit of marketability. All treatments were unmarketable by four weeks. 1-MCP treatments had lower rates of soft fruit than the control at two and for weeks. At two weeks the 1-MCP treatment had no soft fruit and the 1-MCP + MA bags treatment had 9% compared to 35% soft in the untreated control. At four weeks all treatments had over 50% of fruit soft.

Chilling injury (gelling)
At two weeks 1-MCP treatments reduced the level of internal gelling with no chilling injury observed in the 1-MCP treatment and 3% in the 1-MCP + MA bags treatment compared to 13% in the control. At four weeks all treatment had similar amounts of gelling ranging from 13-19%.

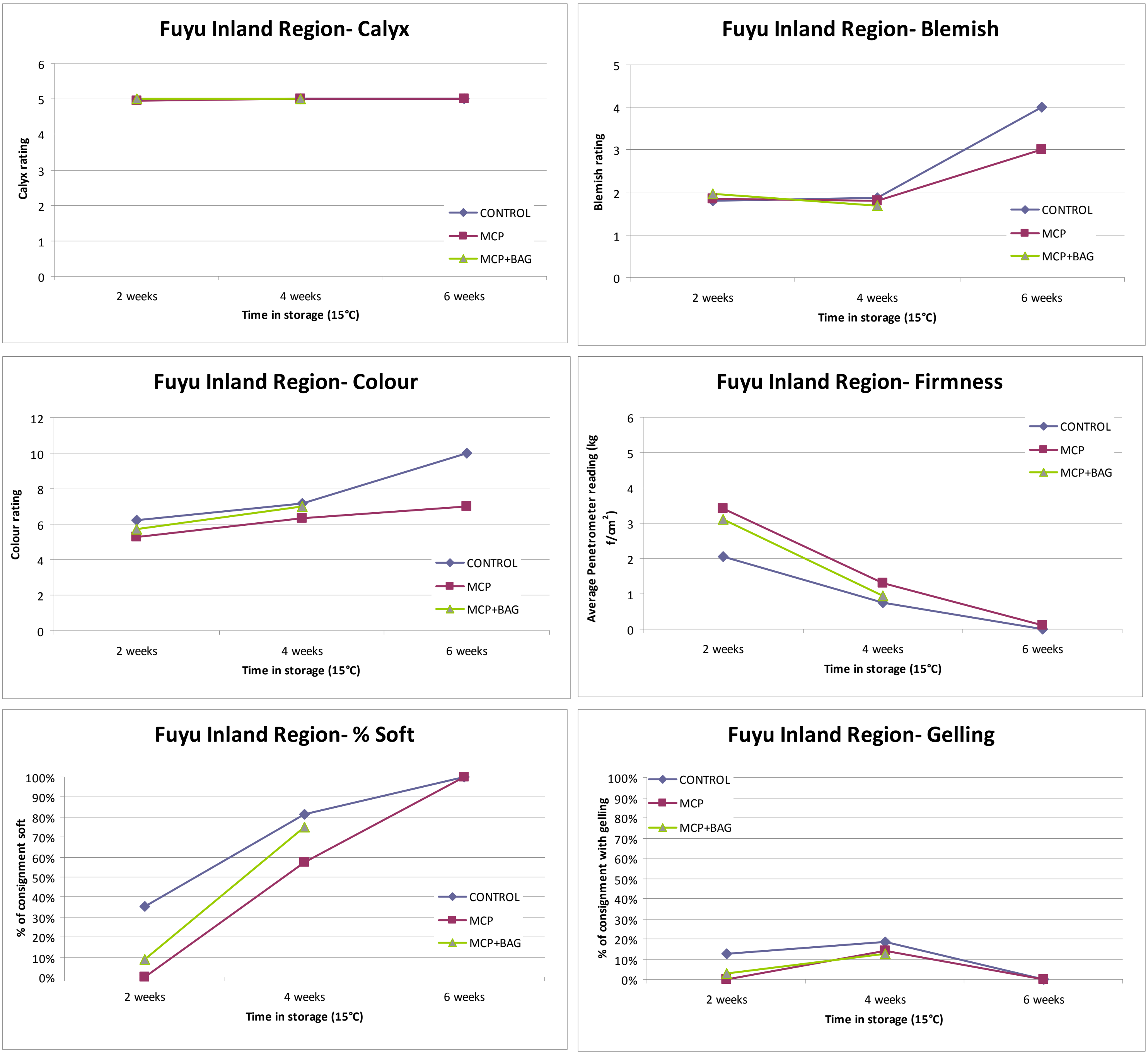


Figure 9. Differences in fruit quality of Fuyu from inland growing regions after treatment with 1-MCP and MA bags and stored for 6 weeks at 15ºC and assessed after seven days at 20ºC.

	Treatment	2 weeks		4 weeks		6 weeks	
Calyx	CONTROL	4.97		5.00		5.00	
	MCP	4.94		5.00		5.00	
	MCP+BAG	5.00		5.00		5.00	
	LSD	**0.08**					
Blemish	CONTROL	1.81		1.88		4.00	a
	MCP	1.85		1.80		3.00	c
	MCP+BAG	1.97		1.69		3.37	b
	LSD	**0.24**		**0.26**		**0.29**	
Colour	CONTROL	6.20	a	7.17		10.00	a
	MCP	5.30	b	6.32		7.00	c
	MCP+BAG	5.75	ab	7.01		8.11	b
	LSD	**0.53**		**0.80**		**0.87**	
Penetrometer	CONTROL	2.07	b	0.75		0.00	
	MCP	3.43	a	1.31		0.10	
	MCP+BAG	3.12	a	0.94		0.06	
	LSD	**0.50**		**0.48**		**0.11**	
% Soft	CONTROL	0.35	a	0.81		1.00	
	MCP	0.00	b	0.57		1.00	
	MCP+BAG	0.09	b	0.75		1.00	
	LSD	**0.15**		**0.21**			
% Gelling	CONTROL	0.13	a	0.19		0.00	
	MCP	0.00	b	0.14		0.00	
	MCP+BAG	0.03	ab	0.13		0.00	
	LSD	**0.10**		**0.17**			

Table 7. Means and pair-wise comparisons for Fuyu from inland regions stored at 15ºC for six weeks (means followed by the same letter are not significantly different $P<0.05$).

Storage at 0ºC

Calyx

At two week control fruit had the healthiest calyx rating with a rating of 4.00 compared to 1-MCP with 4.17 and 1-MCP + MA bags with 5.00. At four and six weeks the use of MA bags in combination with 1-MCP resulted in significantly better calyx quality. There were no differences between treatments from between six and twelve weeks.

Blemish

Generally fruit treated with 1-MCP + MA bags had a reduced level of blemish at each removal stage, particularly at the longer storage durations with significantly lower ratings between six and twelve weeks storage.

Colour

1-MCP treatments reduced colour at each storage interval between two and twelve weeks when compared to the control. There was little difference between 1-MCP treatments over the twelve week storage period apart from at eight weeks when the 1-MCP + MA bags treatment achieved significantly lower colour that the other treatments.

Firmness and % soft

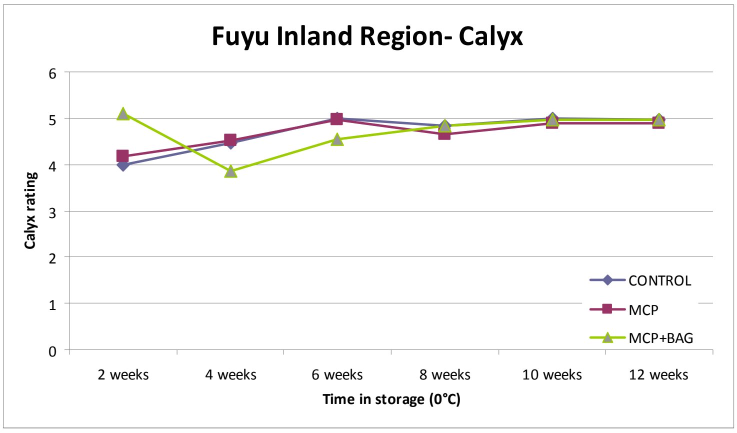
Fruit treated with 1-MCP maintained an average firmness of over 2.0 kg f/cm^2 for ten weeks. Fruit in the 1-MCP + MA bags treatment maintained a similar firmness for twelve weeks. Very small differences in firmness and soft fruit were observed between the 1-MCP treatments between two and six weeks. All fruit in the control treatment had become soft by six weeks and had a penetrometer reading of zero. At eight weeks fruit treated with 1-MCP + MA bags only had 8% soft fruit compared to 28% for 1-MCP; however at ten weeks the 1-MCP treatments had 19% soft fruit compared to 47% for the 1-MCP + MA bags treatment. At twelve weeks only 39% of fruit had softened in the 1-MCP + MA bags treatment.

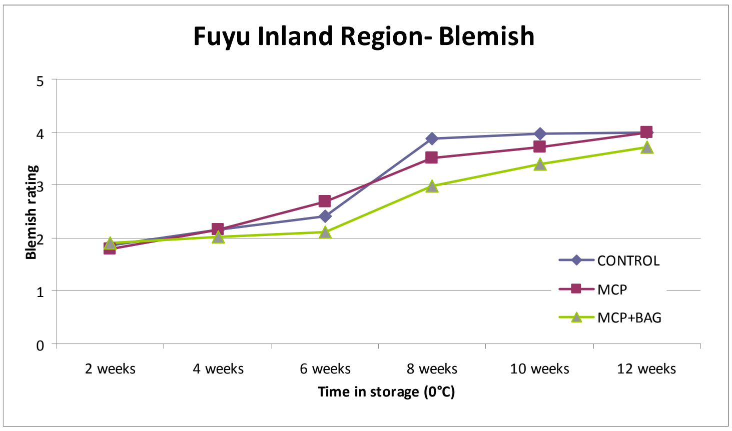
Chilling injury (gelling)

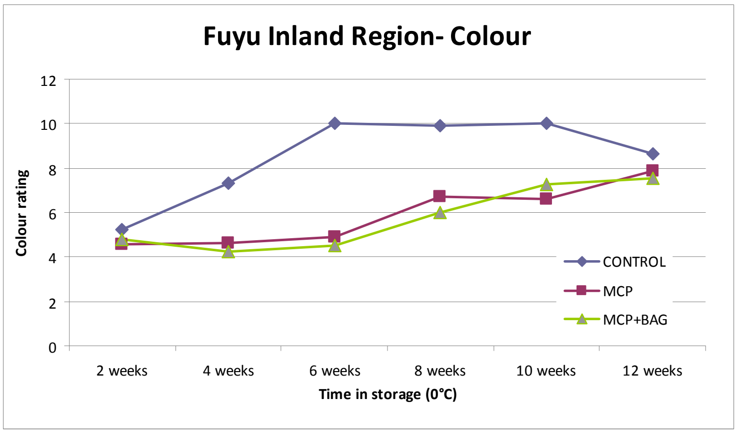
MCP treatments significantly reduced the amount of gelling between four and ten weeks when compared to the control. The 1-MCP treatment received no gelling in the two and four week storage intervals and had a maximum of 33% gelled fruit at twelve weeks. 1-MCP + MA bags had a maximum of 31% gelled fruit at ten weeks and as low as 3% at twelve weeks.

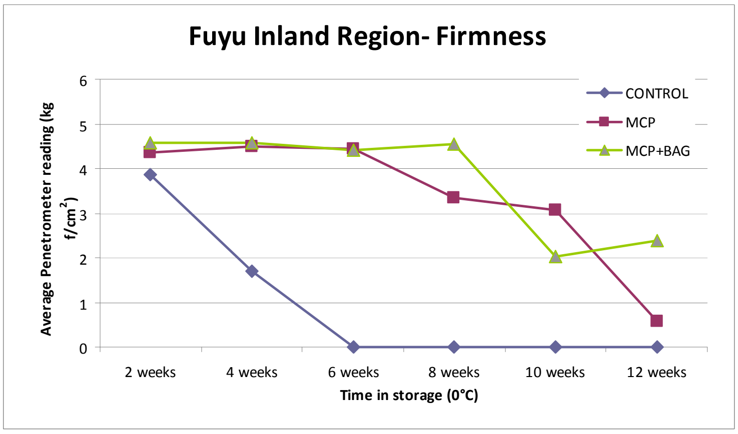
Internal blackening

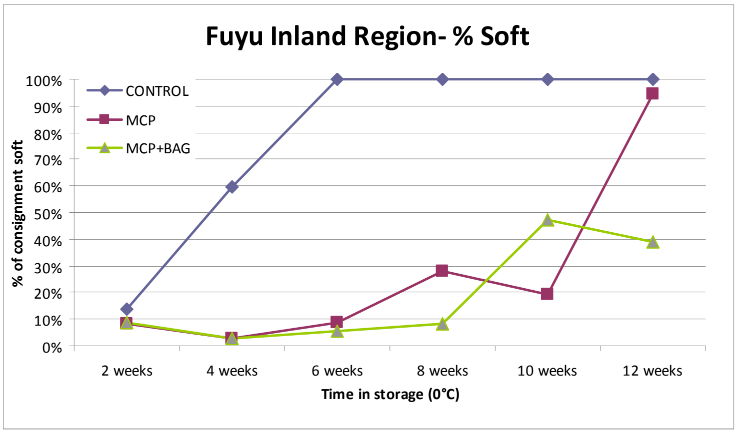
Minimal internal blackening was observed in all treatments over the twelve week storage period. The largest amount this internal disorder was observed in the 1-MCP treatment at six weeks with 11% of fruit affected.

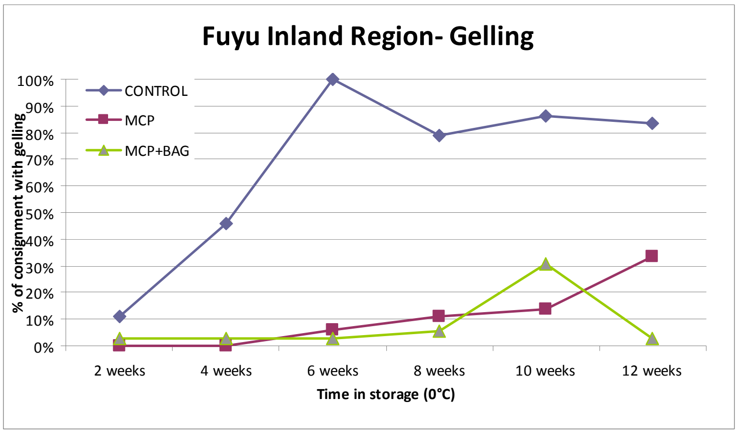












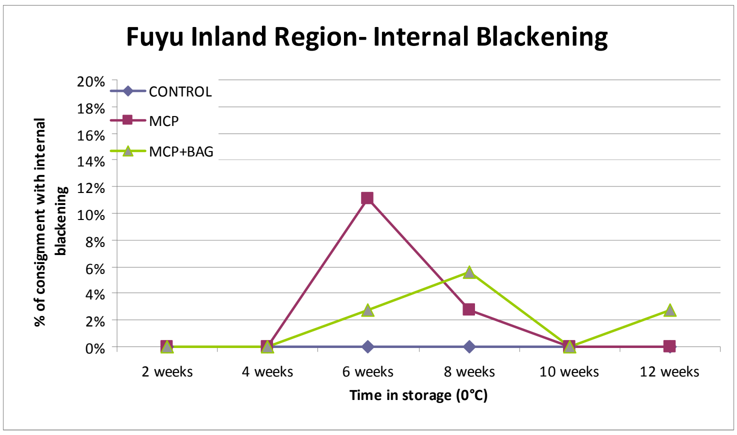


Figure 10. Differences in fruit quality of Fuyu from coastal growing regions after treatment with 1-MCP and MA bags and stored for 12 weeks at 0ºC15ºC and assessed after 7 days at 20ºC.

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	Treatment	**2 weeks**		**4 weeks**		**6 weeks**		**8 weeks**		**10 weeks**		**12 weeks**	
Calyx	CONTROL	4.00		4.46	a	5.00	a	4.84		5.00		4.97	
	MCP	4.17		4.53	a	4.97	a	4.64		4.89		4.89	
	MCP+BAG	5.09		3.86	b	4.56	b	4.83		4.97		4.97	
	LSD	**2.36**		**0.38**		**0.18**		**0.25**		**0.12**		**0.14**	
Blemish	CONTROL	1.86		2.16		2.42	a	3.87	a	3.97	a	4.00	a
	MCP	1.78		2.15		2.68	a	3.50	b	3.72	b	4.00	a
	MCP+BAG	1.91		2.03		2.11	b	2.97	c	3.39	c	3.72	b
	LSD	**0.21**		**0.25**		**0.29**		**0.25**		**0.21**		**0.17**	
Colour	CONTROL	5.23		7.32	a	10.00	a	9.91	a	10.00	a	8.67	a
	MCP	4.56		4.61	b	4.87	b	6.72	b	6.59	b	7.89	ab
	MCP+BAG	4.76		4.23	b	4.51	b	5.99	c	7.24	b	7.56	b
	LSD	**0.64**		**0.87**		**0.59**		**0.58**		**0.69**		**0.82**	
Penetrometer	CONTROL	3.87		1.69	b	0.00	b	0.00	c	0.00	c	0.00	a
	MCP	4.37		4.48	a	4.43	a	3.34	b	3.07	a	0.57	b
	MCP+BAG	4.57		4.57	a	4.40	a	4.53	a	2.03	b	2.38	c
	LSD	**0.72**		**0.65**		**0.51**		**0.66**		**0.64**		**0.51**	
% Soft	CONTROL	0.14		0.59	a	1.00	a	1.00	a	1.00	a	1.00	a
	MCP	0.08		0.03	b	0.09	b	0.28	b	0.19	c	0.94	a
	MCP+BAG	0.09		0.03	b	0.06	b	0.08	c	0.47	b	0.39	b
	LSD	**0.14**		**0.15**		**0.10**		**0.14**		**0.17**		**0.15**	
% Gelling	CONTROL	0.11		0.46	a	1.00	a	0.79	a	0.86	a	0.83	a
	MCP	0.00		0.00	b	0.06	b	0.11	b	0.14	b	0.33	a
	MCP+BAG	0.03		0.03	b	0.03	b	0.06	b	0.31	b	0.03	b
	LSD	**0.10**		**0.14**		**0.08**		**0.15**		**0.18**		**0.19**	
% Internal Blackening	CONTROL	0.00		0.00		0.00		0.00		0.00		0.00	
	MCP	0.00		0.00		0.11		0.03		0.00		0.00	
	MCP+BAG	0.00		0.00		0.03		0.06		0.00		0.03	
	LSD					**0.09**		**0.08**				**0.05**	

Table 8. Means and pair-wise comparisons for Fuyu from inland regions stored at 0ºC for 12 weeks (means followed by the same letter are not significantly different $P<0.05$).

Fuyu from SA/Vic growing regions

Storage at 15ºC

Calyx
No differences in calyx quality were observed between treatments at any of the removal/storage stages. All treatments received a maximum rating of 5 from two weeks onwards.

Blemish
Blemish levels at two weeks were similar for all treatments; however 1-MCP treatments (+/- MA bags) reduced blemish at four weeks when compared to the control. Fruit treated with 1-MCP + MA bags had significantly lower blemish at six weeks compared to other treatments.

Colour
There was little variation in colour between treatments at each storage interval. The largest difference was between 1-MCP + MA bags and the control which had a significantly lower average colour of 6.37 and 7.56 respectively at two weeks.

Firmness and % soft
MCP treatments had significantly higher firmness than the control at two and four weeks however no fruit were of a marketable firmness at any of the storage intervals, with and average penetrometer reading of 1.70 and 1.98 kg f/cm^2 for 1-MCP and 1-MCP + MA bags respectively. At two weeks 84% of fruit was soft in the control compared to 51% for 1-MCP and 46% for 1-MCP + MA bags. All treatments had 100% fruit soft for the four and six week intervals.

Chilling injury (gelling)
MCP treatments significantly reduced the incidence of gelling at two weeks when compared to the control. The 1-MCP treatment recorded 10 and 6% gelling at four and six weeks respectively

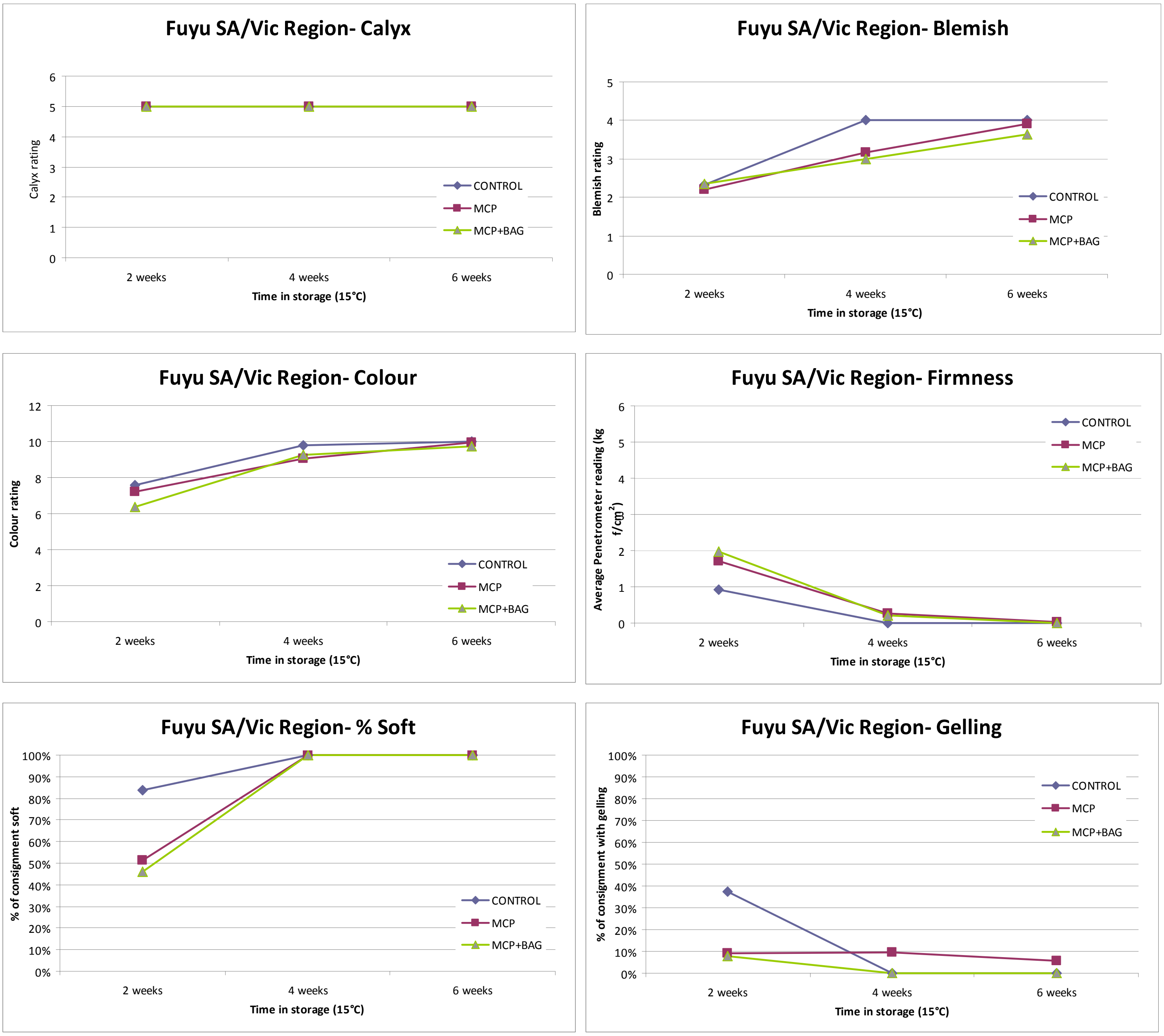


Figure 11. Differences in fruit quality of Fuyu from SA/Vic growing regions after treatment with 1-MCP and MA bags and stored for 6 weeks at 15ºC.

	Treatment	2 weeks		4 weeks		6 weeks	
Calyx	CONTROL	5.00		5.00		5.00	
	MCP	5.00		5.00		5.00	
	MCP+BAG	5.00		5.00		5.00	
	LSD						
Blemish	CONTROL	2.33		4.00	a	4.00	a
	MCP	2.21		3.16	b	3.91	a
	MCP+BAG	2.35		3.00	b	3.63	b
	LSD	**0.29**		**0.27**		**0.15**	
Colour	CONTROL	7.56	a	9.79	a	10.00	a
	MCP	7.19	a	9.04	b	9.92	ab
	MCP+BAG	6.37	b	9.26	b	9.74	b
	LSD	**0.53**		**0.44**		**0.19**	
Penetrometer	CONTROL	0.91	b	0.00	b	0.00	
	MCP	1.70	a	0.26	a	0.02	
	MCP+BAG	1.98	a	0.20	a	0.00	
	LSD	**0.29**		**0.13**		**0.03**	
% Soft	CONTROL	0.84	a	1.00		1.00	
	MCP	0.51	b	1.00		1.00	
	MCP+BAG	0.46	b	1.00		1.00	
	LSD	**0.18**					
% Gelling	CONTROL	0.37	a	0.00	b	0.00	
	MCP	0.09	b	0.10	a	0.06	
	MCP+BAG	0.08	b	0.00	b	0.00	
	LSD	**0.14**		**0.07**		**0.06**	

Table 9. Means and pair-wise comparisons for Fuyu from SA/Vic regions stored at 15ºC for six weeks (means followed by the same letter are not significantly different P<0.05).

Storage at 0ºC

Calyx
At two weeks fruit treated with 1-MCP + MA bags had significantly better calyx quality compared to other treatments. At six and ten weeks the 1-MCP treatment had significantly better calyx ratings than the 1-MCP + MA bags and control treatments. No other significant differences were observed.

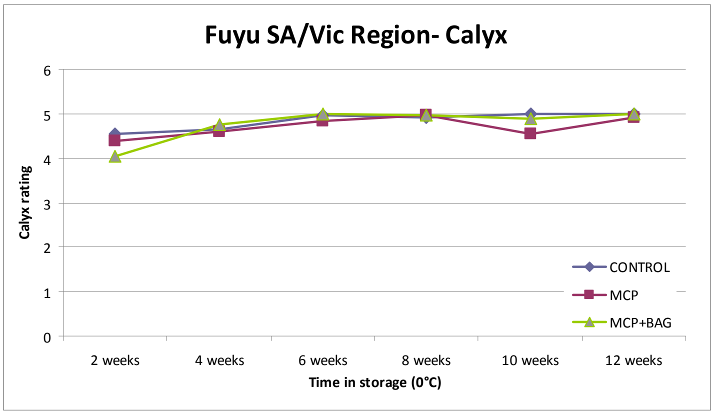
Blemish
Blemish levels were significantly higher in the 1-MCP + MA bags treatment at two weeks compared to other treatments. At ten weeks both 1-MCP treatments had significantly lower blemish levels than the control.

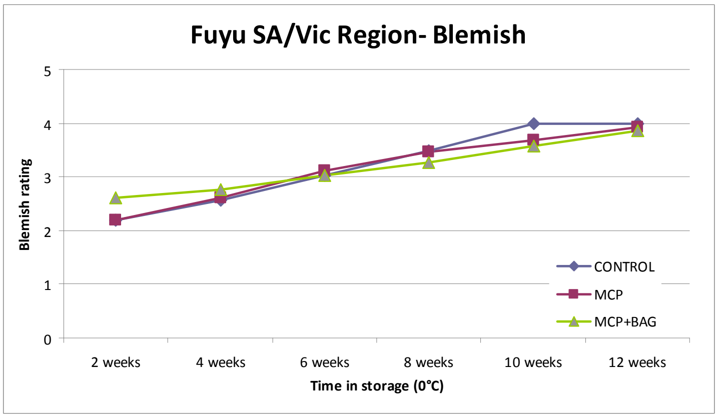
Colour
Colour was reduced by 1-MCP treatments with the best result achieved by the 1-MCP + MA bags treatment at ten weeks with an average colour of 7.84 compared to the control with 9.23. Both 1-MCP treatments reduced the average colour between six and twelve weeks.

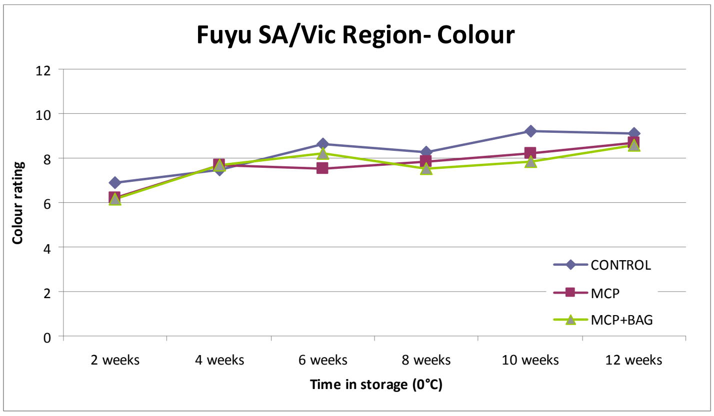
Firmness and % soft
While both 1-MCP treatments had higher levels of firmness than the control at each storage interval, only the 1-MCP + MA bags treatment had marketable fruit at two weeks with an average of 2.26 kg f/cm^2 and 41% soft fruit. All treatments from four weeks onwards had an average firmness level of less than 1.0 kg f/cm^2 and an unacceptable proportion of soft fruit.

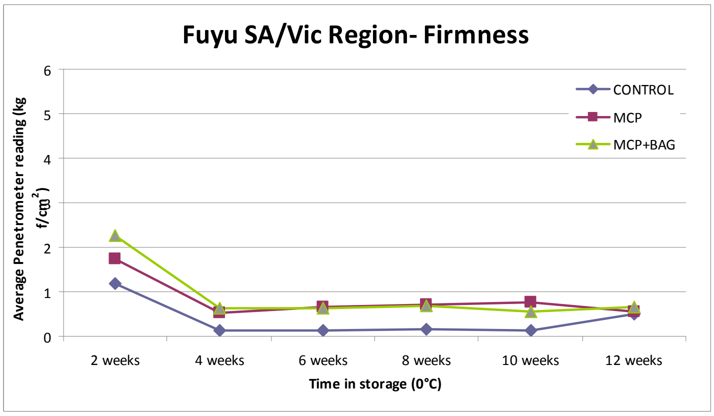
Chilling injury (gelling)
At most storage intervals the use of 1-MCP reduced the levels of gelling. At two weeks the use of 1-MCP and 1-MCP + MA bags achieved 37% and 33% gelled fruit respectively, compared to 59% in the control. Similar results were evident at four weeks.

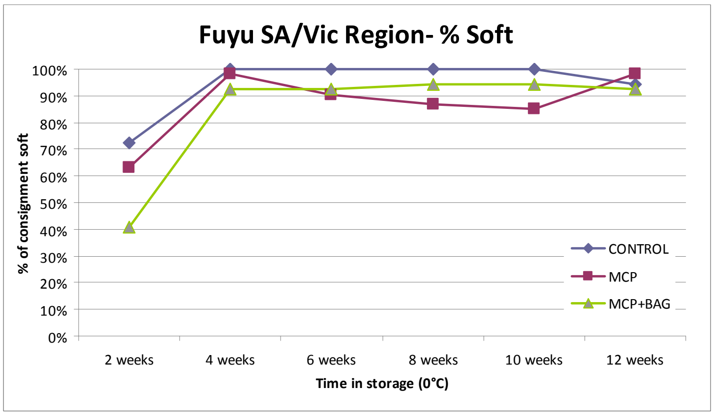
Internal blackening
No internal blackening was observed in any of the treatments between two and ten weeks. At twelve weeks some internal blackening was evident in the control and 1-MCP treatments with 2% and 6% respectively.

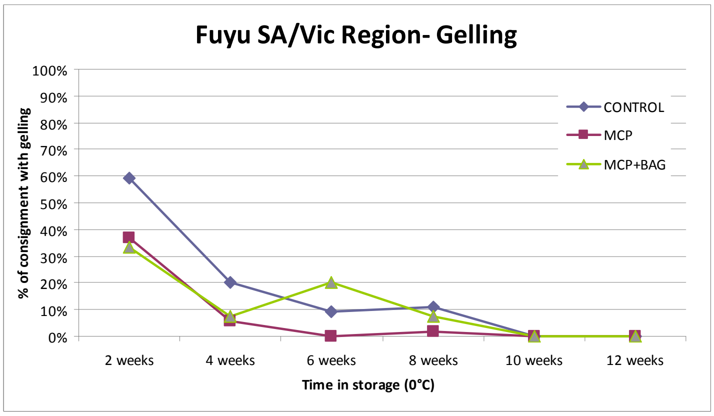












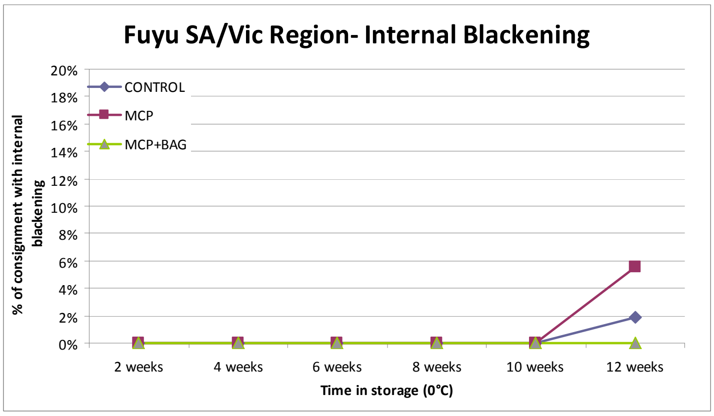


Figure 12. Differences in fruit quality of Fuyu from SA/Vic growing regions after treatment with 1-MCP and MA bags and stored for 12 weeks at 0ºC and assessed after 7 days at 20ºC.

	Treatment	2 weeks		4 weeks		6 weeks		8 weeks		10 weeks		12 weeks	
Calyx	CONTROL	4.56	a	4.65		4.98	a	4.93		5.00	a	5.00	
	MCP	4.39	a	4.61		4.83	b	4.98		4.56	b	4.93	
	MCP+BAG	4.06	b	4.76		5.00	a	4.98		4.89	a	5.00	
	LSD	**0.30**		**0.23**		**0.10**		**0.07**		**0.13**		**0.06**	
Blemish	CONTROL	2.19	b	2.57		3.02		3.48		4.00	a	3.98	a
	MCP	2.20	b	2.61		3.11		3.46		3.69	b	3.93	ab
	MCP+BAG	2.61	a	2.76		3.02		3.26		3.57	b	3.85	b
	LSD	**0.29**		**0.43**		**0.33**		**0.27**		**0.22**		**0.10**	
Colour	CONTROL	6.88	a	7.47		8.63	a	8.26	a	9.23	a	9.13	a
	MCP	6.22	b	7.70		7.53	b	7.85	ab	8.20	b	8.67	b
	MCP+BAG	6.15	b	7.67		8.22	a	7.54	b	7.84	b	8.56	b
	LSD	**0.49**		**0.65**		**0.50**		**0.57**		**0.36**		**0.41**	
Penetrometer	CONTROL	1.19	c	0.14	b	0.13	b	0.15	b	0.13	b	0.49	
	MCP	1.74	b	0.53	a	0.66	a	0.72	a	0.76	a	0.55	
	MCP+BAG	2.26	a	0.62	a	0.64	a	0.67	a	0.54	a	0.67	
	LSD	**0.51**		**0.21**		**0.24**		**0.25**		**0.25**		**0.24**	
% Soft	CONTROL	0.72	a	1.00		1.00		1.00	a	1.00	a	0.94	
	MCP	0.63	a	0.98		0.91		0.87	b	0.85	b	0.98	
	MCP+BAG	0.41	b	0.93		0.93		0.94	ab	0.94	ab	0.93	
	LSD	**0.18**		**0.07**		**0.09**		**0.09**		**0.09**		**0.08**	
% Gelling	CONTROL	0.59	a	0.20	a	0.09	b	0.11	a	0.00		0.00	
	MCP	0.37	b	0.06	b	0.00	b	0.02	b	0.00		0.00	
	MCP+BAG	0.33	b	0.07	b	0.20	a	0.07	ab	0.00		0.00	
	LSD	**0.19**		**0.12**		**0.11**		**0.09**					
% Internal Blackening	CONTROL	0.00		0.00		0.00		0.00		0.00		0.02	
	MCP	0.00		0.00		0.00		0.00		0.00		0.06	
	MCP+BAG	0.00		0.00		0.00		0.00		0.00		0.00	
	LSD											**0.06**	

Table 10. Means and pair-wise comparisons for Fuyu from SA/Vic regions stored at 0ºC for 12 weeks (means followed by the same letter are not significantly different P<0.05).

Recommendations for storage of 'Jiro' in major regional growing regions

Coastal region 15ºC
Calyx, blemish and colour didn't vary greatly between treatments at 15°C. Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) was observed in 1-MCP treated fruit; however the use of MA bags increased the level of gelling. No internal blackening was observed. Jiro from coastal regions can be stored for up to two weeks at 15°C when treated with 1-MCP with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Coastal region 0ºC
Jiro treated with 1-MCP alone and in combination with MA bags maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 6 weeks for fruit treated with 1-MCP alone or in combination with MA bags. Untreated fruit rapidly softened after 2 weeks and incurred high levels of gelling. Chilling injury (gelling) remained below 10% for 4 weeks in fruit treated with 1-MCP. A large amount of internal blackening was observed in fruit stored in MA bags + 1-MCP. Jiro from coastal regions can be stored between 4 and 6 weeks when treated with 1-MCP with and expected shelf life of 7 days at ambient temperature. Do not use MA bags for Jiro stored at 0°C.

Inland region 15ºC
Fruit treated with 1-MCP maintained firmness longer than untreated fruit at 2 weeks, however there was no advantage gained by using MA bags. Chilling injury (gelling) was evident in all treatments however no internal blackening was observed. Jiro from inland regions can be stored for up to 2 weeks at 15°C when treated with 1-MCP, with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Inland region 0ºC
Jiro treated with 1-MCP alone or in combination with MA bags maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 6 weeks for 1-MCP treated fruit and 8 weeks for fruit treated with 1-MCP and MA bags. Chilling injury (gelling) was reduced by 1-MCP and MA bag treatments. High levels of internal blackening were observed in 1-MCP treated fruit, especially in MA bags.
Jiro from inland regions can be stored for 6 weeks when treated with 1-MCP with and expected shelf life of 7 days at ambient temperature. Do not use MA bags for Jiro stored at 0°C.

Recommendations for storage of 'Fuyu' in major regional growing regions

Coastal region 15ºC

Calyx, blemish and colour didn't vary greatly between treatments at 15°C. Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) and internal blackening were observed. Fuyu from coastal regions can be stored for up to two weeks at 15°C when treated with 1-MCP with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Coastal region 0ºC

Fuyu treated with 1-MCP alone and in combination with MA bags reduces blemishing and maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 10 weeks for 1-MCP treated fruit and 12 weeks for fruit treated with 1-MCP and MA bags. Untreated fruit rapidly softened after 2 weeks and incurred high levels of gelling. Chilling injury (gelling) remained below 10% for 10 weeks in fruit treated with 1-MCP. Small amounts of internal blackening was observed in 1-MCP treated fruit but generally stayed below 5%. Fuyu from coastal regions can be stored for 8 weeks when treated with 1-MCP and 10 weeks when using a combination of 1-MCP and MA bags with and expected shelf life of 7 days at ambient temperature.

Inland region 15ºC

Fruit treated with 1-MCP maintained firmness longer than untreated fruit, however there was no advantage gained by using MA bags. Very little chilling injury (gelling) and no internal blackening were observed. Fuyu from inland regions can be stored for up to 3 weeks at 15°C when treated with 1-MCP, with an expected shelf life of 7 days at ambient temperature. Do not use MA bags at 15ºC.

Inland region 0ºC

Fuyu treated with 1-MCP alone or in combination with MA bags reduces blemishing and maintains colour during long-term storage at 0°C. Fruit firmness is maintained above 2kg f/cm^2 for 10 weeks for 1-MCP treated fruit and 8 weeks for fruit treated with 1-MCP and MA bags. Chilling injury (gelling) remained below 10% for 6 weeks using 1-MCP and MA bags and 8 weeks using 1-MCP alone. Small amounts of internal blackening were observed in 1-MCP treated. Fuyu from inland regions can be stored for 6-8 weeks when treated with 1-MCP alone or in combination with MA bags with and expected shelf life of 7 days at ambient temperature.

South Australia and Victoria

Recommendations for this growing region cannot be made as a result of this trial. The delay in treating fruit with 1-MCP and possible exposure to ethylene which was caused by freighting fruit to Queensland significantly affected the results of this trial. Trials will be carried out in the next phase of this project and will be treated locally prior to transportation to Queensland for storage and evaluation. Storage guidelines for other growing regions will give some indication of possible storage durations for this region until further trials have been completed.

CLONAL PROPAGATION OF PERSIMMON

INTRODUCTION

Variation in performance and growth of a variety within an orchard is often due to the variability in seedling rootstocks. Some trees in the orchard, even though they are on the same rootstock species can produce three- to four-times the number of fruit than other trees.

Growers would prefer that all trees in the orchard were similar to those that produced the highest yields and best quality. Similar to avocado, uptake of nutrients such as calcium and fruit quality of persimmon can also be highly variable and this also can be attributed to variation between and within rootstock species.

Persimmon rootstocks are generally propagated by seed due to the poor rooting ability of cuttings. Variability in tree growth and fruit productivity can be attributed to heterozygous nature of seedling rootstocks (Kagmi, 1999). Single-node stem cuttings from root suckers has been a successful technique for rapid multiplication of persimmon rootstock (Tetsumura et. al. 2000) however this process requires mature tree to be cut down and exposing roots to the air to develop suckers. A study that investigated the comparative rooting ability shoot tips vs. shots regenerated from roots showed shoots regenerated from roots had a superior root strike rate and grew more vigorously (Tetsumura and Yukinaga, 2000). Some persimmon varieties have been classified by their clonal rooting ability, these include Fuyu and Hana Gosho (low), Hiratanenashi (moderate) and Jiro (high) (Tetsumura and Yukinaga, 2000).

A clonal propagation technique which has proven to be effective in macadamia propagation was tested on persimmon cultivars Fuyu, Jiro and Rojo Brillante using tip cuttings.

MATERIALS AND METHODS

12 tip cuttings (30cm) were taken from mature trees of cultivars Fuyu, Jiro and Rojo Brillante (Plate1 a.) in early December 2013. Cuttings were then shortened to approximately 20cm by making a cut across the nearest leaf node (Plate 1b.). All but the two terminal leaves were removed (Plate 1 c.). The bark around the circumference of the base of the cutting was then scraped with a sharp implement to expose the cambium (Plate 1 d.) and the dipped in Clonex rooting hormone gel purple (3g/L indole-3-butric acid) (Plate 2 e.). Cuttings were then left for five minutes to allow the gel to penetrate the cutting. Cuttings were then planted in 50mm tubes filled with a potting media comprised of 50% coconut fibre and 50% perlite (medium) (Plate 1 f.). Tubes were placed in a misting house with micro-jet irrigation for 20 seconds every 4

minutes. Cuttings were removed from the misting house on the 16th of April 2014 and were evaluated for root development prior to planting in larger bags.

Plate1. Persimmon cutting preparation process.

RESULTS AND DISCUSSION

All cuttings from each cultivar achieved 100% survival and had formed a root callus at the stage of re-potting in April. Rojo Brillante achieved the largest root callus diameter (24.5mm) followed by Jiro (19.2mm) and Fuyu (18.2mm) (Figure 1 and Plate 2). Cuttings will be maintained in a glasshouse during autumn and winter and will assessed for root and shoot development in spring 2015.

This clonal propagation technique may provide the industry with an alternative to seedling rootstocks. Larger trials will be established in the following project to test a wide range of rootstocks through this process.

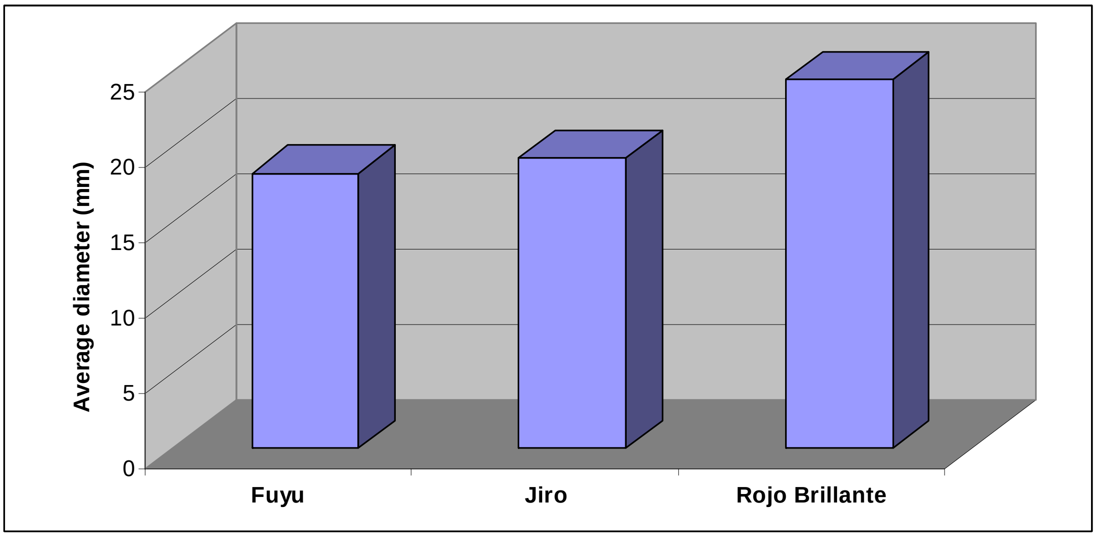


Figure 1. Average root callus diameter of cuttings in April 2014.

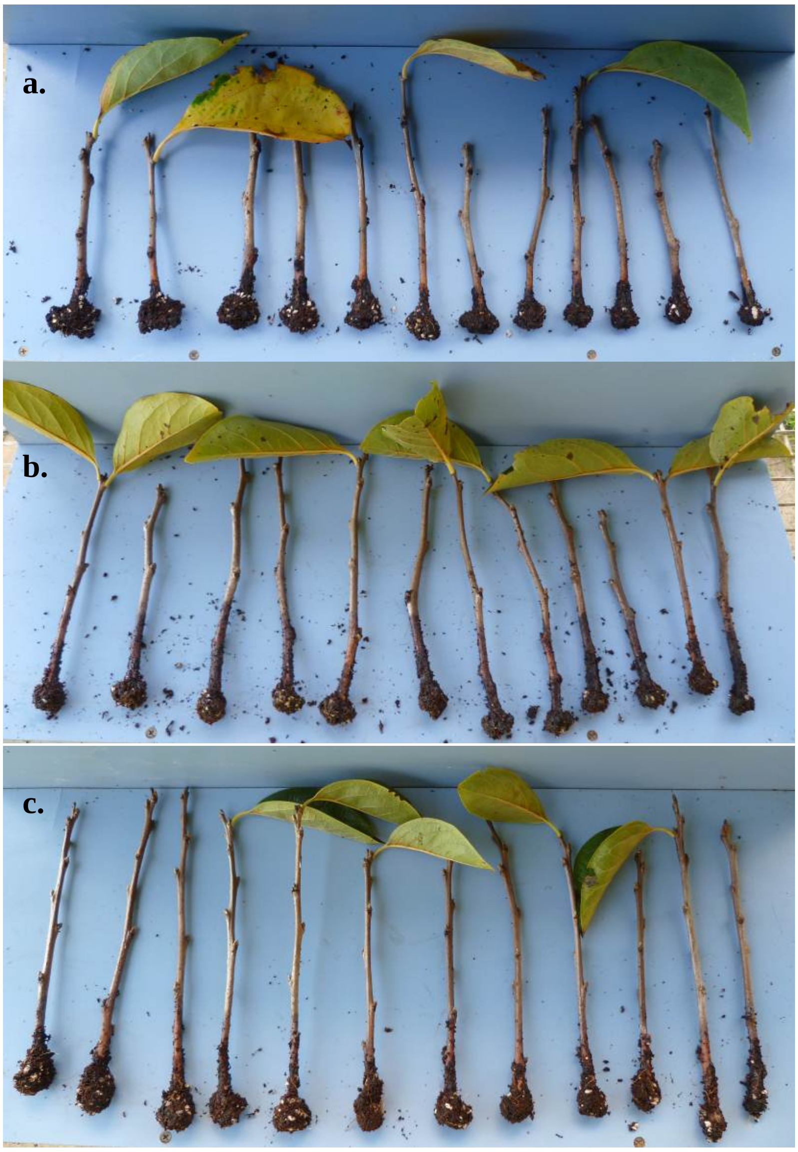


Plate 2. Root callus formation on Rojo Brillante (a), Jiro (b) and Fuyu (c).

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TECHNOLOGY TRANSFER

INDUSTRY ADVISORY MEETINGS

NEWSLETTER ARTICLES

Persimmon Press

Bignell, G. (2012). Persimmon R&D Update 2012, *Persimmon Press,* Issue 54, pp. 9-12.

Bignell, G. (2013). Persimmon R&D Update, *Persimmon Press,* Issue 55, pp. 5-7.

Senior, L. (2013). Life-cycle and seasonal activity of mealybug in persimmon, *Persimmon Press*, Issue 56, pp.10-11.

Bignell, G. (2013). Persimmon defects, blemishes and disorders, *Persimmon Press,* Issue 56, pp. 12-14.

Senior, L. (2014). Mealybug sex pheromones as monitoring tools, *Persimmon Press,* Issue 57, pp..

Bignell, G. (2014). Factors influencing mating disruption for controlling clearwing moth, *Persimmon Press,* Issue 57 pp..

4.3 FIELD DAYS AND WORKSHOPS

- Field day was held at Goomboorian, Queensland in September 2012 and was attended by 15-20 growers. Presentations on research findings were delivered by Grant Bignell and David Bruun.

- South-east Queensland growers, which incorporated growers from coastal Queensland and Kingaroy/Burnett regions, visited the Maroochy Research Facility on the 31st August 2013. Growers were updated on current R&D and were actively involved in discussions on other crop management issues during a field walk.

- A grower workshop for South Australian and Victorian growers was held in Mildura on the 17th October 2013. Ten growers attended a presentation on pest and disease management, storage, nutrition and possible new varieties for the industry. Three orchards were visited by Grant Bignell and Lara Senior (entomologist).

- A workshop and field day was held at the Maroochy Research Facility on the 13th December 2013 for south-east Queensland growers. Eight growers were updated on R&D findings and were also given a presentation from the state manager of Sumitomo on the use of Samurai®.

RECOMMENDATIONS

- Samurai® (clothianidin) used as a soil drench is an effective chemical for controlling mealybug populations in Australian persimmon orchards. Application of Samurai® at 5g/tree in mid-October gave the best results.
- Monitoring methods for mealybug such as pheromone trapping, sticky bands and visual inspections of various parts of trees have the potential to provide an insight into the population dynamics of various species. Limitations of these monitoring methods have been identified and require further research to optimise their effectiveness.
- Mating disruption pheromones applied at density of between 1000 and 1500 ties per hectare in late August have shown to reduce borer damage caused by clearwing moth (larvae). A second application in January is required for large infestations and needs to be determined by monitoring. Limitations of their use have been identified and further research is required. Pheromones should be used as part of an integrated approach for management of this pest. Best results are achieved when combined with mechanical removal (water blasting) and insecticides.
- Altacor® has shown to have the best efficacy in controlling clearwing larvae damage from the range of insecticides trialled. Samurai® and Movento® have also proven to significantly reduce damage compared to untreated trees.

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- Monitoring and sampling of moths causing borer (larvae) damage in South Australia has identified one potential species, however a more intensive collection is required in order to obtain more samples to confirm which borer species are of significance. Larvae collection indicates there is possibly two species causing dame to persimmon orchards in this region.
- Leaf and fruit disease has been less prevalent during this project due to extended periods of dry conditions during fruit development. Recommendations for the management of major diseases affecting Australian persimmon have been updated in the ‘Integrated Pest and Disease Management Manual’.
- We have identified the disease *Alterneria alternata* as a possible cause of leaf and fruit spot in persimmon orchards. We have also found the disease *Pestalotiopsis diospyri* requires damaged tissue to become pathogenic.
- Development of storage protocols for Jiro and Fuyu from major growing regions of Australia have been assisted by the results of postharvest trials. Recommendations have been distributed to growers in the ‘Persimmon Postharvest Manual’.

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