Accelerating the Development of the Australian Custard Apple Industry

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

Project Number: CU11000

CU11000

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FINAL REPORT FOR HAL PROJECT CU11000

(2014)

ACCELERATING THE DEVELOPMENT OF THE AUSTRALIAN CUSTARD APPLE INDUSTRY

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HAL Project Number: CU11000

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

This project was funded by Horticulture Australia Limited (HAL) using the Custard Apples Australia Incorporated (CAA) 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**
Trevor Olesen	**Senior Scientist, NSW DPI**
Ann and Peter Radke	**Manager, Yuruga Nursery, Walkamin QLD**
Joseph Tara	**Project Officer, Yuruga Nursery, Walkamin QLD**

This is a final report for RD and E work conducted for the Australian custard apple industry from 2012-2014.

Date of report: May 2014

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SUMMARY
MEDIA SUMMARY

The aim of this project was to accelerate the development of the Australian custard apple industry through provision of better varieties and rootstocks, better crop management techniques, increased reliability of production, maintenance of minor use permits and extension activities.

One of the major components of the project was to select and breed new varieties of custard apple. This project supported an intensive breeding program conducted at the Maroochy Research Facility. Breeding efforts were focussed on the development of high yielding red skin varieties with excellent eating quality. We expect rapid adoption of new green skin varieties bred during this project. Two of the new elite selections will be released for large-scale on farm testing. This project has also bred two red-skinned varieties with low seed number, good fruit set and good flavour. These are currently undergoing commercial on-farm testing.

Two rootstock trials were established during the project. We have evaluated semi-dwarfing rootstocks which may be suitable for reducing tree vigour in high density plantings. Development of a reliable clonal propagation technique has resulted in the industry standard Cherimoya rootstock achieving a strike rate of 99%. Other rootstock and varietal selections have also performed well through the propagation process. This clonal material will be used for field trials which will evaluate the performance of clonal rootstocks and varieties on their own roots.

This project has assisted with renewing minor use permits and development of new permits for a range of chemicals. Maintenance of these permits has given growers effective tools for the management of major pests and diseases in custard apple orchards.

We expect greater adoption of the high yielding trellis and mechanically pruned hedge row systems during the next three years. Improved recommendations on how to manage trees on these various systems have been developed. An instructional video on growing KJ Pinks on a vertical trellis has been developed and is available to growers on the industry website. Field days and workshops held in major growing regions have given custard apple growers access to the latest research and development results.

A combination of new varieties, clonal rootstocks and training systems will lead to greater profitability and reliability of production, which will re-invigorate the Australian custard apple industry.

TECHNICAL SUMMARY

- This project continued the development of the Australian custard apple industry through provision of better varieties and rootstocks, improved crop management techniques, better pest and disease management, increased reliability of production, increased production of quality fruit, and decreased costs of production.

- Breeding for high, natural fruit setting types with good external appearance and flavour continues. As this breeding objective is nearly met, there has been a shift in emphasis in the breeding program towards selecting red-skin and seedless types.

- Two new selections from the breeding program were released to industry for commercial testing. These new selections may eventually replace or complement the current production from the leading, high-yielding commercial variety 'KJ Pinks'. This project has also released high quality red-skinned selections for on-farm testing.

- Elite selections were taste tested and compared with the industry standard 'KJ Pinks' which identified new flavours that can attract consumers who dislike the taste of currently available cultivars.

- In a comparison of different rootstock species and varieties, we found that moderately vigorous rootstocks produced higher yields. In northern NSW, we found that intermediate vigour 'African Pride' rootstocks moderately reduced vigour of scion varieties resulting in significantly higher yields. Very low vigour rootstocks such as Taiwanese sugar apple were too dwarfing under cooler sub-tropical conditions but much less so under more tropical regions of northern Australia.

- A highly significant breakthrough was the development of a reliable clonal propagation technique using softwood cuttings. This new clonal propagation technique was developed at Yuruga Nursery, North Queensland. Some rootstock selections achieved a 90% strike which is commercially acceptable. This propagation technique has successfully cloned difficult-to-root rootstock species such as cherimoya (*A. cherimola*). Clonal propagation will greatly reduce the variability in tree performance due to genetic variation of seedling rootstocks.

- Many farmers are now trialling and adopting the new tree training systems. These new tree training were developed in previous HAL project CUO7001, 'New training systems for custard apple – Phase 2'. We expect greater adoption of the high yielding Maroochy V-trellis and palmette-trellis training systems because of their ease of management and reduced labour costs associated with pruning, training and harvesting. Improved recommendations on how to manage trees on these various systems have been developed and incorporated into a tree training manual.

- We obtained and maintained minor use permits from APVMA for selected fungicides and pesticides based on their efficacy performance and residue testing.

- A minor use permit for prochloraz (Octave®) Octave was approved after taint testing trials identified no flesh tainting is evident after spraying at early flowering and fruit set.

- Field days and farm walks (on average about four per year) in each major custard apple growing region were held. Many articles by project personnel have been written for the custard apple industry newsletter. These articles have kept industry and growers up to date with RD&E results, and also provided other day-to-day crop management information. One-to-one grower contact and group activities were held on a regular basis.

- The custard apple RD and E team assisted in the preparation, program development and running of the Fifth Australian Custard Apple Conference held at Twin Waters on Queensland's Sunshine Coast in July 2011. Project team members prepared papers for the conference, and were instrumental in organising other inter-state and overseas speakers.

INTRODUCTION

Based on current database figures in 2012, the industry produces around 120,000 trays or 1,000 tonnes of fruit annually. There are about 150 active growers. About 20% of custard apples are exported to mainly Asian markets. Between 2006-2012, 26,000 plants of one new variety, KJ Pinks, were planted. This is a significant development given that 'KJ Pinks' is a very high and consistent bearer. Yields of this cultivar on new training systems such as the open V trellis have reached close to 60 tonnes per hectare. Currently the industry is made up of 29,000 African Pride, 2,000 Pinks Mammoth, 9,600 Hilary White, 26,600 KJ Pinks and 1,300 Maroochy Gold trees.

Ten promising green skin selections and three red skin selections were released for commercial testing between 2010 and 2013. We expect at least two green skin selections to supersede 'KJ Pinks' and expect new red skin selections to attract a premium price once released. The recent release of new germplasm provides improvements in production and reliability of performance.

Australia has the world's largest custard apple breeding program. We currently have the best varieties and a market niche in terms of timing of production for which there is no existing competition. In this project we concentrated on the breeding of red-skin varieties. The red-skin colour is highly attractive and preferred by Asian consumers. At present there is unsatisfied export demand. The measurable benefits of this work will be accelerated successful commercialisation of new varieties and rootstocks.

Excessive tree size and vigour has been associated with poor quality and productivity. Lower vigour, semi-dwarf trees are also better suited to new high density training systems such as the open V trellis and mechanically-pruned hedge-row systems. Findings from the rootstock trials conducted during this project have produced new recommendations for regions and for high density training systems. New techniques associated with clonal propagation of trees have been evaluated. Clonal propagation will eliminate variability due to rootstock genotype and advance the selection of elite rootstock lines.

The Australian Custard apple Industry predominantly grows hybrids types; *Annona Cherimola x Annona Squamosa* (commonly called *Annona Atemoya*). This species is unique to Australia and is not grown extensively outside Australia. The *Annona Atemoya* species has undesirable genetic traits. Many of the Annonaceae species grown worldwide also have undesirable fruit and cropping characteristics but there are several species which have certain desirable genetic traits that are highly desirable. These traits need to be evaluated and included in the breeding program with the aim of improving the progeny produced to meet the Australian Custard Apple Industry grower needs and ultimately Australian and Asian consumer preferences.

The methodology used in this report is based on previous and current research conducted by DAFF and extensive consultation with the industry advisory committee (IAC) of CAA (Custard Apples Australia) and Horticulture Australia Limited (HAL) to ensure the breeding program is using the most appropriate methods and technology within the budget. Other specific research areas undertaken by this project are presented in the results section. Each research section also contains a discussion on findings of the research.

BREEDING PROGRAM

Since 1999, the DAFF breeding program in custard apple has, and continues to be funded, by the Australian custard apple industry through the previous Horticulture Australia Limited (HAL) projects CU04000, CU07000 and the current HAL project CU11000 'Accelerating the Development of the Australian Custard Apple Industry'.

The breeding program is conducted by DAFF research team based at Maroochy Research Facility. Breeding blocks are maintained at the Maroochy Research Facility, Nambour, Queensland. To date, about 35,000 breeding lines have been evaluated.

The current breeding program is reviewed annually by the industry advisory committee (IAC) of CAA (Custard Apples Australia) and the business manager for HAL.

The methodology presented and used in this project is based on recurrent phenotypic selection with parents showing desirable genetic traits of performance general combining value and specific combining value. If progeny produced has not flowered or fruited after 3 years them the progeny is culled. Further culling is then based on disease incidence (leaf and fruit) and fruit susceptibility to splitting. Interspecific crosses between four different species have been made and inter-generic crosses have also been made. Breeding has been focused on the production of high yielding red skinned cultivars with excellent flavour characteristics.

Productivity breeding with interspecific crosses and breeding for fruit quality characteristics e.g. fruit weight, symmetry and shape, flesh and skin colour, less seeds, flavour and texture are discussed and outcomes tabulated and presented.

INDUSTRY IMPROVEMENT RESEARCH

To achieve acceleration of the Australian custard apple industry, research was focussed on new varieties and rootstocks, chemical permits, and extension activities. Results from rootstock and clonal propagation trials are presented in this report.

Grower manuals developed in previous phases of this project have been updated to include the latest available information and are an extremely useful resource for growers and researchers.

RESULTS AND DISCUSSION

OVERVIEW OF DAFF CUSTARD APPLE BREEDING PROGRAM

HISTORY

Since 1999, the DAFF breeding program in custard apple has been funded by the Australian custard apple industry through the current and previous HAL projects CUO4000 and CUO7000. Details of previous findings of the breeding program can be found in the final HAL Reports for these two projects.

The breeding program is conducted by DAFF officers and breeding blocks are maintained at the Maroochy Research Facility, Nambour, Queensland. To date, about 35 000 breeding lines have been evaluated.

The current breeding program is reviewed annually by the management committee of Custard apples Australia Inc. (CAA) and the business manager for HAL.

METHODOLOGY

RECURRENT SELECTION

We have used recurrent phenotypic selection as the main breeding strategy which is similar for most tree fruit breeding programs. To date we have made 650 different crosses using 35 parents. We have tested about 35 000 seedling progeny to date.

During the life of this project (2012-2014), 25 different crosses were made and about 2 000 seedling progeny planted out and field tested.

Parents are selected on the basis of:

- Past phenotypic performance
- Individual progeny performance
- General combining value of the parents
- Specific combining values of parents

A high level of selection intensity has been used including:

- Culling of all progeny that have not flowered or fruited 3 years after planting
- Culling of progeny affected by fruit or leaf diseases
- Culling of progeny where fruit split

We have established heritability estimates and calculated rates of genetic response for yield and fruit quality traits. Breeding values (BLUPs) and selection indices still need to be determined.

Genes from 'wild' populations were introgressed into custard apple varieties through interspecific hybridization. Inter-specific crosses have been made between custard apple and four different species:

- *Annona cherimola* (cherimoya)
- *Annona squamosa* (sugar apple)
- *Annona reticulata* (Bullock's Heart)
- *Annona diversifolia* (Ilama)

Inter-generic crosses have also been made between *Rollinia deliciosa* and custard apple.

We are also conducting mutation breeding using gamma radiation to reduce seed numbers (in progress).

FIELD PROCEDURES AND EVALUATION STAGES

Stage 1

Field pollination

At Maroochy Research Facility, two thousand pollinations were made per season. Custard apple flowers exhibit protogynous dichogamy so it is necessary to hand pollinate selected parents. Pollen was normally collected in the late afternoon between 2 to 3 pm. The flowers were spread out on paper and left overnight for the pollen sacs to dehisce. Pollen was extracted and placed into vials ready for hand-pollinating the next morning usually about 9.0am. Hand pollinating generally gives good fruit set with between 60-90% of flowers setting. Flowers were not emasculated, as the level of natural pollination for most varieties is less than 3%. However, for high setting varieties, such as 'KJ Pinks' and 'Martin', emasculation would be desirable.

Seed germination

Seeds were extracted from fruit between April to June, treated with GA_3 (0.1%) for 24h at 40°C and planted out in easy-outs tubes in the glasshouse. These seedlings are then potted up into 5 L bags about 3 to 4 months after germination. Normally it took about 9 to 12 months for the seedlings to be ready for field planting.

Field planting

About 800 seedling progeny were field planted annually at Maroochy Research Facility in 2012 and 2013. Field planting was done in February – March each year although, if the seedlings grow fast enough, they may be planted in November/December. It normally takes three years after planting for the trees to flower and fruit. As one of the key selection criteria is precocity of bearing, if trees have not fruited at three years of age, they are culled. Some progeny were given an extra year after adverse weather conditions in 2013 devastated the crop.

Flowering and yield assessments

Progeny are evaluated three years after planting for different traits including:

- yield
- precocity of bearing
- fruit quality
- disease susceptibility

Flowering intensity of progeny was visually rated on a scale of 0-10, 0 = no flowering, 10 profusely flowering. The number of fruit per tree was also counted after fruit set is finished, usually in February, when they are large enough to be seen.

Fruit quality assessments

Fruit quality assessments were made in year three after planting. Some selections were assessed for two years before proceeding to Stage 2 of testing. Promising selections were propagated up for field testing at commercial orchards (Stage 2 - see next section).

Stage 2

Stage 2 field assessments were made at eight commercial grower sites in Queensland/NSW. Growers sign non-propagation agreement for the field testing of the new selections. Based on commercial field performance, and in consultation with growers, new selections are selected for large-scale propagation.

Stage 3

Selections warranting large-scale testing are released for on-farm testing with a minimum planting of 20 trees. Growers are required to sign a Material Transfer Agreement (MTA) and provide DAFF officers with access to trial trees to perform assessments. Growers are also asked to keep records on each selection released.

Stage 4

After a commercialization plan for the selection(s) is developed by Custard Apples Australia Inc, the variety is released to industry through propagation by licensed nurseries. If the variety exhibits significant improvements over existing varieties it may be presented for PBR or alternatively, its name may be trademarked.

SELECTION CRITERIA

Some of the major traits being selected for in custard apple are presented in Table 1. The industry has put great importance on selecting consistently high yielding types.

TABLE 1.
Criteria for selection of superior custard apple cultivars.

Trait	Desired performance
Tree morphology	
degree of apical dominance	low
number of fruit bearing laterals	high
Yield capacity	
percentage of flowers set	>20% (KJ Pinks is the standard)
precocity of bearing	2-3 years after planting
tree yield at full maturity	>60 kg on vase trained trees >30 kg on palmette trained trees
Fruit quality	
excellent taste	>7 on hedonic scale
firm texture	>7 on hedonic scale
no of seed per 100 g of flesh	<10
fruit size range	500g-800g
skin thickness	moderate to resist bruising
skin colour	green, yellow, red, pink
internal flesh colour	white, red, pink
fruit symmetry	high
fruit shape	symmetrical
skin type	smooth or mildly tuberculate or impressa
resistance to chilling injury	no russetting
fruit rots (anthracnose, *Diplodia, Pseudocercospera*)	resistant to all diseases and pests
Post- harvest	
storage life	>10 days
storage characteristics	little or no skin discolouration
fruit fly susceptibility	low

SELECTION FOR HIGH PRODUCTIVITY

INTRODUCTION

Besides cultural methods to improve productivity, we are selecting for this trait in the DAFF breeding program. We have crossed very high fruit set types such as 'KJ Pinks'. Of the current budsports, 'KJ Pinks' has become the new industry standard because of its high yield capacity and excellent flavour (Table 1).

On new training systems such the Maroochy Open V trellis it has produced close to 60 tonnes per hectare (George *et al*., 2011). In contrast, yields of the parent 'Pink's Mammoth' would average about 5 tonnes per hectare without hand pollination.

Despite having some excellent traits, vase-trained 'KJ Pinks' fail to size under moderate to heavy crop loads producing a high percentage of second grade fruit (range 20-50%) (George *et al*., 2011). The variety is susceptible to splitting under cooler growing conditions. In addition, consumers are also demanding fruit with few seeds.

Better quality varieties than 'KJ Pinks' need to be bred but with similar fruit setting ability as 'KJ Pinks'.

METHODOLOGY

Specific crosses

Crosses have been made between the highest yielding varieties such as 'KJ Pinks' and 20 other high yielding selections. Fifteen hundred progeny of these selections were evaluated during the course of this project (2012-2014).

Selection criteria

We described high yielding progeny as those that set ten or more fruit on 3-year-old seedlings, the age of first assessment. Trees which had not set fruit at three years of age were culled because we were interested in selecting for precocity of bearing as well as for high fruit set. We also estimated flowering intensity.

We developed an index for estimating fruit set by the following ratio: fruit no. per tree/flowering intensity rating.

RESULTS

LEAF CLASS SEGREGATION

Crosses between different species and varieties segregate out into different leaf and growth habit classes. Seedling progeny can be categorised by their leaf characteristics, in particular the leaf shape, texture and furriness (Table 1). However, there is overlap between each of the groups (Figure 1).

Leaves have been classified as follows:

- SA= sugar apple
- SAAT=intermediate between sugar apple and custard apple
- A=atemoya (custard apple)
- CHAT intermediate between atemoya (custard apple) and cherimoya
- C=cherimoya,
- RET=reticulata

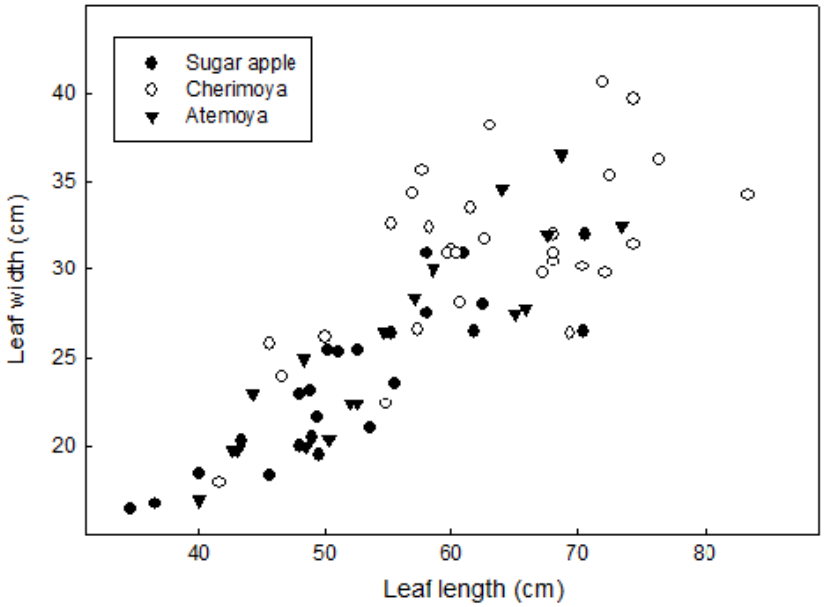

Figure 1. Relationship between leaf length and width for different *Annona* species.

TABLE 1.

General leaf characteristics for the major species of Annona.

Species type	Leaf shape	Leaf size	Leaf colour	Leaf hairiness and texture
Sugar apple	pointed, lanceolate	small	light green	smooth
Custard apple	intermediate	intermediate	olive	intermediate
Cherimoya	round	large	dark bluish green	very hairy
Reticulta	pointed	large	emerald green	smooth, leathery with a distinct aniseed smell

LEAF CLASS SCREENING

Progeny closely related to sugar apple (*A. squamosa*) phenotypes throw poor quality fruit (small size, seedy) whereas those closely related to cherimoya (*A. cherimola*) generally have poor fruit set and mature prematurely under subtropical conditions of Australia. Because of these limitations, it was desirable to eliminate this progeny before planting. A leaf screening technique was developed to eliminate this seedling progeny before planting thus saving valuable land and increasing the intensity of the selection process. About 20-30% of progeny can be culled.

By viewing the leaf hairiness on the underside of the leaf, we have developed a leaf hairiness rating from 1-5, 1=no hair, 5=extremely hairy (Plate 1). At one end of the spectrum are sugar apple types which have glabrous, pointed leaves and at the other end are cherimoya leaves which are extremely hairy and rounded, with custard apple types intermediate between the two extremes.

Using this system, we could eliminate up to 70% of progeny with undesirable sugar apple or cherimoya traits. Evaluation of this trait also allows selection of parents which throw a higher percentage of more desirable fruit quality, atemoya (custard apple) types.

Annona cherimola *Annona spp. hybrids* *Annona squamosa*

Plate 1. Hairiness of the undersurface of the leaf for a range of species. This trait can be used for determining suitable parents and for screening seedling progeny.

Due to a large amount of backcrossing being carried out in recent years this method has become less reliable. We have observed fruit with an atemoya appearance with leaf types classed as cherimoya or sugar apple. As a result all recently planted progeny have not been subjected to this selection process.

GENETIC LINKAGE

Linkage occurs because the two genes in question reside adjacent to each other on the same chromosome. This means that they are not subject to random independent segregation of chromosomes as they are passed from parent to offspring. Crosses between sugar apple (*A. squamosa*) and custard apple produce a higher proportion of sugar apple types whilst crosses between cherimoya (*A. cherimola*) and custard apple produce a higher proportion of cherimoya types (Figure 2). Crosses between custard apple and *A. reticulata* produce a higher proportion of reticulata types (Figure 3).

It should be noted also that there is strong linkage between the species traits and fruit quality traits e.g. sugar apple types have smaller, seedier fruit and reticulata types have fruit which set later and have a strong undesirable phenolic flavour. To overcome these strong linkage effects, several generations of back-crossing may be needed to remove the phenolic flavours of custard apple x reticulata crosses.

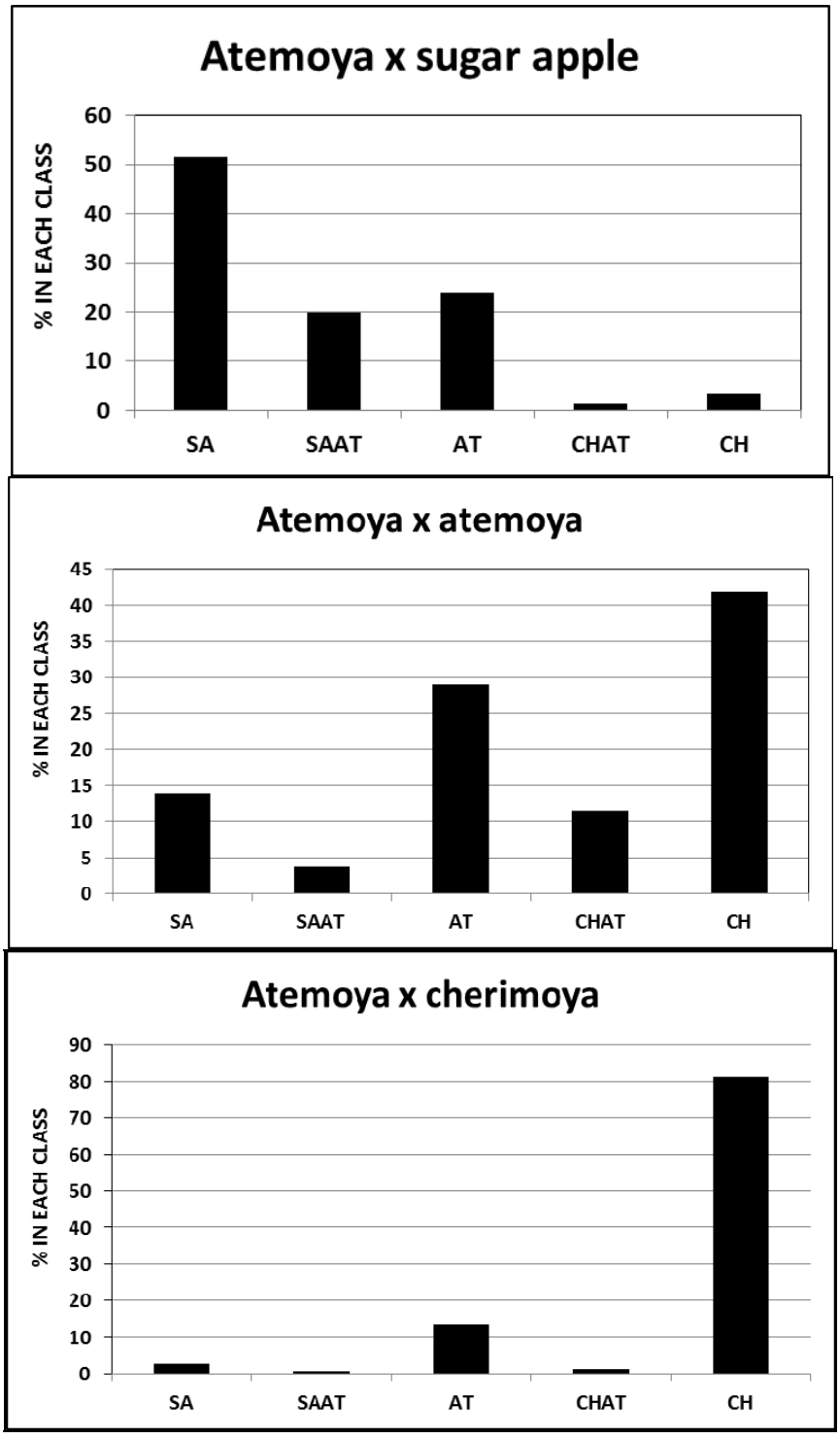

Figure 2. Effects of cross type on distribution of leaf classes. Leaves have been classified as follows: SA=sugar apple, SAAT=half-way between sugar

apple and atemoya (custard apple), A=atemoya, CHAT halfway between atemoya and cherimoya, C=cherimoya, RET=reticulata.

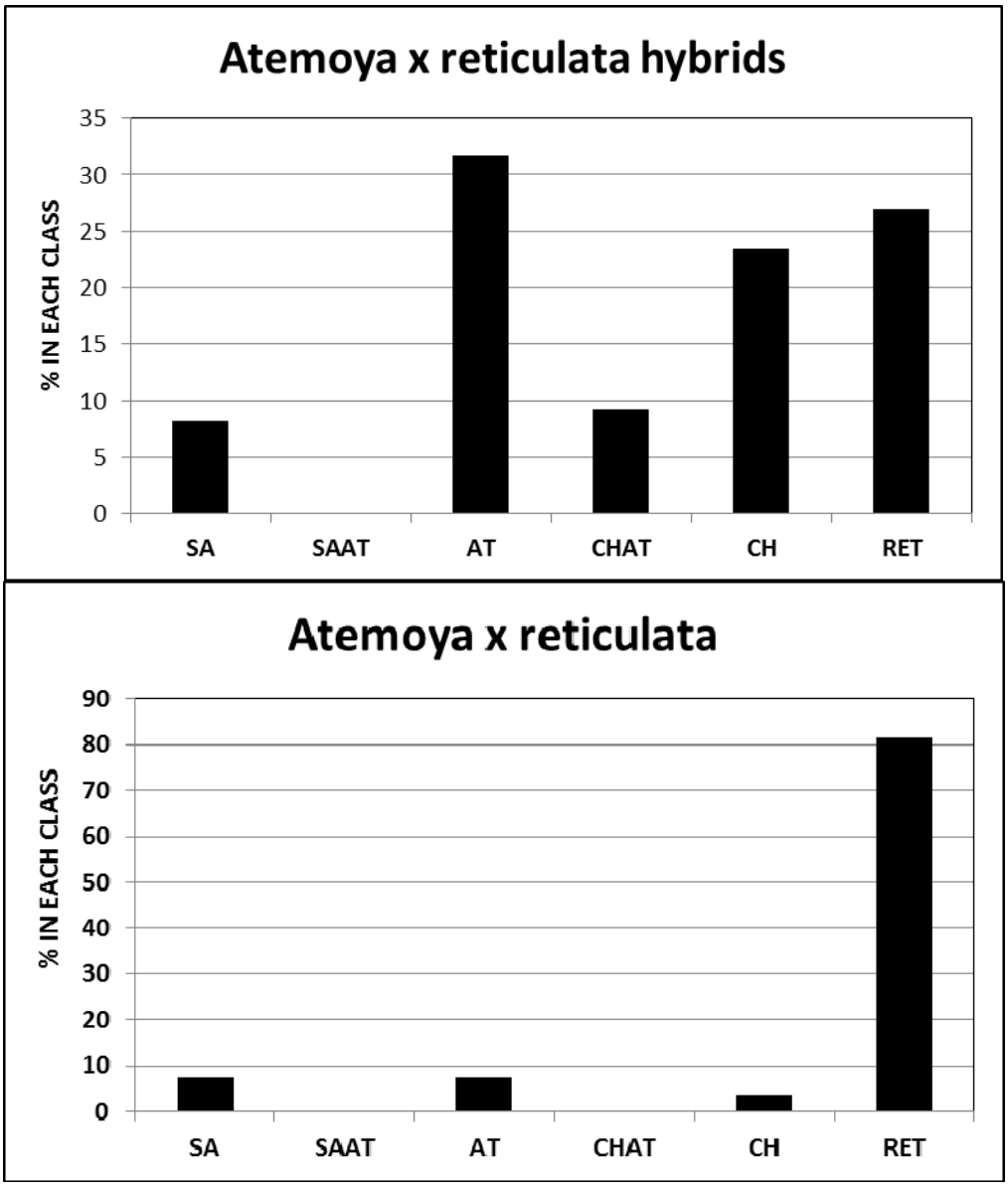

Figure 3. Effects of cross type on distribution of leaf classes. Leaves have been classified as follows: SA=sugar apple, SAAT=half-way between sugar apple and atemoya (custard apple), A=atemoya, CHAT halfway beween atemoya and cherimoya, C=cherimoya, RET=reticulata.

RELATIONSHIP BETWEEN LEAF CLASS TYPE AND FLOWERING AND FRUIT NUMBER

We found that over a wide range of crosses that SA and SAAT leaf types exhibited greater flowering and fruit numbers per tree (Figures 4 and 5). In contrast, CH leaf types exhibited the lowest flowering and the second lowest fruit number per tree.

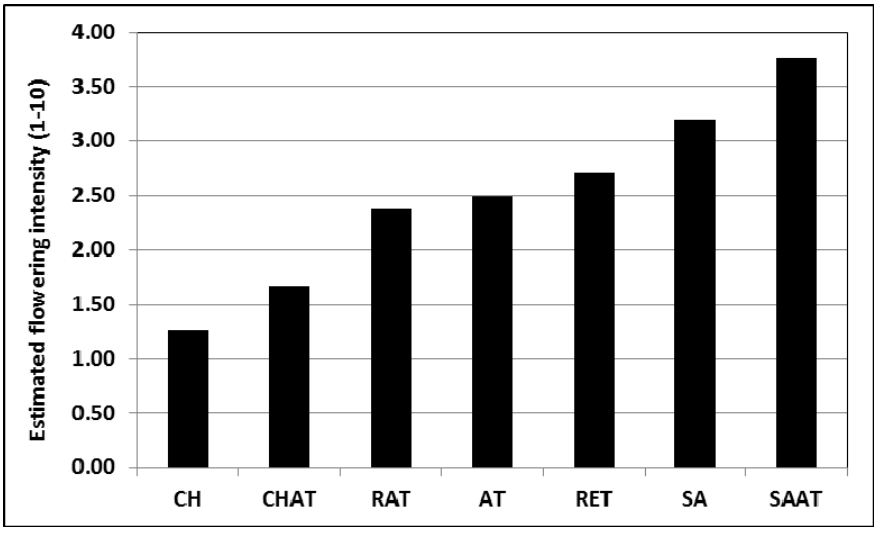

Figure 4. Relationship between leaf class type and flowering intensity per tree. Data collated for 190 different crosses.

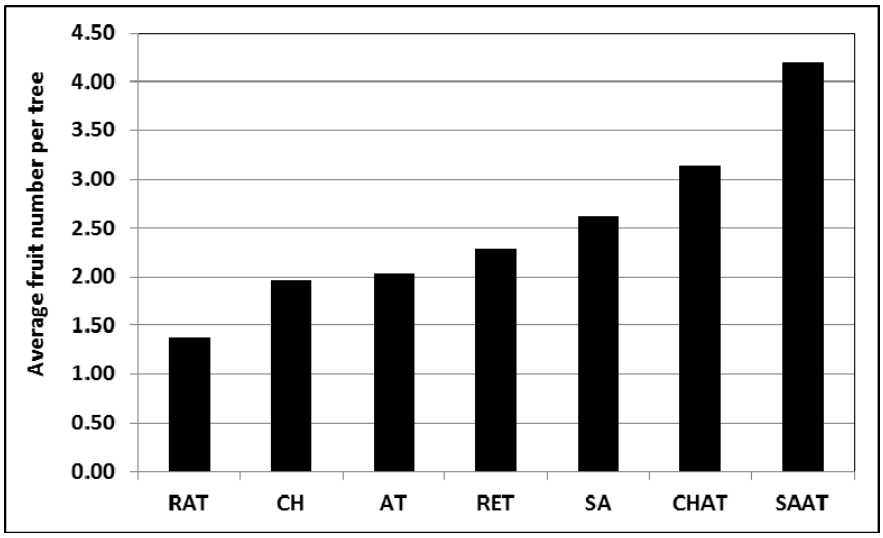

Figure 5. Relationship between leaf class type and average fruit number per tree. Data collated for 190 different crosses.

Although there was poor correlation between flowering intensity and average fruit number per tree, the general trend was for increased fruit set with greater flowering intensity (Figure 6). Figure 6 also highlights that some crosses produce very heavy fruit set at very low flowering intensities. We are particularly interested in selecting these progeny.

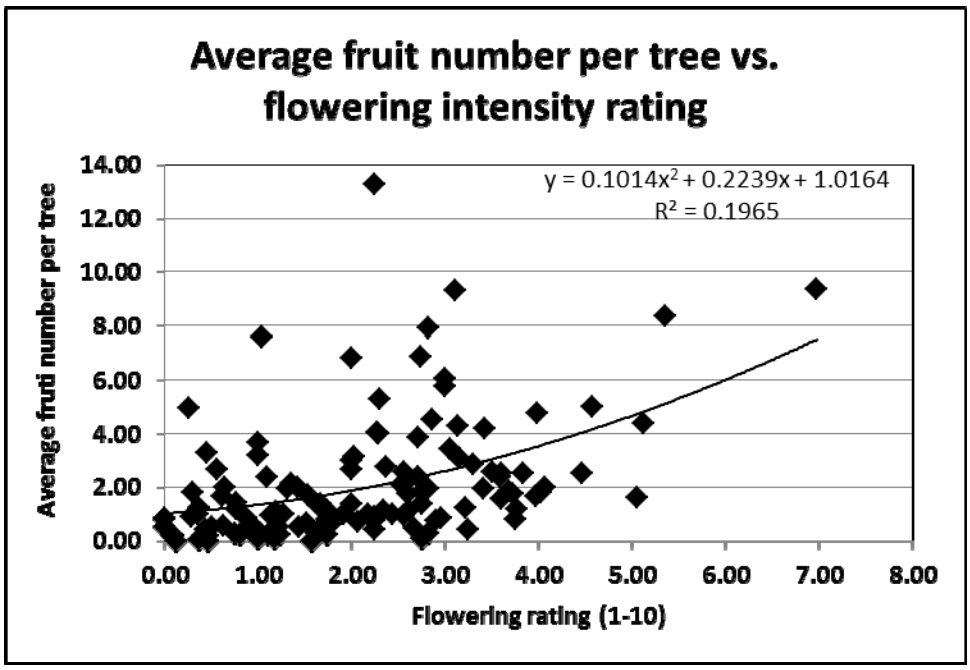

Figure 6. Relationship between flowering intensity and average fruit number per tree for 190 crosses.

We found a good relationship between average fruit number per tree and percentage of progeny setting more than 10 fruit per tree (Figure 7). Either selection criteria could be used for selecting high fruit set progeny.

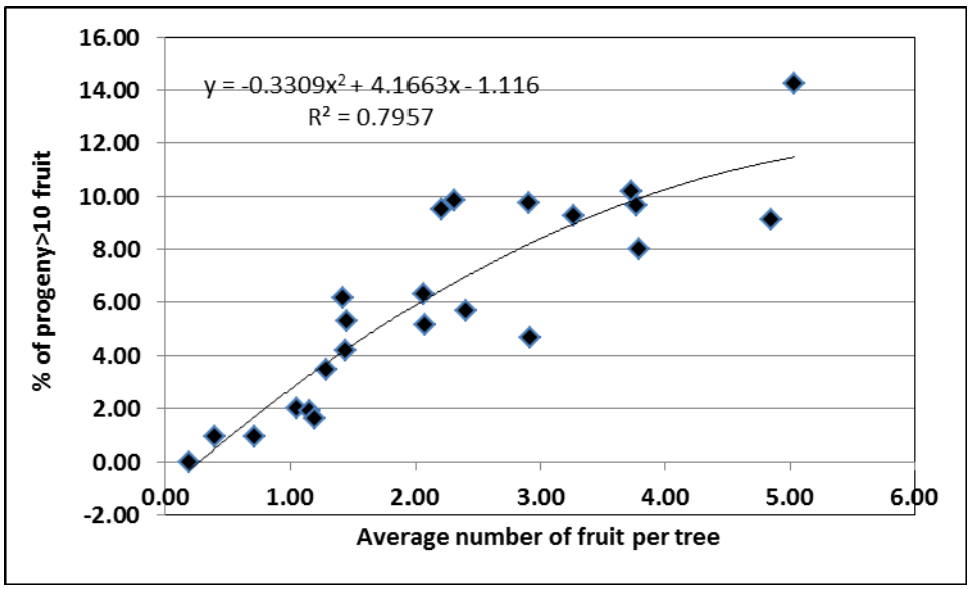

Figure 7. Relationship between average fruit number per tree and % of progeny with >10 fruit per tree, three years after field planting.

VARIATION IN FRUIT SET

The ranges in fruit number per tree, % of progeny which fruited and the % of progeny which set more than ten fruit per tree, three years after field-planting, are presented in Figures 8, 9, and 10 .

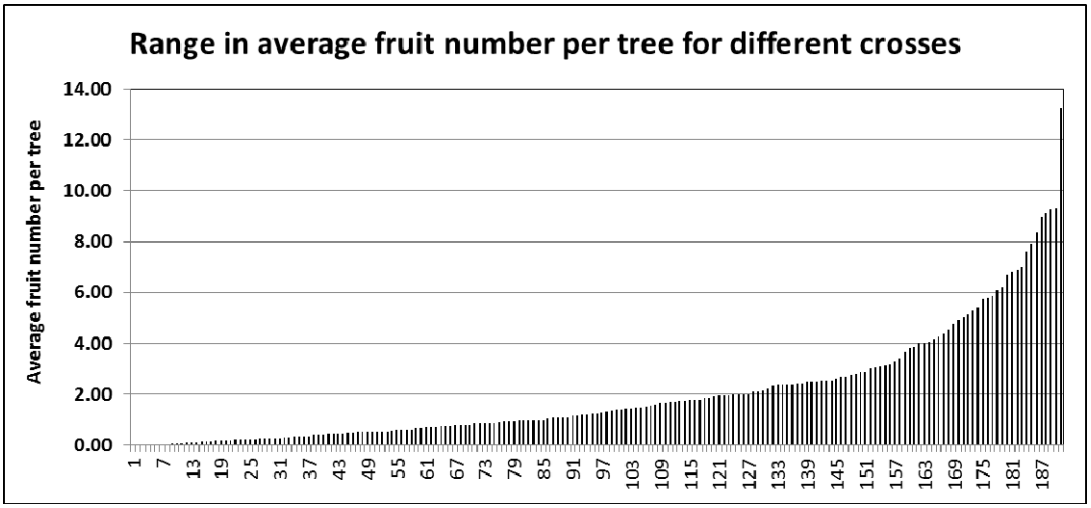

Figure 8. Range in average fruit number per tree per cross for 190 different crosses. Seedling progeny were assessed three years after field planting.

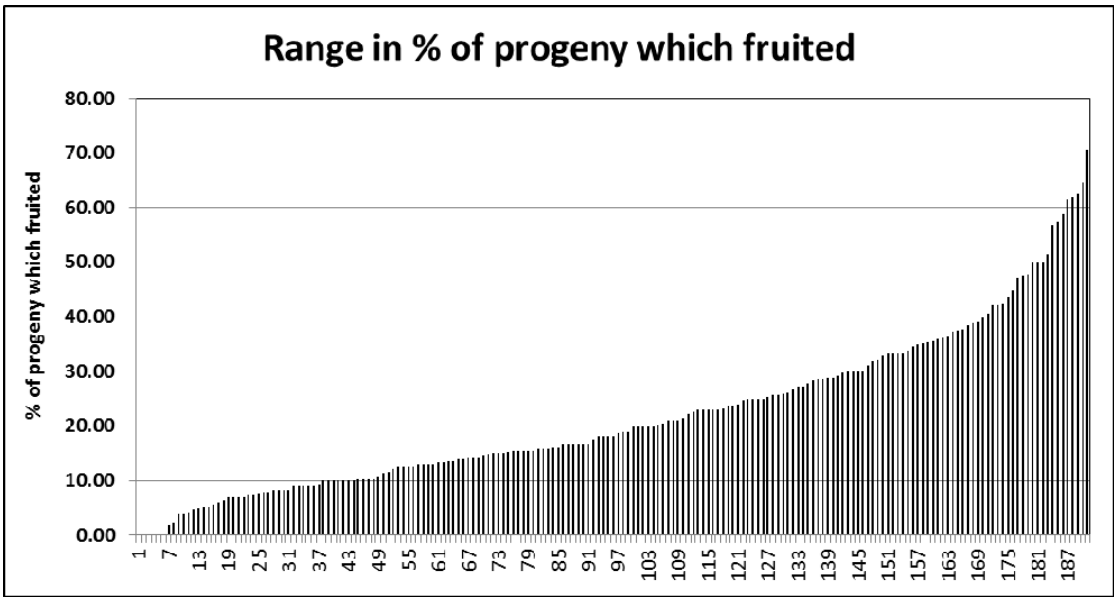

Figure 9. Range in % of progeny per cross which fruited for 190 different crosses. Seedling progeny were assessed three years after field planting.

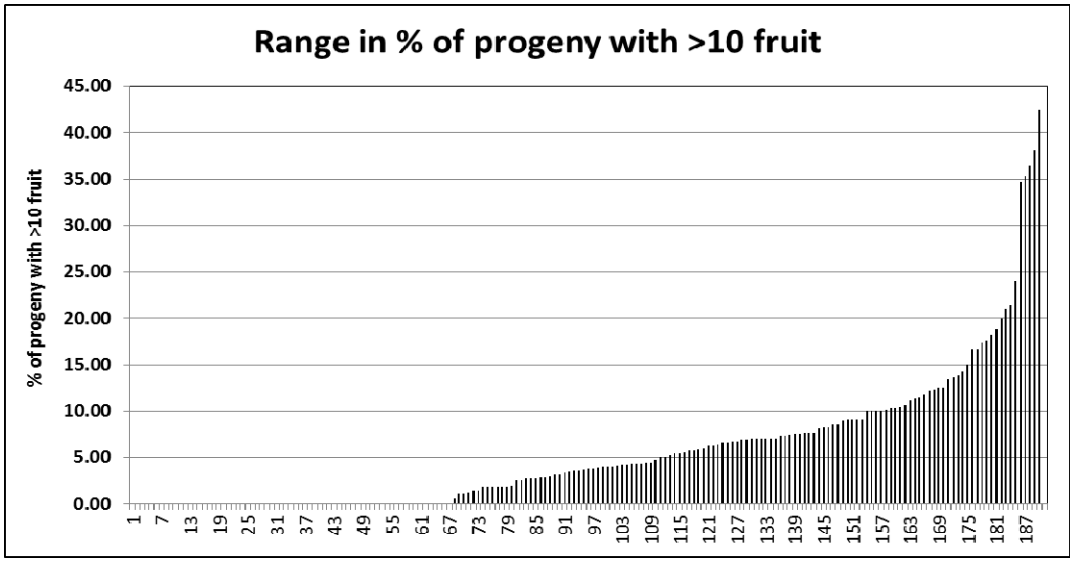

Figure 10. Range in % progeny per cross with >10 fruit per tree for 190 different crosses. Seedling progeny were assessed three years after field planting.

SPECIFIC COMBINING ABILITY

Combining ability is a statistical value indicating the capacity of a parent to transmit genetic superiority to its offspring. Combining ability is usually general or specific depending on the type of inheritance pattern being evaluated. The specific combining ability (SCA) is the degree to which the average performance of a specific family (usually full sibs) departs from the average of its parental breeding values. Specific combining ability is sometimes used to denote the departure of an individual clone from the performance of its sibs. The specific combining ability for the best crosses is presented in Figures 11, 12 and 13.

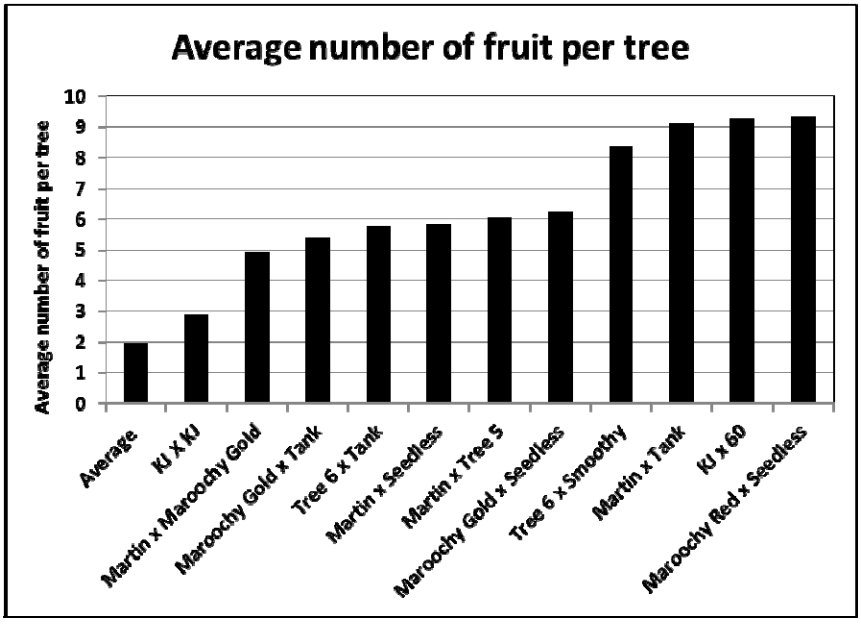

Figure 11. Specific combining ability of the best crosses for average fruit number per tree. Data recorded three years after field planting.

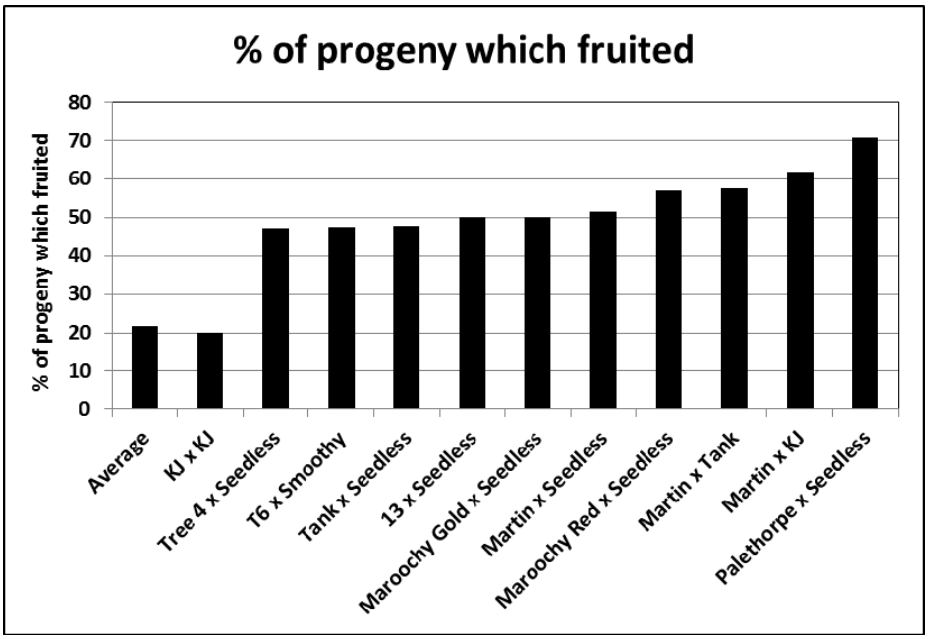

Figure 12. Specific combining ability of the best crosses for the % of progeny which fruited. Data recorded three years after field planting.

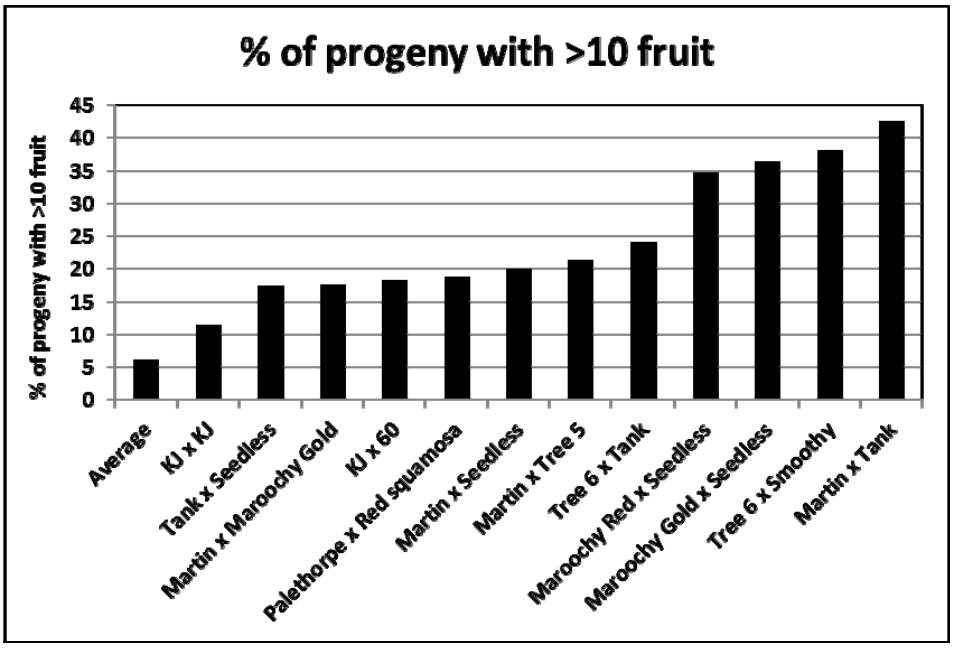

Figure 13. Specific combining ability of the best crosses for the % of progeny which set more than 10 fruit per tree. Data recorded three years after field planting.

GENERAL COMBINING ABILITY

The general combining ability (GCA) is the relative ability of an individual to transmit genetic superiority to its offspring when crossed with other individuals. The general

combining ability of a parent signifies the average performance of its progenies in various crosses, compared with progenies of other parents in the same test. The general combining ability is shown in Figures 14, 15 and 16.

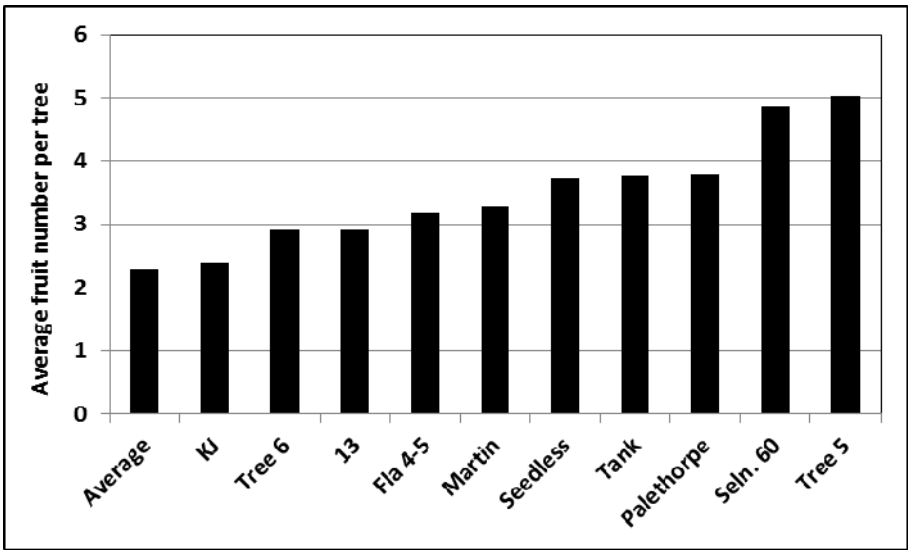

Figure 14. Selections and varieties showing the highest general combining ability for fruit number per tree. Data recorded three years after field planting.

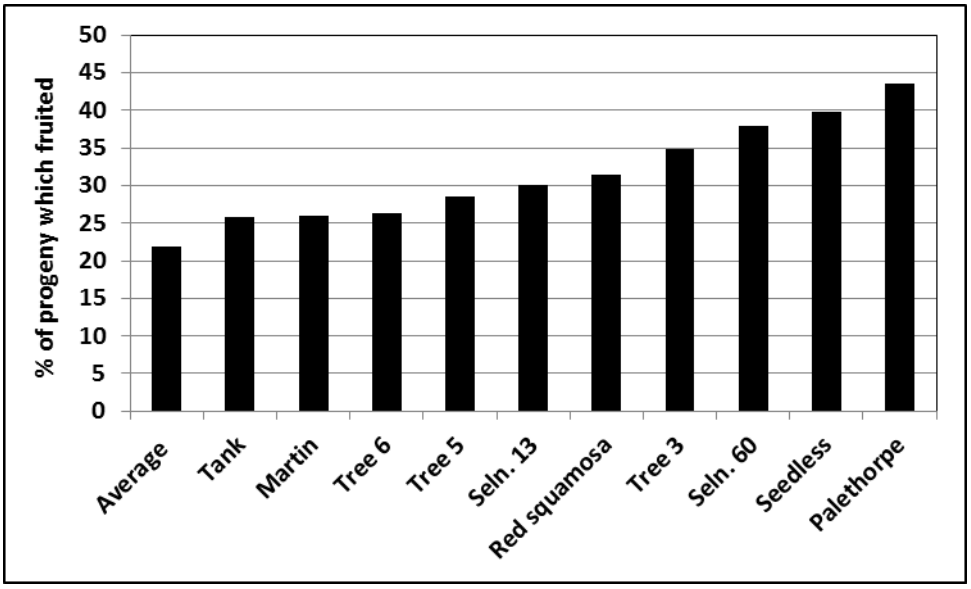

Figure 15. Selections and varieties showing the highest general combining ability for % of progeny which fruited. Data recorded three years after field planting.

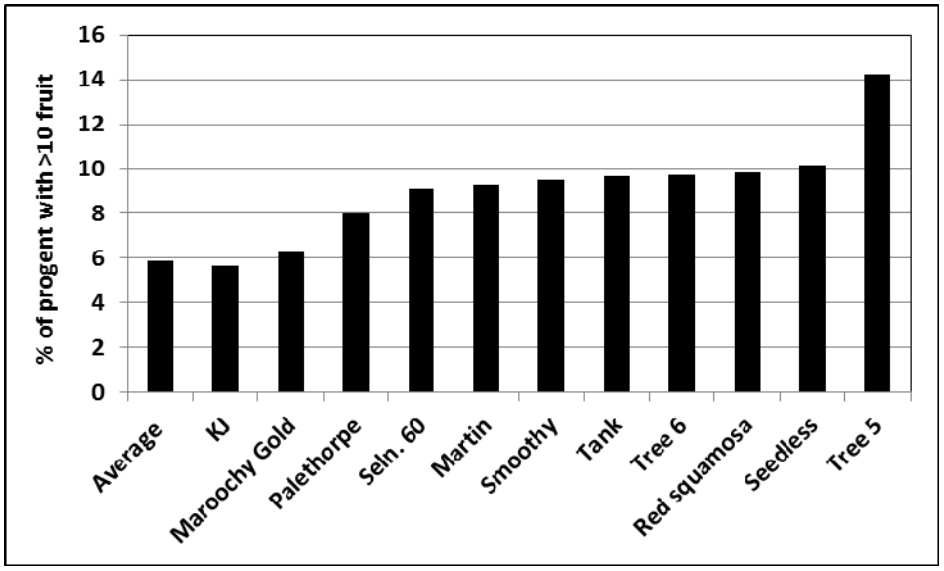

Figure 16. Selections and varieties showing the highest general combining ability for % of progeny with >10 fruit per tree. Data recorded three years after field planting.

To date, based on the GCA, the best overall parents were:

- MRS Tank
- Martin
- MRS tree 6
- Seedless sugar apple
- Maroochy Gold

Selection 'MRS Tank' is a cross between custard apple cv. 'Hillary White' and cherimoya cv. Fino de Jete. Tree 6 and 'Maroochy Gold' have similar parentage being crosses between 'Hillary White' and 'Red sugar apple'. Martin is a cross between custard apple varieties 'Hillary White' and 'Bullocks Heart'.

POLYLINE CROSSES WITH 'KJ PINKS'

Due to its very high fruit set and yield performance we have used cv. KJ Pinks extensively in our breeding program to improve overall productivity. Initial crosses were made with 'KJ Pinks' during the previous project and further crosses have been made during the life of this project (2012-14). About 1 400 seedling progeny from 30 different parents have been assessed to date at Maroochy Research Station. A further 1 000 seedling progeny of 'KJ Pinks' were assessed in 2012. Of the seven advanced selections that have been made from 'KJ Pinks' crosses, two have been propagated up for Stage 2 regional testing. All selections for regional testing have inherited the high fruit setting characteristic of 'KJ Pinks' (Plate 1).

GENERAL COMBINING ABILITY OF KJ

In terms of general combining ability for yield, 'KJ Pinks' ranked 9th out of 35 parents tested to date for average fruit number per tree and 12th for % of progeny setting >10 fruit per tree.

Surprisingly, we expected this 'KJ' to rank higher than this due to its own high yield performance.

SPECIFIC COMBINING ABILITY

The specific combining ability of 'KJ Pinks' for the trait of 'high fruit set' varies greatly (Figure 17). Selection of the most suitable parents to cross with 'KJ Pinks' is crucial to the success of the breeding program. The most successful crosses to date have been between 'KJ Pinks' and Seedless sugar apple and Selection 216 which is a cross between custard apple cv. 'Maroochy Gold' and red sugar apple.

Plate 1. Breeding line exhibiting very high fruit set. Nearly 90% of flowers set fruit.

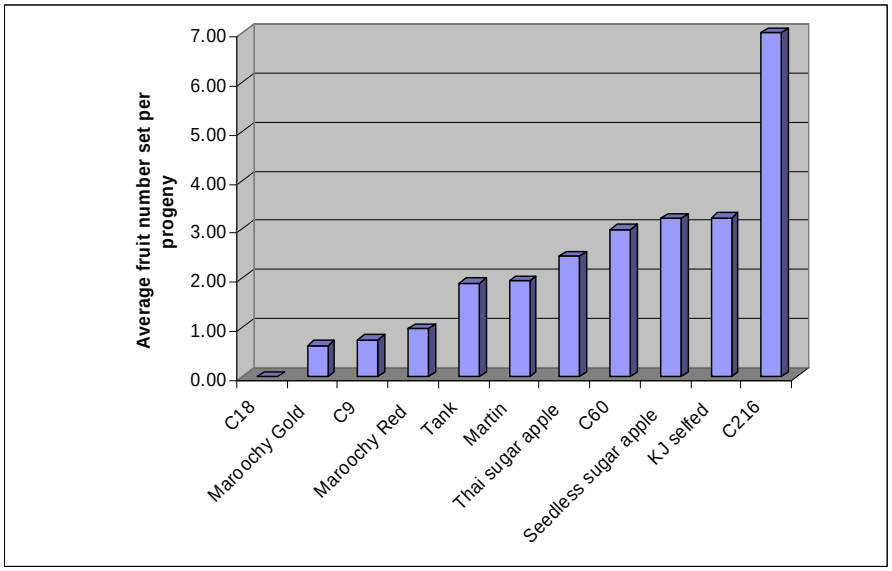

Figure 17. Specific combining ability of 'KJ Pinks' with other parents on average fruit number per tree. Data recorded three years after field planting. For comparison, fruit numbers of 'KJ Pinks' selfed progeny are also included.

SELECTION FOR RED SKIN COLOUR

INTRODUCTION

Wild species of *Annona* exhibit a wide range of skin and flesh colours. Some of these species are cross compatible with custard apple (*Annona* spp. hybrids). During previous HAL projects CUO7000 and CUO4000, we have been breeding for red and pink skin colour types using mauve-, maroon- or plum-coloured parents of *Annona reticulata* and *Annona squamosa.*

Unfortunately all of the progeny from the F1 generation of custard apple x red skin *A. reticulata* crosses has inherited the poor eating and phenolic flavour traits of the *A. reticulata* parents. Several generations (at least 3) of back-crossing to custard apple may be needed to achieve better flavoured types.

Progeny of custard apple crosses with either red skin *A. reticulata* or *A. squamosa* can exhibit a range of flesh and skin colours (see below).

Range in flesh colour

Custard apple can also exhibit a range of flesh colours. These colours include:

- Red
- Pink
- Combination of white and red/pink

Sometimes the region near the skin or seeds is coloured whilst the rest of the flesh is coloured white. Some of the ranges in flesh colour are shown in Plate 1.

Range in skin colour

Custard apple can exhibit a range of skin colours. These colours include:

- Dark red (maroon)
- Crimson red
- Mauve
- Dark purple
- Dark green
- Pale green
- Yellow/green

Instices (the area between carpels) are often a lighter colour than the carpel colour and these are also recorded. Some of the ranges in skin colour are shown in Plate 2.

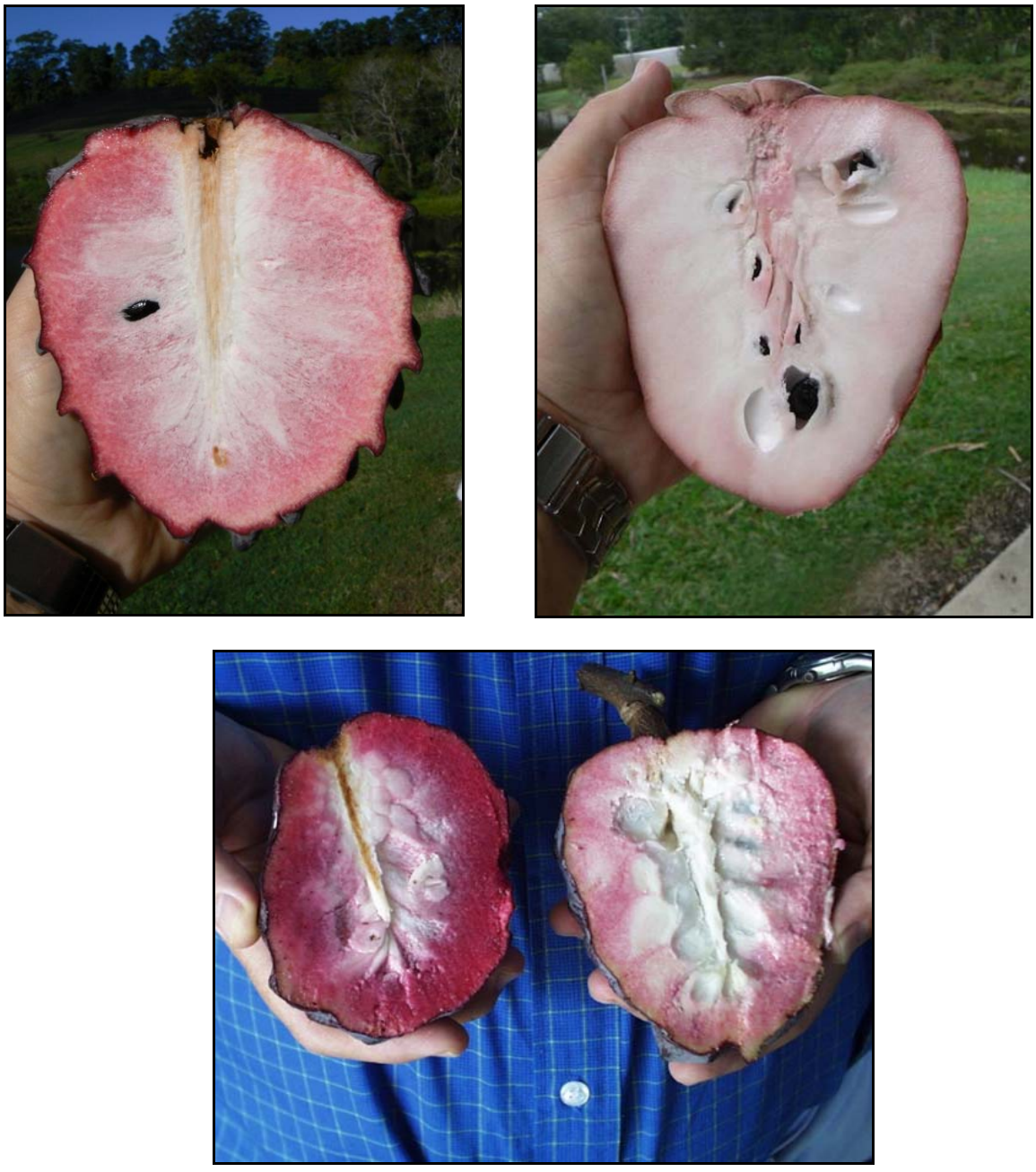

Plate 1. Some internal flesh colours recorded in breeding progeny.

Plate 2. Range of skin colours for custard apple hybrids. Note that the instice colour is often lighter than the carpel colour.

METHODOLOGY

Genes for red skin colour have been introgressed into custard apple from either red skin *A. reticulata* or red skin *A. squamosa*.

Unfortunately crosses between custard apple and *A. reticulata* inherit the phenolic flavour of reticulata; the traits of red skin colour and phenolic flavour are strongly linked. Several generations of back-crossing to custard apple are being used to try and remove the phenolic flavours of *A. reticulata*. We are currently conducting the third level of backcrossing of reticulata hybrids.

Crosses of custard apple with *A. squamosa*, which are small and seedy, inherit the seediness of sugar apple. Backcrossing to custard apple is needed to produce lower seeded phenotypes.

RESULTS AND DISCUSSION

General combining ability

Inheritance of genes for red skin colour appears complex. With some crosses, inheritance appears to follow a simple Mendelian pattern and appears to be due to double recessive genes. However, in other crosses, there are incomplete dominance effects.

The general combining ability of selected parents for red skin colour is presented in Figure 1. This figure shows that custard apple (atemoya) can effectively inherit red skin colour from either red skin sugar apple or the red skin *A. reticulata.*

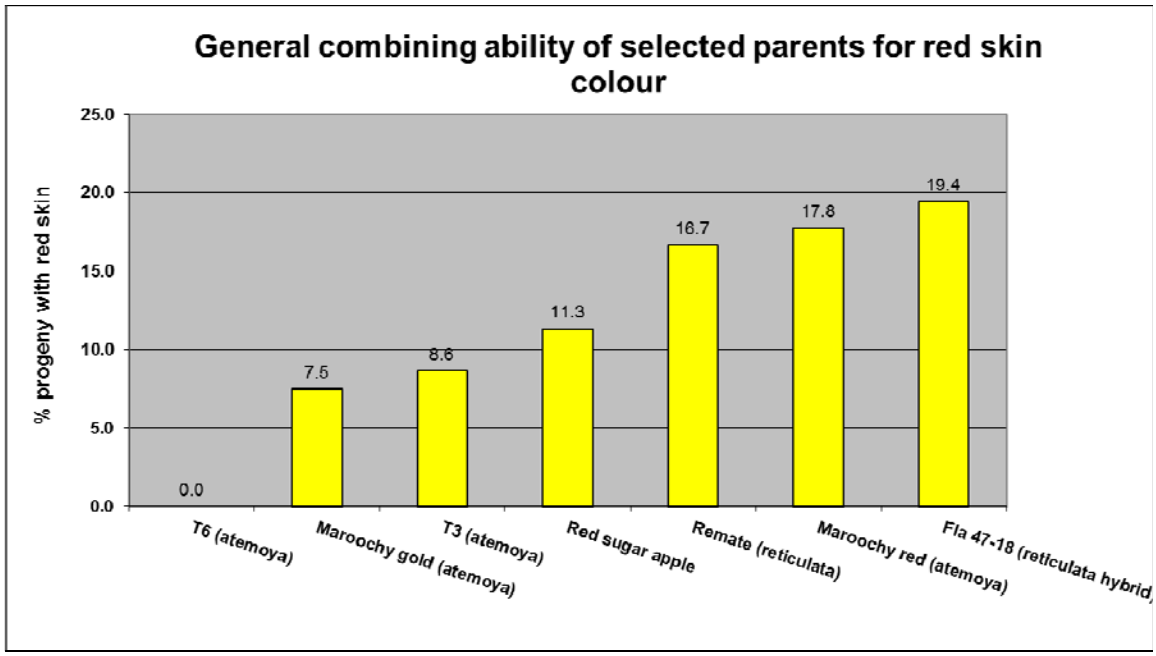

Figure 1. General combining ability of selected parents for red skin colour.

Specific combining ability

The specific combining ability of selected parents for red skin colour is presented in Figure 2. This figure shows that red skin reticulata and reticulata hybrid parents produce nearly double the percentage of red skin progeny compared with red sugar apple hybrids.

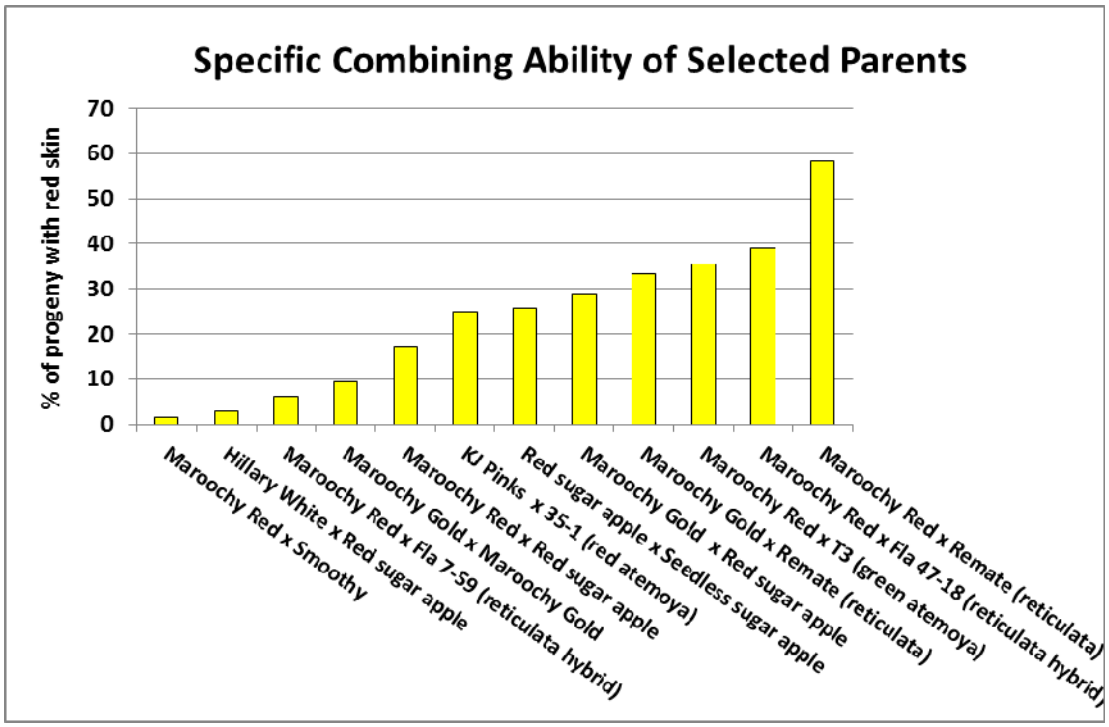

Figure 2. Specific combining ability. Percentage of red- and pink-skin progeny resulting from crosses between red-skin *A. squamosa*, *A. reticulata* and *A. reticulata* hybrid parents.

Genetic linkage

Unfortunately the red skin colour inherited from red skin *A. reticulata* is strongly linked with the phenolic flavour trait associated with reticulata. Two generations of backcrossing to custard apple parents have failed to remove the phenolic flavours. At least three or four generations of back-crossing may be needed to eliminate this undesirable trait.

We have found that a better alternative has been to use the red skin custard apple variety 'Maroochy Red' as a parent. Maroochy Red is a cross between red sugar apple and custard apple cultivar Hillary White. Although 'Maroochy Red' does not throw as high a percentage of red skin progeny as *A. reticulata*, the progeny inherit its excellent flavour characteristics.

Backcrossing

Two generations of backcrossing has failed to remove the phenolic flavour trait associated with *A. reticulata.* Several more generations of backcrossing may be necessary to remove this undesirable trait completely.

In contrast, a single backcross between custard apple and red sugar apple hybrids has produced progeny with the desirable red skin trait and acceptable flavour. Even though most of the progeny have inherited the undesirable trait of excessive seediness from *A. squamosa,* some of the red skin selections appear to be commercially acceptable.

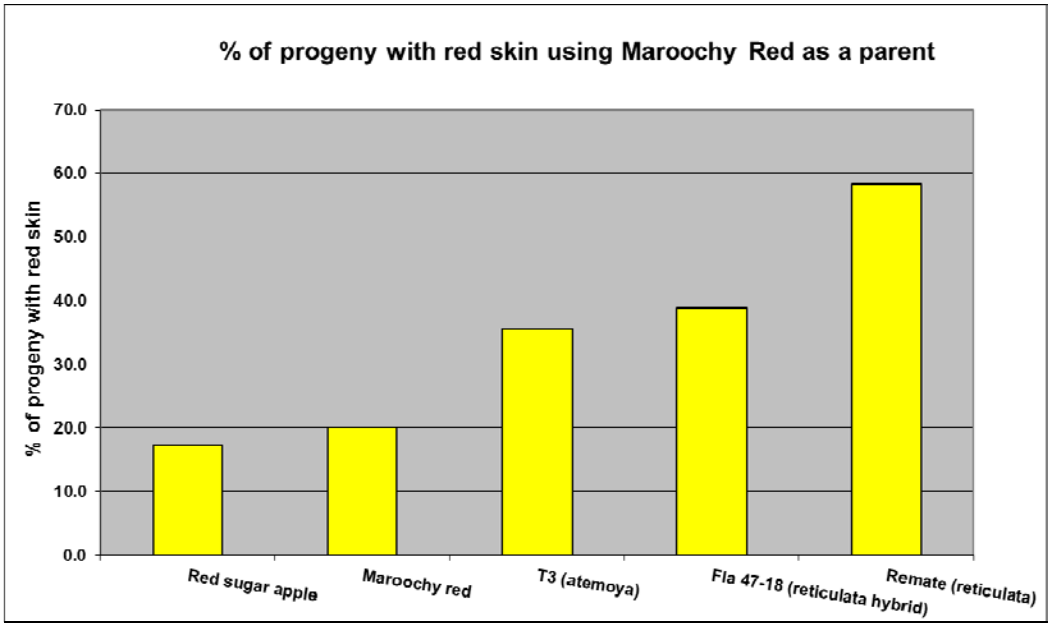

Figure 3. Percentage of progeny with red skin colour using the red skin custard apple variety 'Maroochy Red' as a parent. Crosses with *A. reticulata* types inherit the phenolic flavours of *A. reticulata*. In contrast, crosses with red sugar apple inherit the excellent flavour characteristics of 'Maroochy Red'.

One particular selection (MRS 649-1), a cross between the custard apple variety 'KJ Pinks' and Selection 35-1, a hybrid sugar apple type, has produced a very promising red skin line with excellent flavour characteristics (Plate 3).We have also found that crossing selections of custard apple, with pale yellow skin, to the maroon skin *A. squamosa* or *A. reticulata* varieties produces the more desirable pink skin colour. Characteristics of MRS 649-1 are presented in Table 1.

Plate 3. Selection 649-1, high yielding red skin type with good eating quality.

TABLE 1.
Characteristics of red skin custard apple selection MRS 649-1.

Trait	**Rating**
Tree growth	medium vigour
Pest and disease susceptibility	none
Crop load	moderately high
Fruit quality	
Av. fruit weight	386g
Symmetry* (1-10)	6.3
Skin type	tuberculate
Skin colour	Pink/red
Flesh colour	white
Texture** (1-9)	7.3, some grit
Flavour** (1-9)	7.5, very good
Flavour type	atemoya
Brix (°)	23.7
Seed number per fruit	21.8

*Symmetry rated on scale 1-9, 1=poor, 10=excellent;
Flavour and texture rated on hedonic scale (1=poor, 9=excellent)

SELECTION OF SEEDLESS CUSTARD APPLE VARIETIES

INTRODUCTION

STRATEGIES TO REDUCE SEED NUMBER

The high number of seed in custard apple fruit is a major problem reducing consumer acceptance. Our initial strategy to produce seedless or very low seeded types was to inter-cross the lowest seeded custard apple varieties but this strategy failed to produce progeny with less seed numbers than their parents. Alternative strategies are needed to produce low-seeded or seedless fruit.

Three strategies are currently being evaluated to develop seedless cultivars.

These are:

- Treatment of germplasm (seed, buds) with mutagens, such as either colchicine or gamma radiation, to induce point mutations and less seediness
- Generation of autotetraploids in vitro using colchicine, which subsequently can be used to produce sterile triploids
- F2 progeny of crosses with a seedless sugar apple variety may produce seedless fruit. Lora *et al*. (2011) found that seedlessness in naturally occurring seedless sugar apple varieties was due to a single recessive gene.

Studies to evaluate these strategies were initiated during HAL project CUO7000 and have been previously reported in the final report for HAL project CUO7000.

The studies presented in this report are a continuation of these previous studies.

METHODOLOGY

Treatment of seed with gamma radiation

Previous studies showed that colchicine treatments applied to buds on mature trees were ineffective in inducing auto-tetraploids (Hamill, 2003). Because bud tissue has an extremely low bud/graft success rate after gamma radiation treatment, we selected seeds because of their ready availability.

In early trials, we treated seed of the cultivar Hillary White and in later studies ‘KJ Pinks’. A dose response curve was established before selecting the treatment dose rate. In total, over 10 000 seed were exposed to a range of doses of gamma irradiation from $Cobalt^{60}$. We found that germination of fresh seed extracted early in the growing season began to fall after exposure to greater than 80 Gray of gamma irradiation. Below 80 Gray, the germination rate

was not significantly affected compared to the germination rate of controls, which was quite low (27%). In later experiments, we used higher dose rates of >250 Gray.

We expect that some of the treated seed will produce seedling tetraploids. These tetraploids, if crossed to diploids, may produce seedless triploid types.

Plate 1. Young seedling of custard apple showing distorted leaves after seed was treated with gamma radiation.

In vitro treatment with colchicine to develop autotetraploids

Dr Carlos Encina, a researcher from Estacion Experimental La Mayora, Spain, has developed tetraploid plantlets for the closely related species, cherimoya (*Annona cherimola*) by treatment of nodal plantlets in vitro with colchicine. These tetraploids, if crossed with normal diploids types, have the potential to produce seedless triploid lines.

After discussions with Custard apple Australia Inc. and DAFF scientists on a visit to Australia in 2010, Dr Encina and his organisation have agreed to develop tetraploids for Australian custard apple varieties. Over 1 000 seeds of a high fruit setting custard apple type were sent to Spain to commence this process.

Potential tetraploids will be developed in vitro through treatment with the mutagenic agent colchicine to double up the chromosomes (Plate 2). DNA content will be tested using flow cytometry. Confirmed tetraploids will then be crossed to high fruit set custard apple diploids to produce triploids and subsequently seedless types.

Plate 2. Young micro-propagated hypocotyls of *A. cherimola* treated with colchicine in vitro (Carlos Encina, 2010).

Crosses with seedless sugar apple

Several seedless varieties of sugar apple (*Annona squamosa*) exist in nature including the Thai and Cuban seedless sugar apples. Lora *et al*. (2011) discovered that seedless fruit production in *Annona squamosa* was due to a defect in ovule development. He found that the seedlessness in some sugar apple varieties was due to a single recessive gene.

Theoretically, seed from the F2 selfed custard apple crosses with seedless sugar apple should produce some progeny with seedless fruit. Two hundred seedlings from high yielding crosses of Seedless sugar apple and 'KJ Prinks' were planted out in April 2011 at Maroochy Research Facility.

RESULTS

About 150 seedlings treated with gamma radiation are still in the process of field-testing. To date none of the treated seed have produced seedless fruit.

The Spanish researcher Dr Carlos Encina has been successful in inducing auto-tetraploids in both cherimoya (*A. cherimola*) and custard apple (*Annona* spp. hybrids) seedlings using colchicine as a mutating agent. However, changes in chromosome numbers and DNA content need to be verified by flow cytometry.

52 seedlings of the F2 generation of Seedless sugar apple x 'KJ Pinks' crosses have not fruited to date. We expect that some of these progeny will segregate out into seedless types.

NEW BUDSPORTS OF PINK'S MAMMOTH

HISTORY

A budsport is a part of a plant or tree, for example, a leaf, shoot or flower, which due to a genetic mutation clearly differs from the rest of the plant, and which can also be grafted to grow new plants which retain this genetic difference as a new cultivar.

Seven budsports have been identified on custard apple in south-east Queensland (Table 1, Plates 1 and 2). All of these budsports have arisen on the cv. Pink's Mammoth. The earliest bud sport reported was 'Hillary White' which was found on a very old Pink's Mammoth tree in Redland Bay in 1978. Another five Pink's Mammoth budsports were found in the early 2000s. In April 2014, we found a new budsport of Pink's Mammoth in northern NSW (Plate 3).

All of these budsports have exhibited high fruit setting traits. Unfortunately, one of these budsports has been lost. Another sport initially sets heavily but drops its fruit when they reach about 1 cm in diameter.

Of the current budsports, 'KJ Pinks' has become the new industry standard because of its high yield capacity and excellent flavour (Plate 2). On new training systems such the Maroochy Open V trellis, it has produced close to 60 tonnes per hectare (George *et al*., 2011). In contrast, yields on the parent 'Pink's Mammoth' trees would average about 5 tonnes per hectare without hand pollination and between 10 to 15 tonnes with hand pollination.

Despite having some excellent productivity attributes, vase-trained 'KJ Pinks' often fail to size under moderate to heavy crop loads producing a high percentage of second grade fruit (range 20-50%) (George *et al*., 2011). The cultivar is also susceptible to splitting under cooler growing conditions. In addition, consumers are also demanding fruit with no or few seeds.

Consequently, there is still considerable room for genetic improvement and selection of better quality budsports is one possibility for genetic advancement.

RATES AND CAUSES OF MUTATION IN 'PINKS MAMMOTH'

The somatic mutation rate for most tree crops is normally cited at about 1 per 1 000 000 trees. In comparison, the mutation rate for 'Pink's Mammoth' is rated at 1 per 50 000 trees, which is exceptionally high. More budsports in custard apple orchards probably exist and will be found now that growers have been alerted to their occurrence.
The type of bud mutations in custard apple may be due to single nucleotide changes or alternatively due to an epigenetic methylation change which changes gene expression but not sequence (Andreij Killian, pers. comm., 2010).

TABLE 1.

Description of budsports of Pink's Mammoth

Budsport name	Location found	Traits	Status
Hillary White	Redland Bay	Moderate fruit set	No longer commercial
KJ	Palmwoods	High fruit set	Commercial
L1	Beerburrum	High fruit set	Potentially commercial
L2	Beerburrum	High fruit set	Potentially commercial
Ko	Glasshouse Mountains	High fruit set	Not commercial – fruit drop at 1 cm stage. Low seed number. Useful as a parent.
Ka	Kadanga	High fruit set, red tinge	Grower lost sport through own propagation.
Cn	Clunes	High fruit set, petal adherence similar to Rollinia spp.	Potential for use in breeding program

Plate 1. Various bud sports of cv. Pinks Mammoth showing excellent fruit setting.

Plate 2. Excellent fruit set on commercial cv. KJ Pinks, a budsport of Pink's Mammoth.

Plate 3. Budsport found in April 2014 in northern NSW. Note: petal adherence, a trait associated with Rollinia spp.

Causes for the high somatic mutation rates in 'Pink's Mammoth' are not known. Point mutations, often caused by chemicals or malfunction of DNA replication, exchange a single nucleotide for another. It is more than likely that the main mutagen is either ultraviolet radiation or ionizing radiation. Two nucleotide bases in DNA, cytosine and thymine, are most vulnerable to radiation that can change their properties. UV light can induce adjacent thymine bases in a DNA strand to pair with each other, as a bulky dimer.

Keith Paxton, a commercial grower on whose farm the budsport 'KJ Pinks' was detected, has suggested that 'KJ Pink' sport arose possibly after the parent tree or nearby trees were struck by lightning. We also note that most of later five budsports of Pinks Mammoth appear to have been initiated at about the same time possibly indicating an environmental factor may be involved.

CURRENT GENETIC MARKER STUDIES

In previous projects phases we have been unable to detect the differences between the budsports of Pink's Mammoth using 15 polymorphic SSR (single sequence repeat) markers but were able to achieve unambiguous discrimination of all other genotypes (George *et al*., 2006).

As part of a new HAL project CU12003, further marker studies are being conducted using a sophisticated technique using diversified arrays (Diversity Arrays Technology).

Selection of markers associated with the high fruit setting trait would significantly advance the rate of selection of promising lines given that less than 10% of the 35 000 progeny, tested to date, fruited three years after field planting.

DEVELOPING GENETIC MARKERS FOR CUSTARD APPLE BREEDING

NEW HAL PROJECT

In June 2013, a new HAL project CU12003 commenced to identify molecular markers for red skin and high yields in custard apple. Specific markers associated with these traits can then be used to select future cultivars. Conventional breeding relies on assessing mature trees for yield and quality, and this can be very time consuming. The development of molecular markers will improve this process. These markers can be used to identify potential new cultivars with better yields and quality when they are still young seedlings. Markers also have the potential to identify if a tree will have red or green skinned fruit before a single fruit has been produced.

In the HAL project CU11000, we are concentrating on the development of red-skin, high yielding cultivars which we predict will attract higher returns than standard cultivars. We intend to increase our selection pressure and genetic gain using genetic markers for these attributes.

In previous projects, we used recurrent phenotypic selection as the main breeding strategy which is similar for most tree crops. To date we have made 650 different crosses using 35 parents. We have tested about 35,000 seedlings to date.

Parents are selected on the basis of past phenotypic performance, individual progeny performance, general combining value of the parents and specific combining values of parents. A high level of selection intensity has been used including culling of all seedlings that have not fruited after 3 years, seedlings that are affected by fruit or leaf diseases and seedlings where the fruit split.

Inter-specific crosses have been made between custard apple and four related species; *Annona cherimola* (cherimoya), *A. squamosa* (sugar apple), *A. reticulata* (Bullock's Heart) and *A. diversifolia* (Ilama). Progeny are evaluated three years after planting for yield, fruit quality and susceptibility to diseases.

DIVERSITY ARRAYS TECHNOLOGY

Identification of these markers using Diversity Arrays Technology (DArT) will speed up the selection of new cultivars. This will be achieved by analysing tissue from trees with red and green skin and trees with low and high yields.
The lengthy juvenile stage of custard apple makes plant selection of individuals carrying desired traits time consuming and expensive. Marker technology can move selection from the field to the greenhouse, planting only elite seedlings in the field for further evaluation.

Diversity Arrays Technology allows the identification of traits that are controlled by single or multiple genes. This technology has been used to improve the performance of cereal crops.

We are hoping to accelerate the development of better custard apple cultivars through the use of this technology. Screening of seedling populations before field planting will substantially reduce costs and accelerate the development of new red skin and high fruit set varieties.

TESTING ADVANCED CUSTARD APPLE SELECTIONS

INTRODUCTION

Ten selections were made in the final year (2010) of the previous custard apple project CU07000. These selections are currently being tested on commercial farms. Of these lines, two new custard apple selections have been released for large-scale testing in 2014-2015 (see later section).

Annual releases of advanced promising selections from this project will also continue, and after two years of testing, high quality varieties will continue to be released to industry for commercial testing at eight commercial growers' properties.

METHODOLOGY

Advanced selections were released for testing at eight commercial growers' properties throughout Queensland and northern NSW.

Detailed records on flowering, tree growth and fruit quality of these selections was collected and analysed during the duration of this project.

Fruit quality assessments

Quality assessments are normally made on between 6-10 fruit, randomly selected from each seedling progeny

Fruit weight

Individual fruit weights are recorded for between 6-10 fruit.

Fruit symmetry

Symmetry is rated on a scale of 1-5, 1=poor shape, 5=completely symmetrical.

Skin type

Skin type is classified as:

- Smooth
- Tuberculate

- Impressa

With each of these classifications rated as mild, moderate, or strong.

Skin thickness

Skin thickness is measured at 3 points using digital callipers (Plate 1).

Plate 1. Left: Selection with very thin skin. Right: Selection with very thick skin.

Seed number and seed no per 100g flesh

Seeds are extracted from the flesh and counted and the seed number per 100g of flesh is calculated.

Flavour

Flavour is rated on the hedonic scale 1-9, 1=extremely dislike, 9=extremely like. Normally a panel of 6-10 randomly selected persons rate these characters to avoid individual preference/bias (Plate 2). A description of the flavour is also recorded.

Five different flavour types have been recorded:

- Pink's Mammoth
- African Pride (common)
- Tangy/sherbet
- Cherimoya (floral, violet)
- Pear (mild)

Texture

Flavour is rated on the hedonic scale 1-9, 1=extremely dislike, 9=extremely like. Some selections have very firm texture and pop-out seeds, which is an advantage if used in the restaurant trade (Plate 3).

Plate 2. Flavour and texture is rated by a panel of 8-10 persons.

Plate 3. Selection with very firm flesh. Seeds are easy to remove.

Sweetness

Brix (sweetness) is determined on expressed juice using a hand-held refractometer.

Shelf life

Shelf life is determined at ambient temperature (22°±3°C), with rate of fruit softening recorded at 2 –3 day intervals.

Attributes such as disease, russetting, woodiness and splitting are rated as either present or absent.

Fruit diseases

The major fruit diseases are:

- *Colletotrichum* spp.
- *Cylinocladium* spp.
- *Pseudocercospera* spp.

Fruit are rated for the presence or absence of these diseases.

Skin colour

Skin colours are also described:

- Dark red (maroon)
- Crimson red
- Mauve
- Dark purple
- Dark green
- Pale green
- Yellow/green

Instices are often a lighter colour than the carpel colour.

Flesh colour

Flesh colour can be variable and ranges from:

- Red
- Pink
- Combination of white and red/pink

Often the region near the skin or seeds is coloured and the rest of the flesh is white.

RESULTS AND DISCUSSION

Evaluation of elite selections at Glasshouse Mountains, Queensland has resulted in the largest percentage of trial trees producing yields. Data from trial selections are presented in Table 1 below from three year old trees.

Selection	Tree vigour	Productivity	Shelf life	Weight (g)	Fruit symmetry	Texture	Flavour	Seed per 100g flesh	Brix
363-1	Moderately vigorous	Moderate - High	5.00	491.00	7.17	6.20	7.80	4.69	23.5
430-2	Moderately vigorous	High	5.00	576.67	7.17	6.82	7.27	4.89	20.8
453-1	Vigorous	Moderate	6.00	1002.00	8.00	6.75	7.75	2.59	20.7
464-1	Moderately vigorous	Moderate	6.00	730.50	6.83	6.20	7.00	3.58	20.2
470-2	Moderately vigorous	High	5.00	783.67	6.83	6.50	7.33	5.16	19.2

Table 1. Tree and fruit data (averages) from elite selections at Glasshouse Mountains.

A full description of elite selections is supplied in Appendix 1. Two elite selections 453-1 and 464-1 will progress to large-scale testing in 2014-15.

Large-scale testing in 2014-2015

The Department of Agriculture, Fisheries and Forestry (DAFF) offered two new custard apple selections for large-scale test in 2014-2015 (Plates 4 and 5) as part of the breeding component of the Horticulture Australia Limited (HAL) and Custard Apples Australia (CAA) funded industry development project.
Both selections are green skin 'KJ Pinks' types and have produced consistently high yields of quality fruit at Maroochy Research Facility (Tables 2 and 3). Fruit have been observed on each selection for five years since being selected in 2008.

Large-scale field testing of these elite selections in various growing regions is required to generate evaluation data on which to base a general commercial release decision. Selections 453-1 and 464-1 were available for viewing and tasting at the Maroochy Research Facility during March and April 2014 for those interested in participating in the large-scale testing scheme. Some fruit were also available to view and sample at the NSW CAA field day in April. Final decisions on testing locations will be made by DAFF and the management committee of Custard Apples Australia.

The large-scale testing arrangements and cost of trees will be finalised in July 2014. Tree prices will be considerably less than a commercial nursery tree. Growers are required to plant between a minimum of 50 and maximum (negotiable) number of trees and sign a materials transfer agreement (MTA). Contractual requirements surrounding this testing are detailed in the MTA.

Growers will be required to provide access to trial trees so DAFF staff can carry out assessments over the period of the agreement. DAFF and CAA would like to determine the number of interested growers before July 2014.

Plate 4. Selection MRS 453-1 at Maroochy Research Facility.

TABLE 2.

Description of the tree and fruit quality traits of Selection 453-1.

Selection number	**453-1**
Tree characteristics	Narrow pointed leaves with a high percentage of sugar apple parentage
Tree vigour	Moderately vigorous
Productivity	High
Fruit size	Medium (500-800g)
Skin colour	Green skin with red flecking in the interstices
Flesh colour	White
Shape	Spheroid
Symmetry	Very symmetrical
Skin type	Mildly tuberculate
Skin thickness	3.0mm
Flavour	Good
Flavour description	Pinks Mammoth type but milder with hint of tang
Texture	Good
Seed number per 100g of flesh	4.5
Disease susceptibility:	Does not appear to be susceptible to disease
Pest susceptibility	Does not appear to be susceptible to pests
Susceptibility to splitting	No
Suitability for trellising	Unknown but likely (currently on trial at MRF)
Overall rating	Very promising
Comments	Of the selections from the breeding program evaluated to date, selection 453-1 appears to be the most promising. It has high productivity and excellent appearance. It has a milder flavour than 'Pinks Mammoth' which some people prefer. It has cropped consistently at the Maroochy Research Facility over the past 5 years.

Plate 5. Selection MRS 464-1 at Maroochy Research Facility.

TABLE 3.

Description of the tree and fruit quality traits of Selection 464-1

Selection number	464-1
Tree characteristics	Atemoya type
Tree vigour	Moderately vigorous
Productivity	Moderately high
Fruit size	Medium (500-600g)
Skin colour	Green with large lime green instices
Flesh colour	White
Shape	Oval
Symmetry	Symmetrical
Skin type	Mildly tuberculate
Skin thickness	Thin (2.0 mm)
Flavour	Good
Flavour description	Mild Pinks Mammoth flavour
Texture	Good
Seed number per 100g of flesh	3.6
Disease susceptibility:	Does not appear to be susceptible to disease
Pest susceptibility	Does not appear to be susceptible to pests
Susceptibility to splitting	No
Suitability for trellising	Unknown (currently on trial at MRF)
Overall rating	Very promising (8)
Comments	464-1 is a very attractive fruit with nice white flesh. Productivity is moderately high but not as high as 'KJ Pinks'. It has a mild Pink's Mammoth flavour. The skin holds its colour after harvesting**.**

OVERVIEW OF ROOTSTOCKS

INTRODUCTION

Selection criteria.

There is wide variability in fruit quality and productivity between and within orchards which is due to genetic variability in seedling rootstocks currently used by industry. The current standard in the industry is *Annona cherimola* seedlings. While cherimoya is resistant to disease, it is highly vigorous and this leads to problems with fruit set and internal fruit physiological defects. Excessive tree size and vigour has been associated with poor quality and productivity. Lower vigour, semi-dwarf trees are also better suited to new high density training systems such as the open V trellis and mechanically-pruned hedge-row systems.

Several low vigour sugar apple rootstocks have been accessed from Brazil, Taiwan and Thailand. These rootstocks may be suitable for Australian conditions. These need testing with current scion varieties and evaluations are being undertaken in NSW (see below current rootstock trial). In addition, we are also testing screened seedlings of intermediate vigour of the custard apple cultivar African Pride. Also any chance selections of potential semi-dwarf and dwarf selections found in the breeding program or industry will be collected and propagated at Maroochy Research Facility. The previous CU07000 project selected five, very dwarf, potentially elite rootstock selections which were propagated for testing in this project.

A multiplication and clonal propagation procedure using a special technique developed by Yuruga Nursery has proven to be successful. This project has provided elite rootstock material to Yuruga Nursery for cloning, at no cost to the project. This will greatly assist the industry to develop a rapid multiplication process of these elite rootstock lines. A material transfer agreement has been put in place.

CURRENT ROOTSTOCK TRIALS

Rootstock trial 1 - commercial orchard at Alstonville NSW

Rootstock trial 1 was planted at a commercial orchard at Alstonville NSW in March 2009. Dr Trevor Olesen, Centre for Tropical Horticulture, Alstonville, developed the statistical design for the second rootstock trial.

Four scion varieties are being tested. These are:

- Maroochy Gold (high vigour)
- KJ Pinks (moderate vigour)

- Tropic Sun (moderate vigour)
- Maroochy Star (low vigour).

Six rootstock species and types are being tested. These are:

- Taiwanese sugar apple
- clonal African Pride
- African Pride seedling screened into three different categories based on vigour
- industry standard, cherimoya.

Screening of the 'African Pride' seedlings into three groups was based on leaf characteristics, seedling vigour and internode length. Self-pollinated 'African Pride' seedling are known to segregate out into sub-populations of sugar apple, intermediate hybrids and cherimoya types in a ratio of about 1:2:1. The sugar apple types have low vigour, the intermediate types have intermediate vigour and the cherimoya types have high vigour.

We predict the intermediate types will exhibit semi-dwarfing characteristics. Trees have now established well with only a few replacements. Data on yield and fruit quality will also be collected, collated and analysed. A material transfer agreement has been put in place.

Rootstock trial 2 – commercial grower at Mareeba

A second rootstock trial has been established at a commercial orchard in at Mareeba on the Atherton Tablelands in March 2010.

Rootstocks being tested include:

- *Annona cherimola*
- *Annona squamosa*
- *Annona* spp. hybrids

Data on tree growth, yield and fruit quality is also being collected, collated and analysed during the duration of this project. A material transfer agreement has been put in place.

Other Rootstock Observations

Dwarfing rootstocks

From our breeding program, identification of potential dwarfing rootstocks with low vigour is based upon short internodes and multiple branching structures and lack of vegetative vigour (vigorous shoot growth). We will continue to select these potentially dwarf or semi-dwarf types from the seedling breeding progeny.

Rootstock recommendations

Recommendations on the most suitable rootstocks to use for different regions and training systems will be made at the completion of the project. However, the success of the clonal propagation trial in north Queensland will require testing of clonal rootstocks which potentially could supersede rootstocks recommended from current trials. Taiwanese sugar apple has proved to be too dwarfing for subtropical growing regions, however in tropical areas like north Queensland it may be suitable. African Pride moderate vigour rootstock selections can also be recommended however clonal propagation of these rootstocks is required to ensure uniformity. Two moderate vigour African Pride selections have been recovered from trials and will be trialled though the clonal propagation system at Yuruga nursery.

VICTORIA PARK ROOTSTOCK TRIAL

INTRODUCTION

Three custard apple rootstock trials were conducted on a commercial property at Victoria Park in northern NSW, from 2009-12. The trials compared the performance of varieties KJ Pinks, Maroochy Star and Tropic Sun on a variety of cherimoya, sugar apple and hybrid rootstocks. The trials included African Pride clonal rootstocks and selected sugar apple seedling rootstocks that were used in an earlier NSW trial (George *et al*. 2011b). In the earlier trial the African Pride clonal rootstocks appeared to be too vigorous for NSW conditions, while the sugar apple rootstocks appeared to be too weak. These rootstocks were thus useful markers in the Victoria Park trial in defining acceptable upper and lower limits of vigour.
The trial was assessed in the last year in terms of the vigour and flowering of forced shoots, the number of fruit and butt circumference.

MATERIALS AND METHODS

There were three trials, one for each of the three varieties. The rootstocks were propagated in spring 2007, and grafted to the scion wood in spring 2008. The trials were planted January/February 2009. Within each trial the trees were restrictedly randomised to ensure a good spread of the different rootstock across the planted area.

The codes for the different rootstocks are:

- Ch – Cherimoya
- FC – Cherimoya selection
- APv1 – African Pride (hybrid) low vigour (based on low hairiness on the under surface of the leaf and a more sugar apple-like leaf shape)
- APv2 – African Pride medium vigour
- APv3 – African Pride high vigour (higher leaf hairiness and a more cherimoya-like leaf shape)
- APC – African Pride clonal selection (all other rootstocks were from seed)
- 404 – Taiwanese sugar apple selection
- 355, 550, 551 – Moderate vigour Cherimoya selections

The trees were managed according to recommended industry practices (George *et al*. 1999, 2011a).
The first year of production was 2011, but flowering was light, so only the number of fruit per tree was counted that year, on 4 June.
The main evaluation occurred in 2012. To evaluate vigour and propensity to flower, the highest branch on each tree was spur-pruned on 19 January 2012, and the highest remaining leaf was removed. The lengths of the shoots to develop from the (multiple) buds at the node where the leaf was removed were measured on 16-17 April 2012. For flowering branches, the shoots included the length of the flowering branch itself plus the length of the sympodial branch that developed from immediately below the inflorescence (Olesen and Muldoon 2009). The number of inflorescence scars on each shoot was counted at the same time that the shoot

length was measured. Fruit numbers were counted on 7 May 2012. Butt circumferences were measured on 19 September 2012. SigmaStat (Systat Software, Inc., San Jose, CA, USA) was used to analyse the data.

RESULTS AND DISCUSSION

In 2011, the KJ Pinks trees had from 0 to 10 fruit, the Maroochy Star trees had from 0 to 5 fruit, and there was no fruit on any of the Tropic Sun trees.
In 2012, the extent of flowering was dependent on branch length (Table 1; Fig. 1; $P < 0.05$) for all three varieties, and branch length was dependent on butt circumference. Fruit number per tree was not related to either shoot length or butt circumference for KJ Pinks or Maroochy Star (Table 1; $P > 0.05$), but increased with decreasing shoot length and butt circumference for Tropic Sun ($P < 0.05$; explained variance 0.91 with respect to shoot length, 0.84 with respect to butt circumference). The least vigorous plants, especially those on 404 rootstocks, were more prone to die.

There was a good range of tree vigour amongst the rootstocks collected, as assessed by either shoot length or butt circumference. From the KJ Pinks trial two APv2 rootstocks have been recovered for inclusion in the clonal rootstock assessment program based on moderate vigour control, reasonable yields (65 and 30 fruit per tree respectively in 2012), and ease of recovery. The yield performances of the Maroochy Star and Tropic Sun were poor, and the attempts to recover rootstocks from these trials (pruning the scion; scoring or decapitation below the graft) failed.
Flowering increased with decreasing vigour for all three varieties, a trend we showed in a previous report with respect to KJ Pinks on APC (hybrid) and 404 (sugar apple) rootstocks, and Maroochy Gold on cherimoya, APC and 404 rootstocks (George *et al*. 2011b). Flowering itself probably would have had little effect on vigour because a custard apple flower is only about 20% the dry weight of a custard apple leaf and a much smaller fraction of the total shoot dry weight, and because the release of the sympodial branch is concurrent with the early differentiation of the flowers (Olesen and Muldoon 2009, 2012). More likely a reduction in vigour is promoting flowering, given that George *et al*. (2001) found that the more vigorous shoots that developed from the spur branches of African Pride flowered less than the less vigorous shoots that developed from the canes. There may also have been rootstock effects unrelated to vigour.
Fruit number was not related to vigour for KJ Pinks or Maroochy Star. This may reflect a trade-off between a lower propensity for the branches of more vigorous trees to set fruit, and the greater number of branches in the larger canopies of the more vigorous trees. George and Nissen (1986) demonstrated such a trade-off for Pink's Mammoth and African Pride, where trees on sugar apple rootstocks had higher early yields than those on cherimoya rootstocks, but lower yields in later years. The negative relationship between fruit number and vigour for Tropic Sun is also consistent with this, with Tropic Sun simply coming into production later than the other two varieties.
The use of African Pride seedling leaf characteristics (shape and hairiness) was a reasonably successful means of assessing the vigour control of rootstocks. This may mean that to some extent leaf morphology reflects segregation back towards the original sugar apple or cherimoya parent, but the idea needs to be tested.

Table 1. Results from three rootstock experiments, one experiment on each of three scion varieties, outlining sample sizes, tree deaths, the length and flowering of shoots at the tops of the trees, numbers of fruit per tree and tree butt circumference.

Scion	Rootstock	Number of replicates	Mortality	Mean shoot length (mm)	Mean number of inflorescences per branch	Mean number of fruit per tree	Mean butt circumference (mm)
KJ Pinks	355	4	1	609	0.86	18.67	268
	550	1	0	600	0.50	26	222
	Ch	6	0	816	0.08	15.17	266
	APC	3	0	728	0.50	29	334
	APv3	5	0	592	1.10	19.6	224
	APv2	5	0	555	0.73	27.6	234
	APv1	5	2	265	1.33	23.33	171
	404	2	2				
Maroochy Star	FC	3	0	740	0.00	0.33	262
	APC	5	1	834	0.44	3.25	292
	APv3	5	1	755	0.75	10.75	229
	APv2	2	0	648	0.75	1.5	215
	APv1	5	0	519	1.30	8.2	217
	404	4	3	330	2.00	7.5	204
Tropic Sun	551	1	0	765	0.00	0	265
	Ch	5	0	747	0.00	0	245
	APC	5	0	817	0.00	0	280
	APv3	5	0	619	0.20	0.2	244
	APv2	5	0	732	0.10	0.4	247
	APv1	5	1	718	0.25	0.5	221
	404	5	2	242	0.80	3.33	159

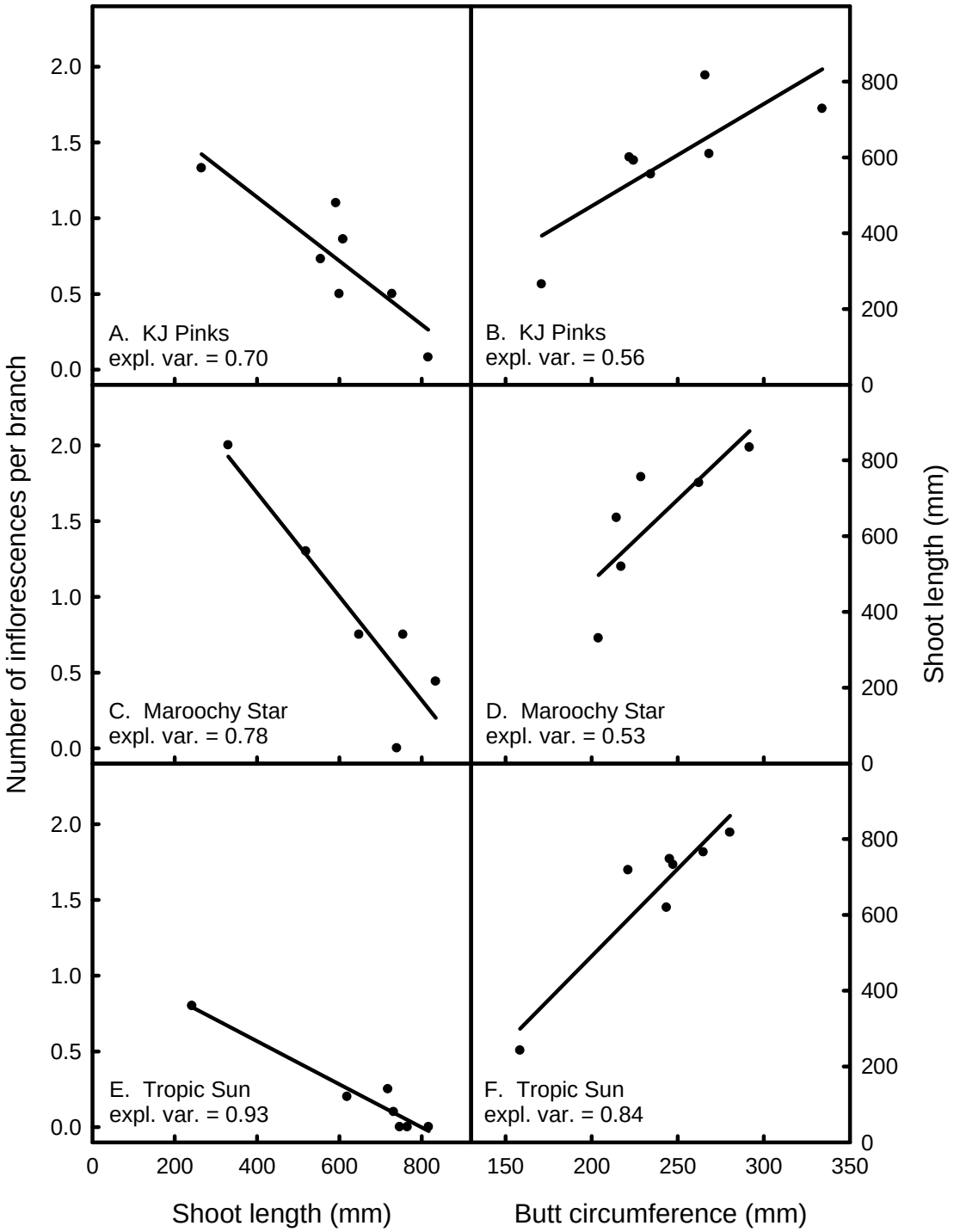

Fig. 1. Across the three varieties flowering was negatively related to shoot length (A,C,E) and positively correlated with butt circumference (B,D,F). Data from Table 1.

MAREEBA ROOTSTOCK TRIAL

INTRODUCTION

Besides the variation in tree yield performance, many custard apple trees particularly on the current industry standard rootstock of cherimoya are excessively vigorous. Lower vigour trees have the potential to produce higher yields with many studies indicating that excessive tree and shoot vigour can reduce yield and fruit quality substantially. For high yielding varieties such as 'KJ Pinks' a rootstock of moderate vigour (semi-dwarfing) would be preferable to either a very vigorous rootstock or a very dwarfing rootstock. As the industry moves to higher density plantings and to trellis training systems the use of moderate vigour rootstocks will become essential. A desirable rootstock for custard apple is one which fits the following criteria:

- Semi-dwarfing/moderately vigorous
- Resistant to water logging
- Resistant to root diseases
- Promotes early bearing
- Maintains good fruit size and quality under heavy crop loads

None of the currently used rootstocks fits all of these criteria. Moderate vigour 550 (Cherimoya), 404 (Taiwanese sugar apple) and African Pride moderate vigour seedling rootstocks were compared to the industry standard Cherimoya rootstock.

MATERIALS AND METHODS

Six replicates of each rootstock selection were grafted to 'KJ Pinks' in 2009 and planted (non-randomised) on a vertical trellis in 2010 at a commercial orchard in Mareeba, north Queensland. Trees spacings were 3m between trees within the row and 5m between rows. Four rootstocks were used (Plate 1);

- 550- moderate vigour Cherimoya selection
- 404- low/moderate vigour Taiwanese sugar apple
- APV2- moderate vigour African Pride seedling selections
- Cherimoya- industry standard rootstock

All trees were subjected to the same pruning schedule while being tree training to a vertical trellis system (4 wires).

Trees were evaluated in February 2014 for shoot extension, trunk circumference and yield.

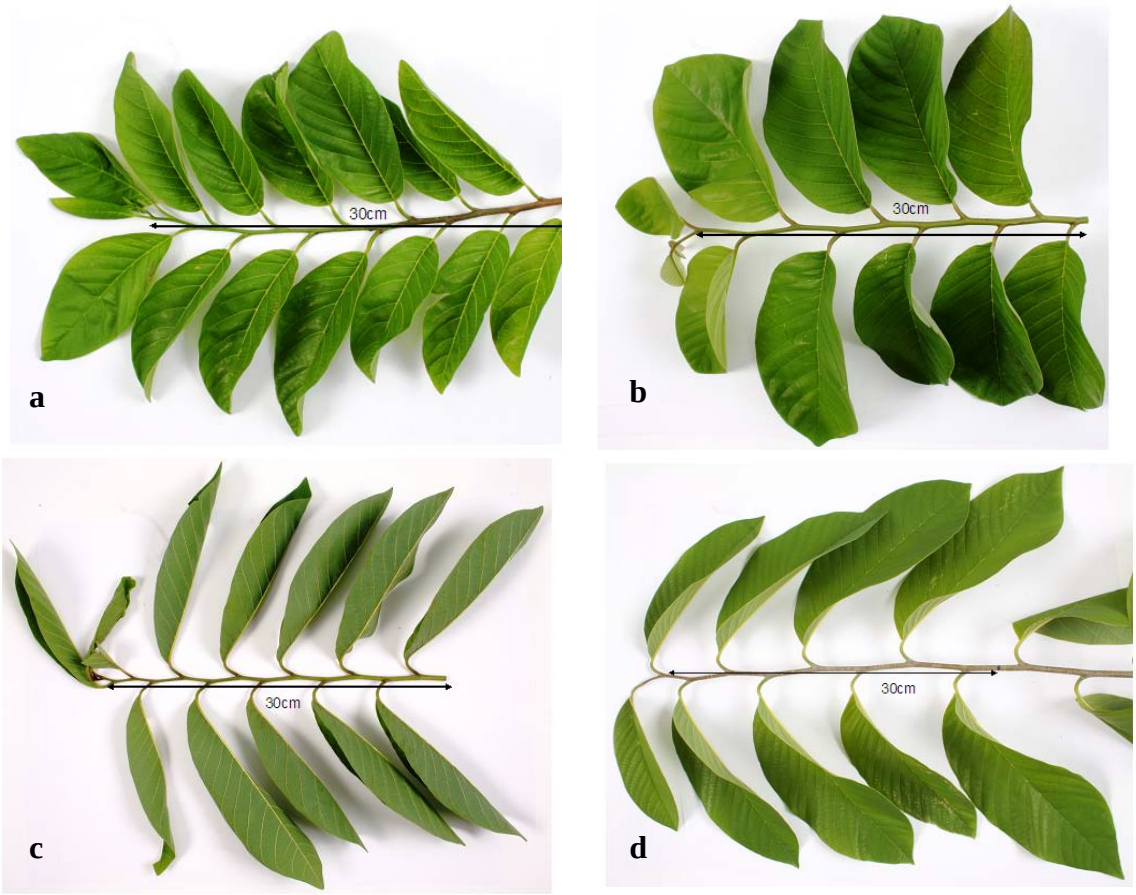

Plate 1. 30cm shoot samples of each rootstock showing differences in internode length (vigour) for 404 (a), Cherimoya (b), 550 (c) and APV2 (d).

RESULTS AND DISCUSSION

'KJ Pinks' grafted onto Taiwanese sugar apple produced the highest average yield per tree (74 fruit) and the lowest shoot extension (58.1cm) (Figure 1). Moderate vigour rootstocks 550 and APV2 produced better yields and lower vigour than Cherimoya rootstock. Cherimoya produced the most vigorous trees with an average shoot extension of 90.4cm, between 13 and 35 percent higher than other rootstocks. Cherimoya also produced the lowest yields with an average of 37 fruit per tree and around 50% less than the top performing 404 rootstock.

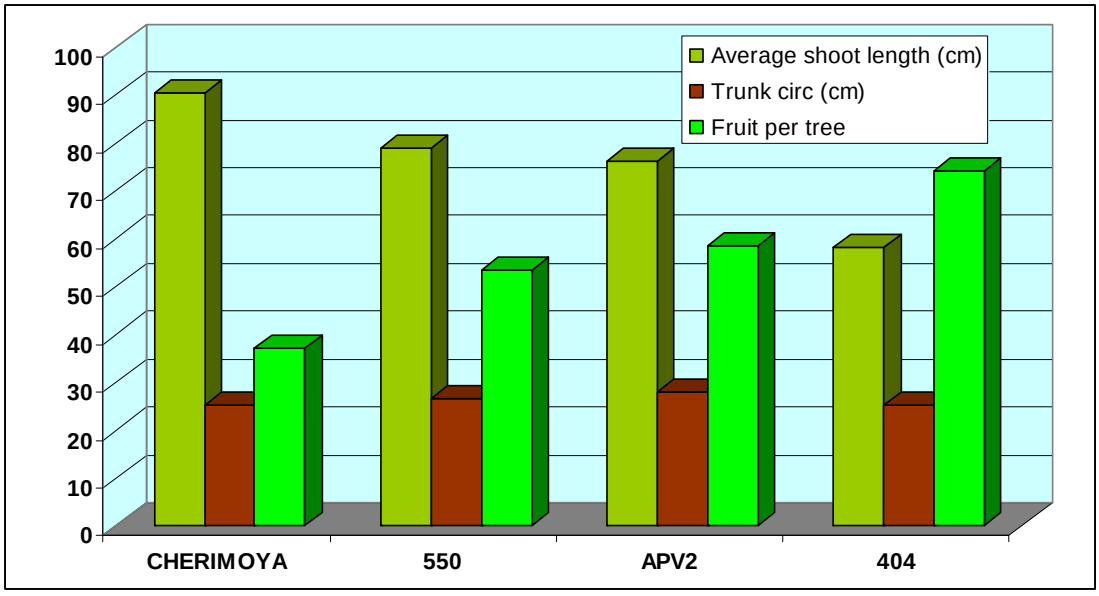

Figure 1. Differences in average shoot extension, trunk circumference and yield for KJ Pinks on various rootstocks.

Large variations in tree vigour within the same seedling rootstocks were observed (Plate 2). Within the six replicates of each rootstock selection (five for 404), low, moderate and high vigour trees were evident. This can be attributed to the selection process used to select rootstocks. While trying to select for moderate vigour, seedlings with high and low vigour characteristics can be inadvertently selected due to the large genetic variation in seedling populations. This further highlights the need for clonal rootstocks.

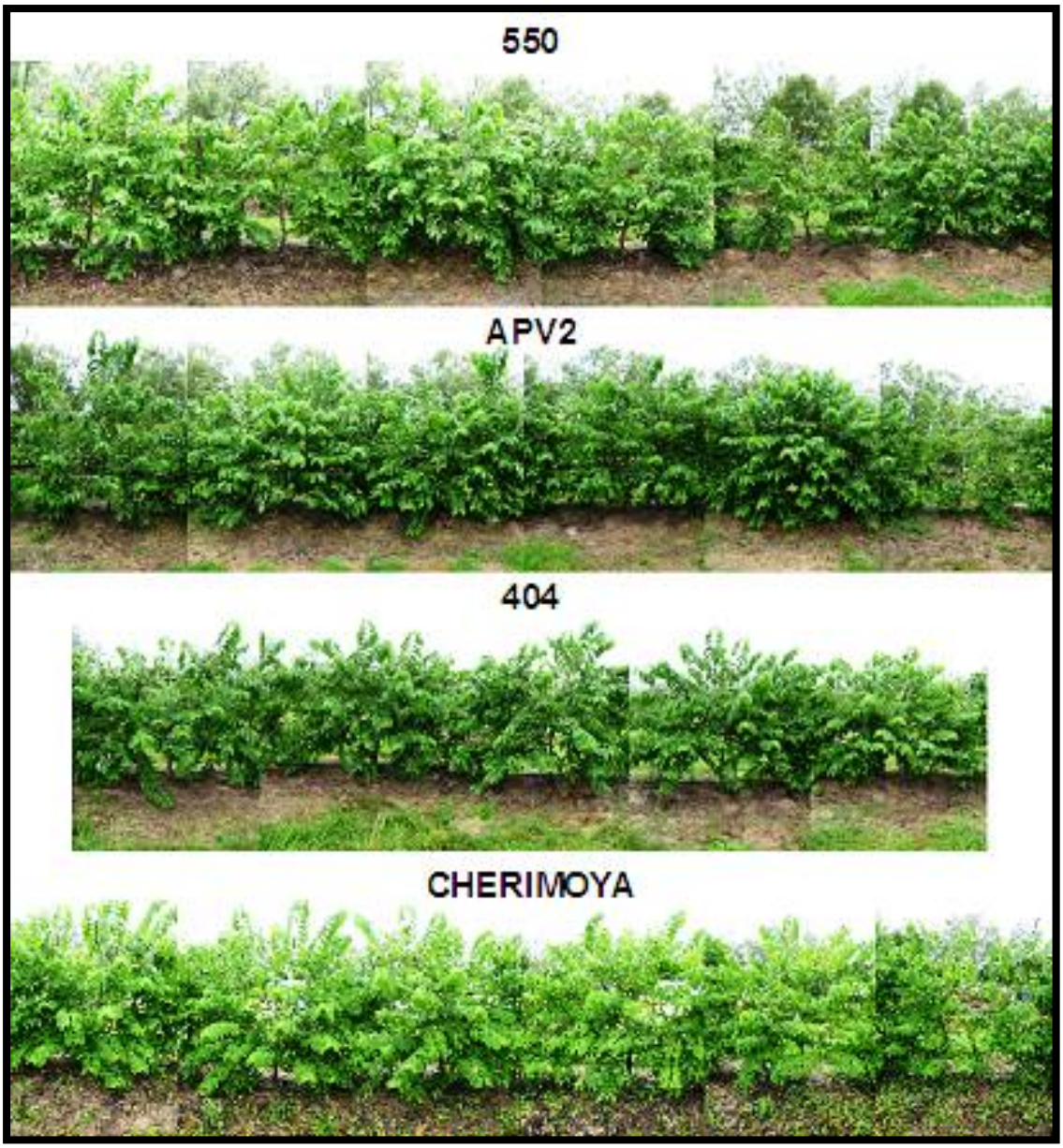

Plate 2. 'KJ Pinks' on four different rootstocks.

Although 404 has not performed well in other regions such as SE Queensland and northern NSW it appears that it may be suited to warmer tropical areas. Selections 550 and APV2 also performed well in this orchard and produced higher yields than the industry standard rootstock Cherimoya. While variability is still evident in all seedling rootstocks within this trial, the best performing trees will be selected and rootstocks will be recovered for inclusion in the clonal propagation trial.

DEVELOPMENT OF CLONAL PROPAGATION METHODS FOR CUSTARD APPLE

INTRODUCTION

Several years of testing at Nambour showed that propagating custard apple by cuttings is difficult with very low strike percentages and problems with root rot diseases.

A new method of propagation developed by Yuruga nursery in north Queensland using juvenile plant material and a sterilised system has delivered promising results. Mother-stock plants incorporating a mix of eleven elite rootstock and cultivar selections were supplied to Yuruga nursery in 2011. Research to date shows a high degree of 'clonality' between the eleven different selections, with cherimoya (*Annona cherimola*) being the standout.

The original mother-stocks supplied to Yuruga Nursery were grafted plants and consequently the initial material available for propagation was relatively mature. Mature material is often more difficult to strike roots than juvenile material. Hence, a key part of Yuruga's clonal research programme is to increase juvenile stock by propagating 'cuttings from cuttings' over successive generations.

There are three factors limiting this clonal research programme:

1. The long cycle for cuttings to strike (8-12 weeks compared with 4-6 weeks for many other crops)
2. The propagation is limited to spring, summer and late autumn
3. The maturity of original mother-stock material

While there is little that can be done about the first two factors, steady progress is being made on the third. Since a substantial bank of juvenile stock has been established both strike rate and the multiplication rate have improved.

Clonally propagated trees do not generate tap roots, since the tap root forms immediately after seed germination. However, this does not mean that a clonal root system is inferior to a seedling. A good clonal root system is strong since the roots originate from multiple points at the base of the stem, providing stable anchorage points (Plate 1).

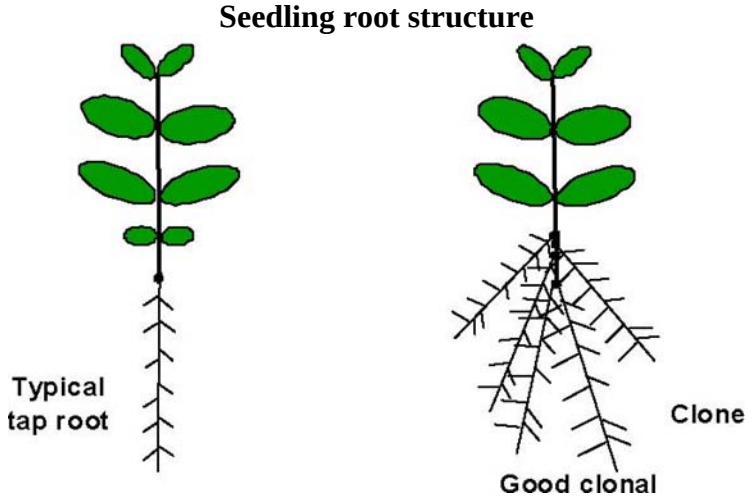

Plate 1. Clonal root system (*right*) compared to seedling root system (*left*).

MATERIALS AND METHODS

A range of varieties and species (eleven in total) was sent to Yuruga Nursery in late 2011. Yuruga Nursery has propagated up this material using their highly specialised technique.

A key part of Yuruga's clonal research programme was to increase the juvenility of the custard apple mother-stock material by taking 'cuttings from cuttings' over successive generations, an approach which has resulted in increased propagation ability of most clones.

Significant progress has been made in increasing the juvenility of mother-stock and a second-generation mother-stock bank has been established from cuttings produced from the original grafted mother-stock (Plate 2).

Assessment

A propagation index determined by strike rate, mother-stock yield and strike time can be used to determine the viability of a cultivar. For instance if a particular clone exhibits a strike rate (i.e. rooting rate) of 90%, the mother-stock yields consistently around five cuttings/plant/month, and the average length of time the cuttings take to strike roots is six weeks, then this most likely equates to a commercially viable clone.

On the other hand, if another clone achieves a strike rate of only about 30%, the mother-stock yields only one cutting/plant/month on average, and the cuttings take three months to strike roots, then this clone would most likely be considered non-commercial.

Plate 2. Second generation mother-stock bank

In custard apple there is no difference in the strike time between the different clones. Hence, the propagation index is determined by strike rate and mother-stock yield.

RESULTS AND DISCUSSION

Excellent progress has been made during this trial with some rootstock and cultivar selections showing promising signs of becoming commercially viable.

Cherimoya (*Annona cherimola*) has been the stand out for the majority of the trial with most recent cuttings (generation 3) achieving a strike rate of 99% (Plate 3). One elite selection from the breeding program (MRS 464-1) has performed well with a strike rate of 80%. Moderate vigour rootstock selections have achieved around 50% strike rate.

Three rounds of cuttings from second-generation mother-stock have now been conducted and based on the limited data, quite a deal of improvement is already evident.

TABLE 1.

The propagation ability of different custard apple clones

DAFF ID	Yuruga ID	Strike Rate	Yield (No. cuttings per mother-stock plant)	Propagation Index (Strike rate x yield)	Propagation Ability Ranking
Cherimoya	Y01	63%	219	137	1
Custard apple selections and varieties					
464-1	Y11	38%	150	57	2
450-1	Y08	26%	140	36	3
430-1	Y07	31%	101	31	4
283-1	Y06	34%	75	25	5
522-1	Y09	47%	45	21	6
453-1	Y10	26%	72	19	7
12-1	Y04	45%	40	18	8
Maroochy Gold	Y02	22%	46	10	9
15-32	Y05	19%	28	5	10
MRF-1	Y03	4%	32	1	11

*Consolidated data all cuttings – generations 1, 2 and 3. Shaded rows represent rootstocks.

It may be feasible to clonally propagate some varieties without grafting onto rootstock provided they can grow satisfactorily on their own roots, without being susceptible to root rot diseases.

Ideally, the cloned tree (on own roots or cloned rootstock) should have moderate vigour. This is because excessive vigour reduces yield and fruit quality. On the other hand, if the tree is too dwarfed it may not have enough resources to fill the fruit. This may be the case with high yielding varieties such as 'KJ Pinks'. Trees with moderate vigour will also be more suitable for high density plantings.

Field trials commencing in 2015 will evaluate high yielding varieties on clonal rootstocks and varieties growing on their own roots (non-grafted). Through the use of clonally propagated material, we predict that these trees will show significant improvements in tree uniformity and productivity. Poorly performing clones have continued their reluctance to strike roots with three selections exhibiting less than 25% strike rate over two generations of cuttings, showing a large variability between different clones.

Unfortunately for clones with low yields and/or low strike rates, the limited amount of material available to work with continues to limit research into improving the propagation ability of these clones. Hence for these clones it is still too early to know whether poor propagation ability is an inherent genetic trait of the clone itself, or whether it can be improved with increased juvenility of the mother-stock.

Decisions on the commercial viability of each clone will be made at the end of the current propagation cycle in May 2014. Once viable clones have been identified and multiplied, a series of field trials will be established to test these rootstocks and varieties in different growing regions. Based on results to date, cherimoya clonal rootstock looks to be a definite possibility for the custard apple industry in the years to come.

Plate 3. Cherimoya (*A. cherimola*) clone with excellent root development.

EVALUATION OF FUNDICIDES AND INSECTICIDES FOR THE CONTROL OF MAJOR PESTS AND DISEASES OF CUSTARD APPLE

INTRODUCTION

REVIEW OF PESTS AND THEIR CONTROL IN CUSTARD APPLES

Growers of horticultural crops frequently suffer from a lack of legal access to crop protection products (pesticides and fungicides). The problem is that whilst their crops, such as custard apples are valuable, they are considered too small individually for agchem manufacturers to bear the high cost of registering pesticides for use on them (Dal Santo, 2008). It is also a problem in larger crops, where a problem may only be localised or spasmodic.

Growers are increasingly trapped in a situation where they face severe losses from diseases, pests and weeds if they do nothing to protect their crops, or face penalties if they use a product that is not registered or available via a permit. The custard apple industry is very aware of the possible consequences that can occur from the use of unregistered or non-permitted pesticides (Dal Santo, 2008).

These can include;

- Produce with unauthorised pesticide residues
- Rejection of produce from local markets
- Temporary exclusion from market access
- Rejection of produce from export markets
- Jeopardising of export trading arrangements
- Fines and penalties

From a pesticide access perspective, the Australian Pesticides and Veterinary Medicines Authority (APVMA) include custard apples as a member of the 'assorted tropical and sub-tropical fruit (inedible peel)' category and are classified as a minor crop.

STRATEGIC AGRICHEMICAL REVIEW PROCESSES (SARP)

As a consequence of the issues facing the custard apple industry regarding pesticide access, a Strategic Agrichemical Review Process (SARP) was conducted in 2008 (DAL Santo, 2008) in conjunction with the Custard Apples Australia Inc. (CAA). A subsequent review was conducted in July 2013.

As a result of the SARP review processes, CAA has prioritised the major pests and diseases affecting custard apple (Table 1 and 2) and identified gaps where acceptable pesticides were not legally available. In addition, it determined new and alternative pesticide control options using:

- Critical selection criteria for potential alternatives and/or new pesticide

- Domestic and overseas information and resources that provide options and assist decision making
- Manufacturer support

The list of pesticide solutions for each identified gap will have the benefit of:

- IPM compatibility, wherever possible
- Improved scope for resistance management
- Sound biological profile
- Residue and trade acceptance domestically and for export

The results of the review process have provided the custard apple industry with sound pesticide options for the future that the industry can pursue for registration with the manufacturer, or minor-use permits with APVMA.

PRIORITY DISEASES

The major diseases and their order of priority are provided in Table 1 below.

The three most important fruit diseases were:

- Anthracnose or Pepper Spot, *Colletotrichum gloeosporioides*
- Pseudocercospora spot, *Pseudocercospora spp.*
- Purple blotch, *Phytophthora capsicii*

TABLE 1

*Diseases of custard apple**

Common name	**Scientific name**	**Major plant organ affected**
High priority		
Cercospora leaf & fruit spot and Pseudocercospora fruit (Masasso) spot	*Pseudocercospora sp. Pseudocercospora annonicola*	fruit and leaf
Purple blotch or Phytophthora fruit rot	*Phytophthora palmivora and P. capsicii*	fruit, twig and leaf
Anthracnose or Pepper spot	*Colletotrichum gloeosporioides*	fruit
Moderate priority		
Black canker	*Phomopsis spp.*	fruit
Cylindrocladium spot	*Cylindrocladium spp.*	fruit and leaf
Low priority		
Diplodia fruit rot	*Lasiodiplodia sp.*	fruit and twigs
Bacterial wilt	*Psuedomonas solanacearum*	roots, trunk and tree
Armillaria root rot	*Armallaria luteobubalina*	roots and trunk
Pink disease	*Corticum salmonicolor*	twigs and branches

Common name	Scientific name	Major plant organ affected
Root rots	*Phytophthora cinamomi*	roots
	Pythium spp.	seedling roots
	Rhizoctonia solani	seedling roots
	Scleroium rolfsii	seedling roots
	Fusarium solani	seedling roots

* Lists provided in reports by Dal Santo, 2008, 2013; Sanewski, 1991; Persley, 1993.

PRIORITY PESTS

The major insect pests are presented in Table 2.

The four most important pests are:

- Banana-spotting bug, *Amblypelta lutescens*
- Mealybugs, *Pseudococcidae spp.*
- Queensland fruit fly, *Bactrocera tryoni*
- Ants, *Formicidae spp*.

TABLE 2.
*Insect pests of custard apples**

Common name	Scientific name
High priority	
Ants	*Formicidae spp.*
Banana spotting bug	*Amblypelta lutescens*
Fruit flies	*Tephritidae spp*
Fruits potting bug	*Amblypelta nitida*
Leafroller moths	*Tortricidae spp.*
Mealybugs	*Pseudococcidae spp.*
Mediterranean fruit fly	*Ceratitis capitata*
Queensland fruit fly	*Bactrocera tryoni*
Scale insects	*Coccidae, Diaspididae, Eriococcidae*
Yellow peach moth	*Conogethes punctiferalis*
Moderate priority	
Blue triangle	*Graphium sarpedon ssp choredon*
Birds	*various*
Caterpillars	*Lepidoptera spp.*
Elephant weevil	*Orthorhinus cylindrirostris*
Fruit piercing moth	*Eudocima salaminia*
Low priority	
Flower eating caterpillars	*Lepidoptera spp.*
Long soft scale	*Coccus longulus*
Loopers	*Lepidoptera spp.*

Common name	Scientific name
Painted vine moth	*Agarista agricola*
Two-spotted (Red spider) mite	*Tetranychus urticae*
Lantania scale	*Hemiberlesia lataniae*

* Lists provided in reports by Dal Santo, 2008, 2013; Sanewski, 1991; Persley, 1993

MINOR USE PERMITS FOR NEW AND EXISTING CHEMICALS

During the duration of this project, the management committee of CAA and DAFF officers have been highly successful in maintaining and obtaining minor use permits for current and a range of new chemicals.

The project sought to obtain and maintain minor use permits for a range of fungicides and pesticides based on successful efficacy testing and meeting complying residue data standards.

These products included:

- copper hydroxide and oxichloride
- prochloraz
- fipronil
- pyraclostrobin
- uniconazole

Purple blotch caused by *Phytophthora capsicii* has become a major disease problem in northern NSW. Currently phosphorus acid is registered for control of this disease. Trials for testing Metalaxyl-M (Ridomil®) were inconclusive due to weather events. Ridomil will be tested for efficacy in the next phase of the project to assist an application for a minor use permit.

Prochloraz (Octave®) can be a more effective fungicide against anthracnose than either of the two currently used fungicides, mancozeb or copper oxychloride. Octave currently has a minor use permit for controlling anthracnose in custard apple after testing confirmed there was no flesh tainting as a result of spraying at early fruit set.

Citrus mealybugs are a major problem in custard apples in south-east Queensland. Currently there are three insecticides available for their control; Supracide® (methidathion), Applaud® (buprofezin) and Confidor ® (imidicloprid). The use of Samurai (clothianidin) as a soil drench has been trialled and a permit application for this use will be lodged in 2014. The industry will also seek a minor use permit for Transform® (Sulfoxaflor). The minor use permit for Fipronil for controlling ants has recently been renewed.

Due to safety concerns, the APVMA has phased out the sale and use of endosulfan, the main insecticide that was used to control fruit spotting bug, a serious pest of custard apple. Insecticides such as beta-cyfluthrin (Bulldock ®) and trichlorofon (Lepidex®), currently have minor use permits for the control of fruit spotting bug in custard apple (Table 1)

MATERIALS AND METHODS

Efficacy and residue testing was conducted for a range of pesticides (see Appendix for testing details) to obtain or maintain minor use permits from APVMA. DAFF officers coordinated on farm trials for residue and efficacy testing and performed the role of principle investigators for field trial and sampling reports.

Due to possibility of flesh tainting with Octave® (prochloraz), sensory analyses trials were also conducted in two growing regions.

RESULTS AND DISCUSSION

After successful efficacy testing and meeting complying residue data standards (see Appendix), minor use permits were issued by APVMA for a range of insecticides, fungicides and growth regulators (Table 1).

The current IPDM manual was also updated with the latest recommendations.

TABLE 1.

Current list of insecticides, fungicides and growth regulators issued with minor use permits by APVMA which can be used on custard apple. Rows shaded green indicate permnits requiring efficacy and/or residue testing.

Permit no.	Chemical	Commercial product name	Purpose	Status of permit	Period for which permit is valid	
Insecticides						
PER 14227	etoxazote	Paramite®	control spotted mite	Current	1 June 2014-	30 June 2016
PER 14743	trichlorfon	Lepidex®	various insect pests	Current	11 Apr 2012	31 May 2014
PER 13027	beta-cyfluthrin	Bulldock® 25EC	spotting bug and various insect pests	Current	12 Jun 2012	30 Sept 2015
PER 11970	imidacloprid	Confidor®	mealybug	Current	12 Jun 2012	30 Jun 2015
PER 14911	fipronil	Regent®	control of ants	Current	28 Mar 2014	30 Jun 2019
Fungicides						
PER 13807	phosphorous acid	Phospot®, Agri-Fos 600®	Control of *Phytophthora spp.*	Current	7 Nov 2012	30 Sept 2017
PER 13952	pyraclostrobin	Cabrio	Control of Pseudocercospora leaf spot	Current	31 May 2013	30 June 2018

Permit no.	Chemical	Commercial product name	Purpose	Status of permit	Period for which permit is valid	
PER 11943	copper and mancozeb	Copper oxychloride	Control of anthracnose	Current	28 May 2012	30 June 2022
PER 11944	prochloraz	Octave®	Control of anthracnose	Current	28 Jun 2013	31 Aug 2016
Plant growth regulators						
PER 13951	uniconazole	Sunny®	control plant growth	Current	28 Jun 2013	30 Jun 2018

CHEMICAL CONTROL OPTIONS FOR CONTROL OF MAJOR PESTS AND DISEASE IN CUSTARD APPLE

INTRODUCTION

The major pests and diseases identified by industry as causing most economical damage to orchards were fruit spotting bugs, mealybug, fruit fly, pseudocercospora, anthracnose and purple blotch. Pests and diseases have been outlined below and include a description of the symptoms, casual organism, history, occurrence and distribution and chemical control.

PSEUDOCERCOSPORA SPOT

Symptoms

Early symptoms consist of a diffuse spot which appear as indentations on the fruit surface (Plate 1). Spots are small (ranging in size up to 15 mm) and dark purple to grey. Spots often coalesce to form large disfigured areas. Large necrotic spots are commonly seen as the disease progresses. In advanced cases, superficial cracks appear in the skin, and the hardened skin prevents normal fruit development.

Plate 1. Left: Pseudocercospora spot mild symptoms. Right: Advanced symptoms.

Causal organism

Pseudocercospora annonicola. This disease organism in custard apple was first reported in Taiwan. It is a different *Pseudocercospora* species that causes husk spot in macadamia.

History

Pseudocercospora fruit spot in custard apples was first recognised in Queensland custard apples in 1987 on the Atherton Tableland, by Mr Ron Peterson, formerly a DPI plant pathologist. He tentatively named it 'Masasso spot' in honour of Mr Joe Masasso, the grower who first brought the disease to the attention of DPI Plant Pathology staff. It was causing up to 35% loss of marketable fruit.

The fungus *Asteromella* spp. was consistently isolated from the spots and identified by John Alcorn. Subsequent work by Roger Shivas furthered the identification of the causal organism of Masasso spot to *Pseudocercospora annonicola* Goh & Hsieh (BRIP 18564a and BRIP 18566a).

The disease has subsequently been identified in south-east Queensland and northern New South Wales by Don Hutton and Roger Broadley, both DAFF officers.

Occurrence and distribution

Pseudocercospora is major problem especially in wet seasons in all production regions. There appears to be a varietal difference in the susceptibility to the disease with cv. African Pride showing greater susceptibility than either cvs. KJ Pinks or Pink's Mammoth.

Chemical control

In previous trials field trials, mancozeb was shown to be effective but not as effective as Cabrio® (pyraclostrobin) under higher disease pressure. In 2010, Cabrio ® received a minor use permit for use on custard apple and after successful permit renewal can be used until 30th June 2018.
We recommend regular protective spray program using mancozeb and Cabrio® with frequency determined by prevailing weather conditions.

ANTHRACNOSE

Symptoms

The symptoms are seen in fruit as dark brown to black spots on the unripened fruit, not unlike black canker. A second symptom caused by the same fungus has pepper spot specks on the surface of the fruit (Plate 2). These pepper spots coalesce on badly affected fruit. Leaf symptoms are also seen occasionally (Plate 3).

Pepper spot is also seen in avocados and lychees. Pepper spots are discrete with well defined margins compared with the diffuse spot seen in *Pseudocercospora.* Pepper spot in avocado has been shown to be associated with a stress factor that limits the disease to pepper spots rather than the quite large rotted spots characteristic of the disease in avocados.

Plate 2. Top: Advanced anthracnose caused by *Colletotrichum gloeosporioides*. Bottom: Pepper spot caused by *Colletotrichum gloeosporioides*.

Plate 3. Leaf symptoms of anthracnose more commonly seen on cherimoya.

Causal organism

Colletotrichum gloeosporioides. Colletotrichum spp. attacks a wide range of fruit, including avocado, mango, banana, passionfruit, fig and papaw.

History

Anthracnose disease has become more significant over the past 5 years (George and Redpath, 2009). This fungal disease has been recognised in Queensland since the mid 1950's. It could become an ongoing major disease problem.

Occurrence and distribution

In avocados, 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. It is likely that the fungus behaves similarly in custard apples. Wet conditions increase severity of the disease. There are a number of factors which probably contribute to anthracnose in custard apple:

- 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.
- In NSW, there is 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 occur where custard apple 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.

Chemical control

Octave (prochloraz) can be applied at flowering and early fruit set before disease pressure builds and is not permitted for use in the later fruit development stages. Spray every two-three weeks with fungicides such as mancozeb, Cabrio® or Biopest®. It is best to rotate each of these fungicides in turn to prevent build-up of resistance. Control with these protectants largely depends on the level of coverage achieved. These sprays also control Pseudocercospora, a major problem in cv. African Pride.

PURPLE BLOTCH

Symptoms

On small fruit, small purple spots quickly grow to cover the entire fruit surface (Plate 4). On larger fruit, the spots or blotches usually reach 2 cm in diameter before being noticed. The spots quickly expand to 5 cm wide. They have a distinct margin and sometimes a halo around the initial spot. The fruit may be covered by white fungal growth, which develops under moist conditions. Affected fruit drop readily. Internal discolouration is extensive and may affect all of the flesh. More mature diseased fruit do not become hard as they do with black canker or Diplodia rot. When it occurs on individual farms, it is a very severe problem. A small spot on a harvested fruit quickly spreads to the whole fruit, and if packed can affect the whole tray.

Causal organism

Purple blotch is caused by the soil-borne fungus *Phytophthora capsicii*.

History

Purple blotch was previously though to be caused by *Phytophthora palmivora*. New molecular technology demonstrated that it was caused by *Phytophthora capsicii*.

Occurrence and distribution

According to Brad Keen, soil microbiologist, NSW DPI, during dry periods *Phytophthora capsicii* will become mostly inactive and survive in a dormant state as oospores or chlamydospores. These structures are very resilient and can survive in the soil, typically protected within organic matter particles for lengthy periods. Oospores in particular have a very thick wall and are very resilient to desiccation and attack from soil microorganisms and survive in the soil for possibly five years or more. When soil moisture and temperatures are favourable these spores will germinate to produce zoosporangia which in turn release zoospores. These zoospores have tails that enables them to swim. They have the ability to recognise electro-chemical signals which means they can swim in a purposeful direction towards the targeted host and towards the soil surface. Under heavy rainfall conditions, the zoospores splash from the ground onto the leaves, braches and fruit up to one metre, or slightly more, above the ground. The zoospores germinate within 24 hours and start producing infective propagules once they arrive at a suitable host. When you have wind-blown rain the spores become airborne in the water droplets which can include the very fine droplets of windblown spray. It has been found even in the tops of large trees. Once *Phytophthora capsicii* is in the soil it is there indefinitely. This disease is usually more of a problem on farms with heavy wet soils and is more prevalent after periods of continuous wet weather.

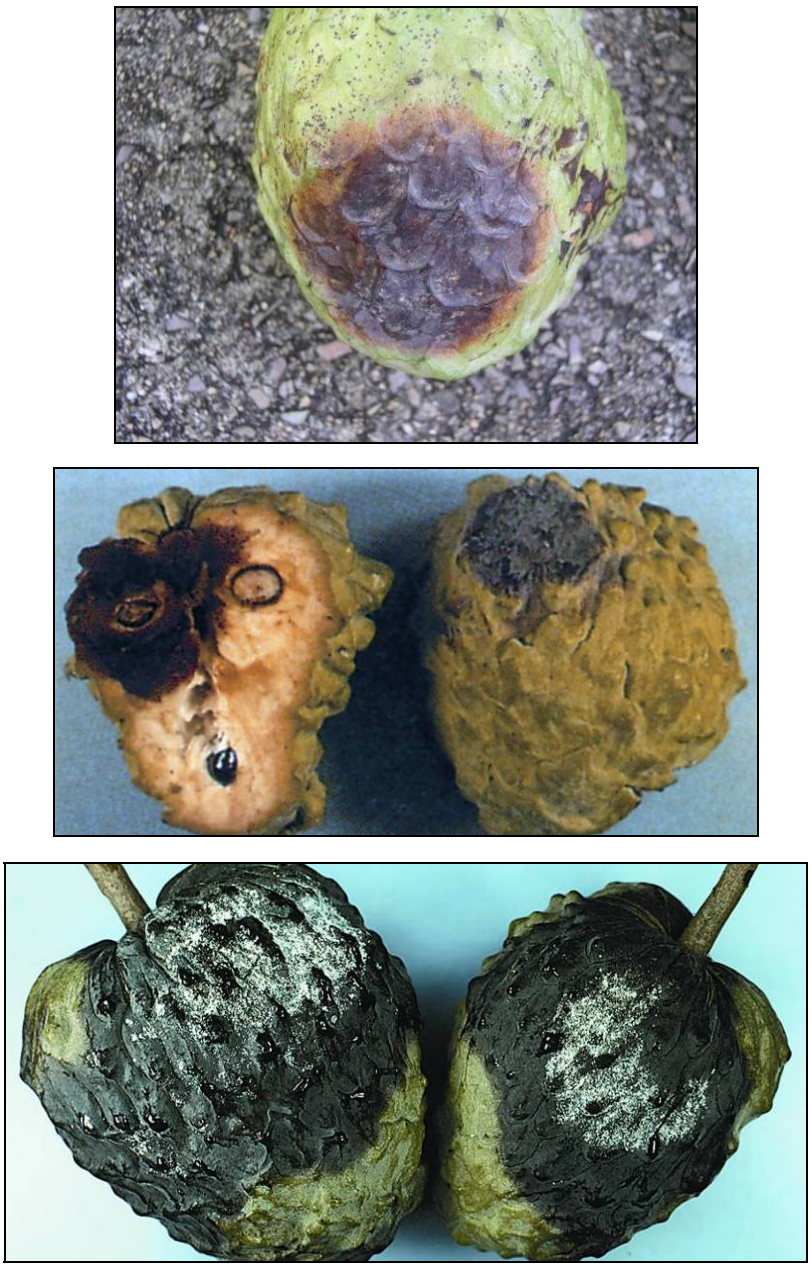

Plate 4. Top: Purple blotch caused by *Phytophthora capsicii*- early symptom. Middle: moderate symptoms. Bottom: severe symptoms.

Chemical control

Mancozeb and copper sprays should be used for control. Fungicide sprays of mancozeb should be started at fruit set. Phosphonate and Metalaxyl-M (Ridomil® and Ridomil Gold®) are highly effective against Purple Blotch but these fungicides are not currently registered for use on custard apple. Ridomil Gold® will probably be more effective than straight Ridomil® because it provides both the protective properties of copper hydroxide and the curative and systemic properties of Metalaxyl-M. Ridomil will be tested in the next phase of this project due to trials being severely affected weather events.

FRUIT SPOTTING BUGS

Damage

While feeding, fruit spotting bugs secrete an enzyme which causes extensive breakdown of cells. Damage is small, round black spots (2 to 10 mm in diameter) on the shoulders of young fruit (Plate 5). Damage penetrates about 1 cm into the fruit. Small twigs and shoots can also be damaged (Plate 6). Adults and nymphs pierce fruit repeatedly and young fruit usually drop off within 5-10 days. Older fruit may not drop off but fruit quality is impaired and diseases, such as anthracnose, and infestation by fruit fly, are more likely. Spotting bug damage can be confused with the diseases Diplodia rot, Cylindrocladium spot and Black Canker.

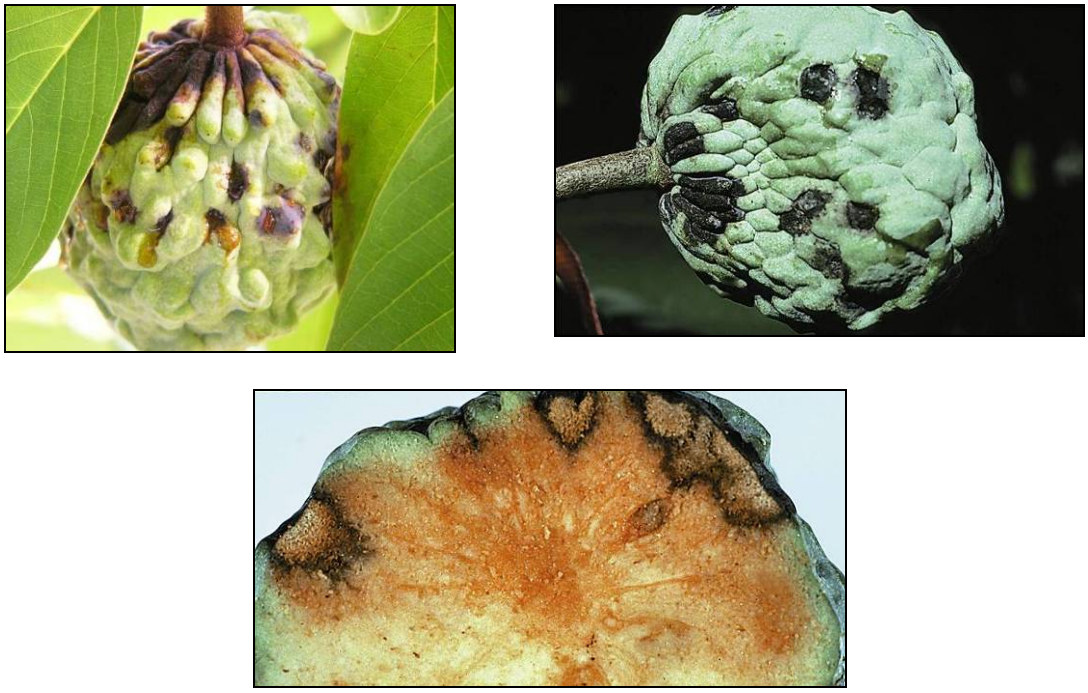

Plate 5. Top: Small, black, round spots on young fruit. Most damage is on the shoulders of the fruit. Bottom: Damage penetrates about 1 cm into the fruit.

Plate 6. Fruit spotting bugs also causes spots on twigs and death of terminal shoots.

Species and description

Banana spotting bug (*Amblypelta lutescens lutescens*) (Plate 7 and 8) and the fruit spotting bug (*Amblypelta nitida*)**.** Adult bugs are yellow/green and about 15 mm long. They can be difficult to find because, when disturbed, they either fly away or quickly hide. Females lay only a few eggs per day, but more than 100 in their lifetime. The eggs are pale green, oval-shaped and about 2 mm long. They are laid singly on fruit or leaves and hatch in 6-7 days in summer. There are five immature stages (nymphs) (Plate 7) before the adult is formed. The nymphs are ant-like, pink to red/brown, with prominent antennae and button-like scent glands on the upper side of the abdomen. The scent glands are most prominent in the banana spotting bug.

Plate 7. Left: A banana spotting bug egg on lychee. Right: Early instar banana spotting bug nymph.

Plate 8. Left: close-up of a late instar nymph of banana spotting bug. Right: adult banana spotting bug.

Importance and distribution

Both the banana spotting bug (*Amblypelta lutescens lutescens*) and the fruit spotting bug (*Amblypelta nitida*) are problems in south-east Queensland and northern NSW but the banana spotting bug is the only pest in north Queensland.

Fruit spotting bugs are capable of causing considerable damage, and the damage can often be insidious when damaged fruit is difficult to see at the tops of trees; and it accumulates quickly if you don't intervene with a spray.

The bugs are very mobile so in addition, if you do manage to stop a particular cohort of bugs in its tracks by spraying, the species' migration behaviour ensures that more bugs continuously move into the orchard for as long as the fruit remains susceptible.

One fruit spotting bug can damage over fifty pieces of fruit per tree. Unlike mealy bug/sooty mould damage that may be cleaned off, fruit spotting bug damage makes the fruit unmarketable. Adults and nymphs pierce fruit repeatedly and young fruit usually drop off within 5-10 days. Nymphs do not travel far from their feeding site (they can't fly) and damage is consequently often concentrated in individual trees or parts of trees. Adult damage can appear rapidly over a larger area.

Fruit spotting bugs seem to have become a more severe problem in all susceptible fruit crops over the last 20 years. The reason for this is not known, but increasing urbanisation and its modification of the vegetation spectrum may have created better breeding opportunities for the bugs. The *Annona* species, *Annona cherimola* (cherimoya), seems to be much more attractive to the bugs than are Annona species hybrids. Within the hyybrids 'African Pride' appears to be more attractive than 'KJ Pinks '. Orchards in close proximity to mango orchards are usually severely affected due to spotting bugs accumulating in the densely foliaged mango trees.

Chemical control

Endosulfan was the insecticide most commonly used for control of fruit spotting bug (*Amblypelta* spp.) in tropical and subtropical tree fruit crops. In October 2010, the APVMA cancelled the approval and product registrations of endosulfan.
.Currently there are three insecticides that can be used for controlling fruit spotting bug in custard apple; methidathion (e.g. Supracide®), beta-cyfluthrin (Bulldock®) and trichlofon (Lepidex®) (suppression only). Suparcide and Bulldock provide adequate control of the pests but tends to disrupt natural enemies and induce outbreaks of other pests such as two-spotted mite. Two or more sprays of Supracide or Bulldock should be made prior to the release of the predators. In warmer areas e.g. Mareeba, spraying will have to commence earlier (September) compared with cooler regions e.g. Alstonville (December). Under high pressure situations, sprays may need to be applied every two weeks for several months.

MEALYBUGS

Damage

Mealybug infestation occurs in fruit crevices (Plate 9). The black patches of sooty mould grow on the honeydew secreted by the mealybugs. In some cases, mealybugs may cover the entire fruit surface. The coastal brown ant (*Pheidole megacephala*) tends the mealybugs for their honeydew. They move the mealybugs around and fend off their natural enemies. The black house ant (*Iridomyrex glaber*) acts similarly. Fruit touching the ground is often covered with tunnels of dirt from ant activity.

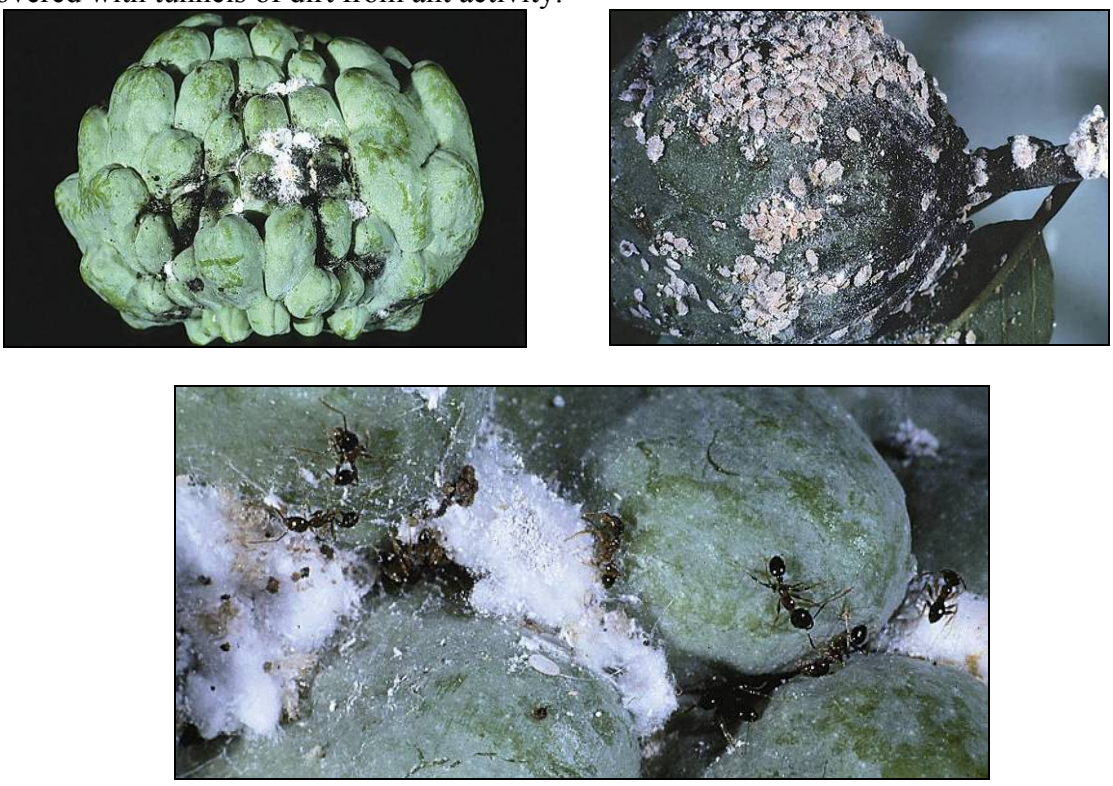

Plate 9. Top: Typical appearance of mealybug in fruit crevices. Bottom: coastal brown ant tends the mealybug for honeydew.

Species and description

Citrus mealybug **(Planococcus citri).** Adult female citrus mealy bugs are white, about 3 mm long, and covered by a white mealy wax. There are 18 pairs of short waxy filaments around the margin of the body. These are shorter at the head end, and lengthen progressively towards the rear end. The last pair is one quarter the length of the body. They have yellow body fluid observable if the insect is crushed. The males are short-lived insects. They are similar to the males of armoured scales, with one pair of fragile wings and non-functional mouth parts. They have two long filaments at the rear end.

Importance and distribution

Citrus mealybug occurs throughout Australia but is much more common in coastal districts and in the areas north of Sydney in the eastern states (Figure 1). 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 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.

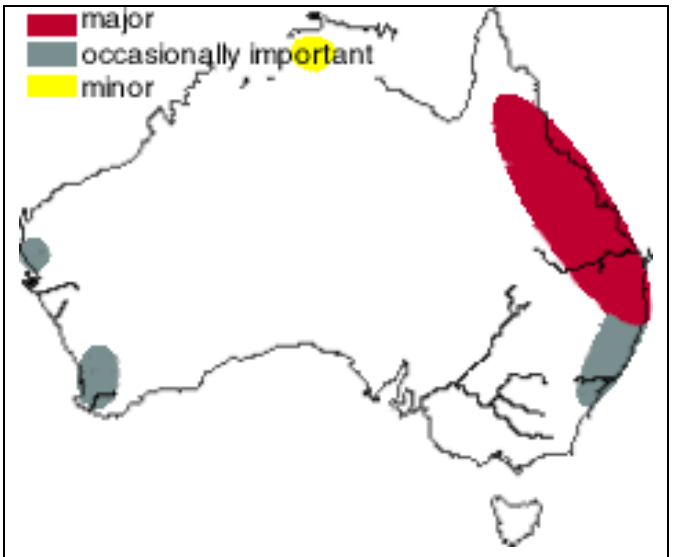

Figure 1. Distribution of citrus mealybug in Australia.

Chemical control

Methidathion is the most commonly used insecticide to control mealybugs in custard apple orchards. Scheduled insecticide spraying of methidathion may fail to give adequate control due to poor coverage in densely foliaged trees. On older trees mealybugs can hide in the bark crevices and also where fruit touch leaves. It may be necessary to spray inside the tree by hand-wand to be effective but this is time consuming, tedious and dangerous for the operator. Timing of methidathion application may need to be adjusted depending on whether beneficials are released. Growers must decide whether to spray or not to spray with

methidathion in December to 'knock' the mealybug population down but still allow enough spray interval before releasing the predators.
The insecticide Applaud® has recently been registered for use in custard apple. Applaud® is a safer option than methidathion for the predators. However, there are a few issues associated with its use that requires careful consideration. Applaud® is an insect growth regulator. The active ingredient, buprofezin (440 grams per litre), interferes with normal growth and development by mimicking the naturally occurring juvenile hormone of insects, levels of which normally fall prior to the moults between stages.
Applaud®, because it only kills juvenile insects when they moult, is best applied when crawlers and young juvenile stages of the target pest are abundant, before too many adults are present as these will not be killed. The effects may take up to two weeks to become apparent, unlike knockdown insecticides, which kill pests very quickly. Applaud is not effective if it is applied when there are mixtures of crawlers and adults.
The systemic insecticide Confidor® (imidacloprid) has a minor use permit for control of mealybug in custard apple as a foliar spray. It works slowly on the nervous systems of insects and directly influences insect behaviour, resulting in an "anti-feeding" effect. Confidor® has been used in custard apple orchards with varying levels of success. Its systemic activity is desirable as it is difficult to treat mealybug on the underside of leaves and inside bunches of fruit with contact kill sprays. Confidor exploits the feeding behaviour of mealybug by being mobile in the sap.

Chemical control of ants

If ants can be properly managed, populations of scales and mealy bug can be reduced by 80%. Ants move pests around on the trees, but more importantly prevent natural parasites and predators from controlling pests. Removing ants allow the parasites and predators to do their job. Control ants in December and, if necessary, again later in the season by spraying the lower trunk and the soil within a 0.5 m radius with firpronil ant control spray

QUEENSLAND FRUIT FLY

Damage

It is virtually impossible to detect symptoms of fruit fly in unripe fruit. In near-ripe fruit, fruit soften around the egg-laying sites, sometimes with associated yellowing and exudate. Egg laying is most common around the stalk end of the fruit particularly in varieties such as African Pride and Palethorpe.

Species and description

Bactrocera tryoni. The adult fruit fly is wasp-like, with an 8 mm long body that is red-brown with yellow marks (Plate 10). The white eggs are 1 mm long and banana-shaped. They are laid in batches of about a dozen just beneath the skin, particularly around the stem of the fruit. The larvae grow into white maggots 7 mm long. These later leave the fruit and pupate in the soil.

Plate 10. Top: Queensland Fruit Fly. Bottom left: Larvae (maggots) of the fly in the tissue of the fruit. Bottom right: pupa found in the soil.

Importance and distribution

There are about 100 species of fruit fly in Australia but only a couple are economic pests of eastern Australia (Mediterranean fruit fly is present in West Australia) (Bull, 2009). Our main one is the Queensland Fruit Fly, *Bactrocera tryoni* and it occurs with a smaller population of the Lesser Queensland Fruit Fly (*B. neohumeralis*) which looks very similar but is darker in colour and lacks the distinctive yellow shoulder spot of the former. They are equally destructive to fruit.

Queensland Fruit Fly mainly infests fruit maturing from March to May. The fly's larvae feed inside the fruit, causing breakdown and rendering it inedible. Some interstate and export markets have strict quarantine restrictions on the presence of this pest in fruit. One infested fruit can result in the whole consignment being rejected.
Distribution of Queensland fruit fly in Australia is presented in Figure 2.

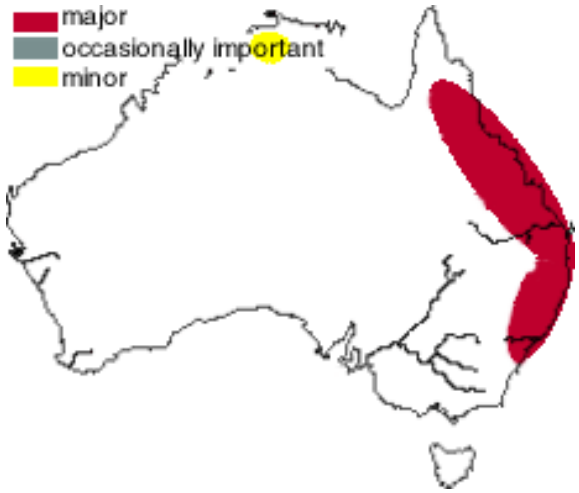

Figure 2. Importance and distribution of Queensland Fruit Fly in Australia.

Chemical control

Most growers will manage fruit fly using bait sprays. An alternative treatment to bait sprays is cover sprays of insecticide; however, this is not as desirable, as it is harmful to the natural enemies of other pests. However, we recommend that covers sprays of an insecticide should be applied if more than 30 fruit flies are caught in cue lure traps. Two broad spectrum insecticides are normally used to control fruit fly. These are:

- fenthion (Lebaycid®)
- trichlorfon (Lepidex® or Dipterex®)

EVALUATION OF POSSIBLE FLESH TAINTING IN CUSTARD APPLE DUE TO OCTAVE® (PROCHLORAZ)

INTRODUCTION

Studies have shown that prochloraz can cause flesh tainting of some fruit crops such as lychee and avocado. Trials were established in Alstonville, NSW and Glasshouse Mountains, QLD to evaluate if Octave® (prochloraz) caused flesh tainting in custard apples (cv. KJ Pinks) when applied three times during flowering and early fruit set. Fruit from treated and untreated (control) trees were collected at time of harvest and used for taint testing using the triangle test method.

MATERIALS AND METHODS

Trial design and data analyses

Triangle testing for flesh tainting is a discriminative form of sensory analysis which indicates if a detectable difference exists between the two samples. In the triangle test the assessor was presented with three coded samples, two of which were the same (controls) and one which was treated with the test chemical.

The survey sheet that accompanied samples is shown in Plate 1. Tests were carried out in the morning prior to morning tea using 36 assessors for each trial. Assessors were asked to make a guess if they couldn't identify any difference between samples. Comments were encouraged to describe differences between samples. Fruit from Glasshouse Mountains was tested on the 2 April 2012 and Alstonville 18 June 2012.

The objective of this test was to determine if the flavour of custard apples treated with Octave® (prochloraz) was different (tainted) when compared to the untreated control.

Spray application

Four tree plots were sprayed in each trial with Octave® (prochloraz 462g a.i/kg) at a rate of 100g/100L. Trees were spayed until just before runoff three times throughout flowering and early fruit set on the following dates:

- Glasshouse Mountains- 16/11/2011, 14/12/2011 and 12/01/2012
- Alstonville- 20/12/2011, 11/01/2012 and 15/02/2012

Four tree plots were used as untreated controls and were separated by six rows of buffer trees to avoid any cross contamination of samples.

Fruit sampling, storage and preparation

Twelve fruit were randomly collected from each plot of four treated- and untreated-trees, 77 and 118 days after last spay application, for Glasshouse Mountains and Alstonville, respectively. Fruit was then delivered via road transport (non-refrigerated) to the Maroochy Research Facility and held at ambient temperature in the postharvest laboratory until ripe.

Samples were prepared in the postharvest laboratory out of sight of the assessors, combining flesh from twelve fruit to create a composite sample for each treatment. Approximately 25g of flesh, at ambient temperature, was placed in each coded sample cup and each cup was presented in an identical manner in the order outlined in Table 1. Assessors were employees of the Department of Agriculture, Fisheries and Forestry and were used no more than once for each trial.

RESULTS AND DISCUSSION

Numbers of correct responses from the 36 assessors were counted and significance was determined by reference to the statistical table for triangular taste test (Table 2).

A total of 16 and 17 judges correctly identified the odd sample from Glasshouse Mountains and Alstonville, respectively. Of the correct responses, four were identified as guesses in both trials (Table 3 and 4).

In Table 2, the row corresponding to n=36 judges and column corresponding to p=0.05 requires 18 correct responses to sufficiently conclude there is a significant difference between samples.

Our results prove that treating custard apples with Octave® during flowering and early fruit development does not significantly influence sensory quality of the fruit.

Triangle Taste Test for Custard Apples

You have been presented with three samples of custard apple coded:

Two of the samples are identical and one is different.

Please assess each sample *in the order presented* and
circle the **sample that is different**.
(cleanse your palate with water between samples)

If you cannot identify a difference **you must make a guess**.

Was your selection a guess (please circle)? **Yes / No**

Please describe the difference (if any)…..

_____
_____
_____
_____

Your name:_____

Thankyou

Plate 1. Data sheet used for triangle taste testing of custard apple samples.

TABLE 1.

Sample order used for triangle testing for flesh tainting in custard apple treated with Octave®.

Glasshouse Mountains	Alstonville
658- OCTAVE	**965**– OCTAVE
964- OCTAVE	**501**- OCTAVE
422- CONTROL - NO OCTAVE	**147**- CONTROL - NO OCTAVE
173- CONTROL- NO OCTAVE	**299**- CONTROL- NO OCTAVE
Tester #1 sample order- 422, 658, 173	Tester #1 sample order- 147, 965, 299
Tester #2 sample order- 422, 658, 964	Tester #2 sample order- 147, 965, 501
Tester #3 sample order- 422, 173, 964	Tester #3 sample order- 147, 299, 501
Tester #4 sample order- 658, 173, 964	Tester #4 sample order- 965, 299, 501
Tester #5 sample order- 658, 173, 422	Tester #5 sample order- 965, 299, 147
Tester #6 sample order- 964, 658, 173	Tester #6 sample order- 501, 965, 299
Tester #7 sample order- 173, 964,422	Tester #7 sample order- 299, 501, 147
Tester #8 sample order- 173, 964, 658	Tester #8 sample order- 299, 501, 965
Tester #9 sample order- 173, 422, 658	Tester #9 sample order- 299, 147, 965
Tester #10 sample order- 964, 422, 658	Tester #10 sample order- 501, 147, 965
Tester #11 sample order- 964, 422, 173	Tester #11 sample order- 501, 147, 299
Tester #12 sample order- 658, 964, 422	Tester #12 sample order- 965, 501, 147
Tester #13 sample order- 422, 658, 173	Tester #13 sample order- 147, 965, 299
Tester #14 sample order- 422, 658, 964	Tester #14 sample order- 147, 965, 501
Tester #16 sample order- 422, 173, 964	Tester #16 sample order- 147, 299, 501
Tester #16 sample order- 658, 173, 964	Tester #16 sample order- 965, 299, 501
Tester #17 sample order- 658, 173, 422	Tester #17 sample order- 965, 299, 147
Tester #18 sample order- 964, 658, 173	Tester #18 sample order- 501, 965, 299
Tester #19 sample order- 173, 964,422	Tester #19 sample order- 299, 501, 147
Tester #20 sample order- 173, 964, 658	Tester #20 sample order- 299, 501, 965
Tester #21 sample order- 173, 422, 658	Tester #21 sample order- 299, 147, 965
Tester #22 sample order- 964, 422, 658	Tester #22 sample order- 501, 147, 965
Tester #23 sample order- 964, 422, 173	Tester #23 sample order- 501, 147, 299
Tester #24 sample order- 658, 964, 422	Tester #24 sample order- 965, 501, 147
Tester #25 sample order- 422, 658, 173	Tester #25 sample order- 147, 965, 299
Tester #26 sample order- 422, 658, 964	Tester #26 sample order- 147, 965, 501
Tester #27 sample order- 422, 173, 964	Tester #27 sample order- 147, 299, 501
Tester #28 sample order- 658, 173, 964	Tester #28 sample order- 965, 299, 501
Tester #29 sample order- 658, 173, 422	Tester #29 sample order- 965, 299, 147
Tester #30 sample order- 964, 658, 173	Tester #30 sample order- 501, 965, 299
Tester #31 sample order- 173, 964,422	Tester #31 sample order- 299, 501, 147
Tester #32 sample order- 173, 964, 658	Tester #32 sample order- 299, 501, 965
Tester #33 sample order- 173, 422, 658	Tester #33 sample order- 299, 147, 965
Tester #34 sample order- 964, 422, 658	Tester #34 sample order- 501, 147, 965
Tester #35 sample order- 964, 422, 173	Tester #35 sample order- 501, 147, 299
Tester #36 sample order- 658, 964, 422	Tester #36 sample order- 965, 501, 147

TABLE 2.

Significance tables for triangular taste test.

Number of Judges	Number of Correct Choices to Determine Significance at Confidence Level		
	5%	**1%**	**0.10%**
6	5	6	
7	5	6	7
8	6	7	8
9	6	7	8
10	7	8	9
11	7	8	9
12	8	9	10
13	8	9	10
14	9	10	11
15	9	10	12
16	10	11	12
17	10	11	13
18	10	12	13
19	11	12	14
20	11	13	14
21	12	13	15
22	12	14	15
23	13	14	16
24	13	14	16
25	13	15	17
26	14	15	17
27	14	16	18
28	15	16	18
29	15	17	19
30	16	17	19
31	16	18	19
32	16	18	20
33	17	19	20
34	17	19	21
35	18	19	21
36	18	20	22
37	18	20	22
38	19	21	23
39	19	21	23
40	20	22	24
41	20	22	24
42	21	22	25
43	21	23	25
44	21	23	25
45	22	24	26
46	22	24	26
47	23	25	27
48	23	25	27
49	23	25	28
50	24	26	28

TABLE 3.

Summary of results from triangle taste tests for custard apple fruit treated with Octave® at Glasshouse Mountains, Qld. Cells highlighted in yellow indicate odd sample.

Tester No.	Sample order given			Sample chosen	Guess Y/N	Correct	Incorrect	Comments
Tester 1	422	658	173	173	N		1	Sweeter aftertaste
Tester 2	422	658	964	658	Y		1	Perhaps slightly less sweet
Tester 3	422	173	964	964	N	1		422 and 173 were quite nice and sweet. 964 almost had an off flavour
Tester 4	658	173	964	964	Y		1	The fisrt two samples are sweeter than the last one.
Tester 5	658	173	422	422	Y		1	Not any noticeable difference to me. All were pleasantly sweet.
Tester 6	964	658	173	964	N		1	658 and 173 were much sweeter than 964 and had a smoother texture.
Tester 7	173	964	422	173	N		1	173 was slightly sweeter than 964 and 422. 173 texture was less grainy than other 2.
Tester 8	173	964	658	964	N		1	964 more bland- 658 and 173 more flavour and tang.
Tester 9	173	422	658	658	N	1		658 was mushier and browner and may have been slightly overripe
Tester 10	964	422	658	422	N	1		964 and 658 were sweeter. 422 had a little bit of tang.
Tester 11	964	422	173	964	N	1		964 slightly more firm, grainy and slightly less sweet.
Tester 12	658	964	422	964	N		1	The other two were slightly more acid.
Tester 13	422	658	173	422	Y		1	
Tester 14	422	658	964	422	N	1		422 tasted better than 658 and 964. So I assume 658 and 964 are similar.
Tester 15	422	173	964	964	N	1		422 AND 173 sweeter, more tangy stronger flavour than 964. I prefer 964
Tester 16	658	173	964	658	N		1	173 and 964 are sweeter than 658.
Tester 17	658	173	422	173	N		1	173 had slightly less flavour. 658 and 422 tasted like pinks mammoth type.

Tester No.	Sample order given			Sample chosen	Guess Y/N	Correct	Incorrect	Comments
Tester 18	964	658	173	173	N	1		Mushier, gritty, stronger flavour
Tester 19	173	964	422	422	N		1	Much better flavour and texture.
Tester 20	173	964	658	173	N	1		964 and 658 were blander than 173. 173 had a fruity taste
Tester 21	173	422	658	658	N	1		658 not as sweet but more flesh and less seed.
Tester 22	964	422	658	422	Y	1		
Tester 23	964	422	173	173	N		1	Slightly more tart.
Tester 24	658	964	422	964	N		1	658 and 422 were sweeter than 964. 964 was definitely more bland. 422 was the sweetest.
Tester 25	422	658	173	658	N	1		I thought sample 658 was slightly sweeter in flavour. Also 658 was not as firm as 422 and 173
Tester 26	422	658	964	964	N		1	422 and 658 were sweet. 964 was more bland and not as sweet.
Tester 27	422	173	964	964	N	1		Didn't taste as sweet or as strong as the other two.
Tester 28	658	173	964	964	N		1	964 not as sweet and more floury texture.
Tester 29	658	173	422	173	N		1	173 is less sweet and less flavour than 422 and 658
Tester 30	964	658	173	658	N		1	Samples 964 and 173 tasted similar so I think they are the same. 658 perhaps not as sweet or slightly different flavour.
Tester 31	173	964	422	964	Y	1		
Tester 32	173	964	658	658	N		1	Not as sweet.
Tester 33	173	422	658	422	N		1	Initially there was a strange taste, did get blurred after trying all 3 samples and different pieces. More of a chemical taste than a custard apple.
Tester 34	964	422	658	422	Y	1		
Tester 35	964	422	173	964	N	1		2nd two tasted sweeter
Tester 36	658	964	422	422	Y	1		Same
						Correct	**Incorrect**	
					Total	**16**	**20**	

TABLE 4

Summary of results from triangle taste test for custard apple fruit treated with Octave® at Alstonville, NSW. Cells highlighted in yellow indicate odd sample.

Tester No.	Sample order given			Sample chosen	Guess Y/N	Correct	Incorrect	Comments
Tester 1	147	965	299	147	N		1	A bit gritty (they have come on the same fruit?). 965 and 299 same but one is a bit bland and another got a bit different taste.
Tester 2	147	965	501	501	N		1	501 has an agreeable aftertaste that lingers on the palate
Tester 3	147	299	501	501	Y	1		Really difficult to tell if different. I think 501 is slightly less acid than the others. i.e tangy.
Tester 4	965	299	501	299	N	1		965 and 501 were nice
Tester 5	965	299	147	299	N		1	965 and to a lesser extent 147 "oily"taste.
Tester 6	501	965	299	299	N	1		Blander flavour, not as tart as the first two. Also more watery texture.
Tester 7	299	501	147	501	Y	1		
Tester 8	299	501	965	501	N		1	Not as much flavour (gritty)
Tester 9	299	147	965	299	Y		1	
Tester 10	501	147	965	147	Y	1		
Tester 11	501	147	299	147	N		1	147 tasted sweeter and more firm than 501 or 299
Tester 12	965	501	147	147	N	1		Sweeter
Tester 13	147	965	299	965	N	1		965 seemed to have a slightly different flavour, perhaps less desirable than the other two.
Tester 14	147	965	501	965	N		1	Flatter flavour and diff texture
Tester 15	147	299	501	147	N		1	Not as much flavour
Tester 16	965	299	501	299	N	1		No. 299 had poor flavour and odour
Tester 17	965	299	147	965	N	1		Samples 299 and 147 are over riper and have off flavour.
Tester 18	501	965	299	299	N	1		Bland in comparison to 501 and 965
Tester 19	299	501	147	147	N		1	Slightly sweeter and more intense flavour
Tester 20	299	501	965	299	N	1		Texture different to 501 and 965. 501 and 965 also tasted sweeter, not by much. But there were still a difference in taste in my opinion. Aftertaste in 965
Tester 21	299	147	965	965	Y	1		965 nicer flavour
Tester 22	501	147	965	965	N		1	Different flavour
Tester 23	501	147	299	147	N		1	Very grainy texture, very little flavour.
Tester 24	965	501	14	501	N		1	501 tasted sweeter,

Tester No.	Sample order given			Sample chosen	Guess Y/N	Correct	Incorrect	Comments
			7					texture a bit more "creamy".
Tester 25	147	965	299	147	N		1	147 bland/less sweet.
Tester 26	147	965	501	147	N	1		147 is slightly more acid
Tester 27	147	299	501	147	Y		1	They all tasted the same to me. I thought there was actually more difference in taste and texture within the samples than between the samples
Tester 28	965	299	501	299	N	1		More rounded flavour- more acid than the other two, which were sweeter
Tester 29	965	299	147	965	N	1		965=less sweet, less grainy
Tester 30	501	965	299	299	N	1		501 and 965 very pleasant. 299 had some additional flavours. Not as sweet and perhaps some after taste.
Tester 31	299	501	147	299	N		1	Very difficult to determine, not definite 299 less intense flavour than other two but all similar flavour profile. 501 slightly different colour (put this oxidation?)
Tester 32	299	501	965	501	N		1	Texture was different which confuses the matter.
Tester 33	299	147	965	147	Y		1	147 tasted sweeter
Tester 34	501	147	965	147	N	1		Sweeter-higher sugar
Tester 35	501	147	299	147	Y		1	Much sweeter, less tart
Tester 36	965	501	147	501	N		1	Not as sweet- not as full bodied? As the others. Slight difference in texture.
						Correct	**Incorrect**	
					Total	**17**	**19**	

THE EFFICACY OF SYSTEMIC INSECTICIDES FOR CONTROLLING MEALYBUG IN CUSTARD APPLE

INTRODUCTION

The custard apple industry relies on a limited number of contact chemical sprays for control of mealybug. Current insecticide registrations and permits for control of mealybug in fruit trees are listed below (source Infopest).

Buprofezin (e.g. Applaud) is registered for control of mealybug and scale in custard apple. Imidacloprid (e.g. Confidor) is permitted for control of citrus mealybug in custard apple (PER 11970). Methidathion (e.g. Supracide) is registered for control of a variety of pests, including mealybug, in custard apple. These current methods of chemical control depend greatly on good spray coverage in densely foliaged trees. Systemic insecticides allow suppression of phloem-feeing insects as the systemic activity directly exploits their feeding behaviour (Cloyd et al., 2012).

Insecticides in the neonicotinoid group (4A mode of action group) act on the nervous system. A number of insecticides in this group are approved for use in various tree crops in Australia (not including custard apple): clothianidin (e.g. Samuarai®, Sumitomo Chemical), thiacloprid (e.g. Calypso®, Bayer CropScience) and thiamethoxam (e.g. Actara®, Syngenta Crop Protection).

Neonicotinoids are systemic with a long residual activity, mainly against sucking insects but also some chewing species. Trials assessing neonicotinoid insecticides for efficacy against mealybugs in various crops have achieved mixed results, with efficacy at least partially dependent on application method.

Neonicotinoids can provide effective control of mealybug, particularly when soil-applied. However, the method and timing of application is critical to efficacy. A range of systemic insecticides were tested for efficacy in controlling populations of mealybug in custard apple.

MATERIALS AND METHODS

Trial 1

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

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

10 fruit from each data tree were randomly selected and inspected for mealybug at peak harvest time in mid-April 2013. Data was statistically analysed using ANOVA (Genstat 11.0).

Trial 2

The custard apple V-trellis trial block on Maroochy Research Facility (MRF) Nambour was used to trial different rates of soil applied Samurai on the variety "KJ Pinks". Treatments were applied in a randomised block design using six individual tree replicates of each treatment.

Samurai was diluted in 2L water and applied as a soil drench on 5th December 2013 at the following rates;

- 2.5g/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. 30 fruit from each data tree were randomly selected and inspected for mealybug at peak harvest time in mid-April 2014. Data was statistically analysed using ANOVA (Genstat 11.0).

RESULTS AND DISCUSSION

Trial 1

No significant differences were observed between treatments for average percentage of fruit with mealybug. Actara had the highest levels of infestations with 27.5% of fruit with mealybug which was similar to Movento with 25%. Confidor resulted in 17.5% of fruit with mealybug which along with Actara and Movento were worse than the control which had 12.5%. Transform had a similar response to the control with 10% of fruit having mealybug. Samurai gave the best result with 2.5% of fruit having mealybug.

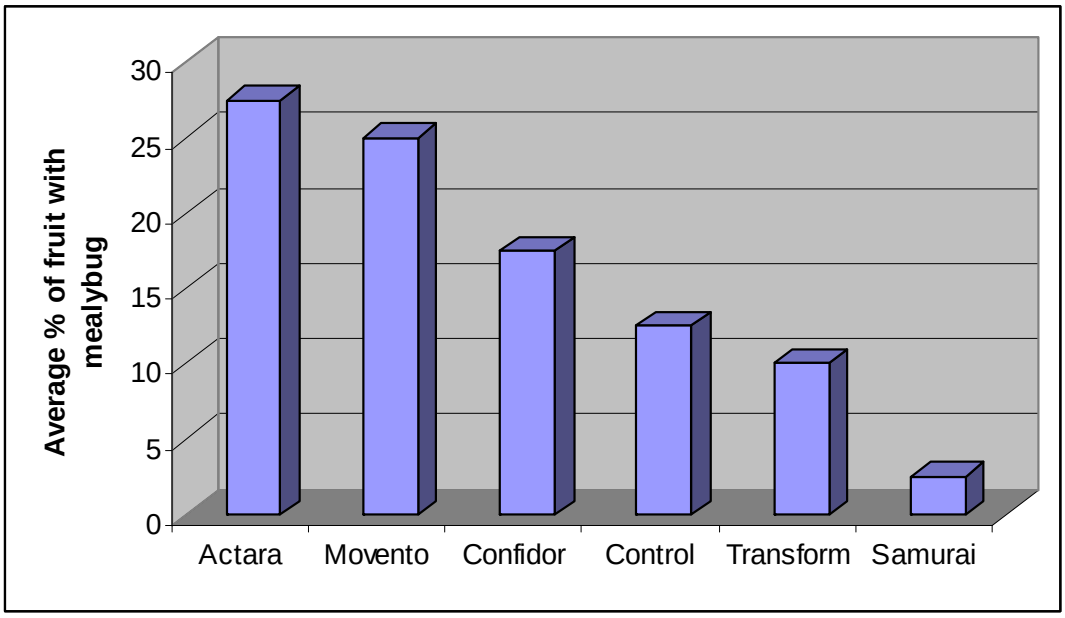

Figure 1. Differences between average percentage of fruit with mealybug infestations for various insecticide treatments (LSD-22.15).

Trial 2

No significant differences were observed between treatments. Fruit on control trees averaged 3.3% of fruit with mealybug compared to 1.93% for the 2.5g/tree treatment and 1.06% for the 5g/tree treatment. Mealybugs were generally in lower numbers in the season this trial was conducted.

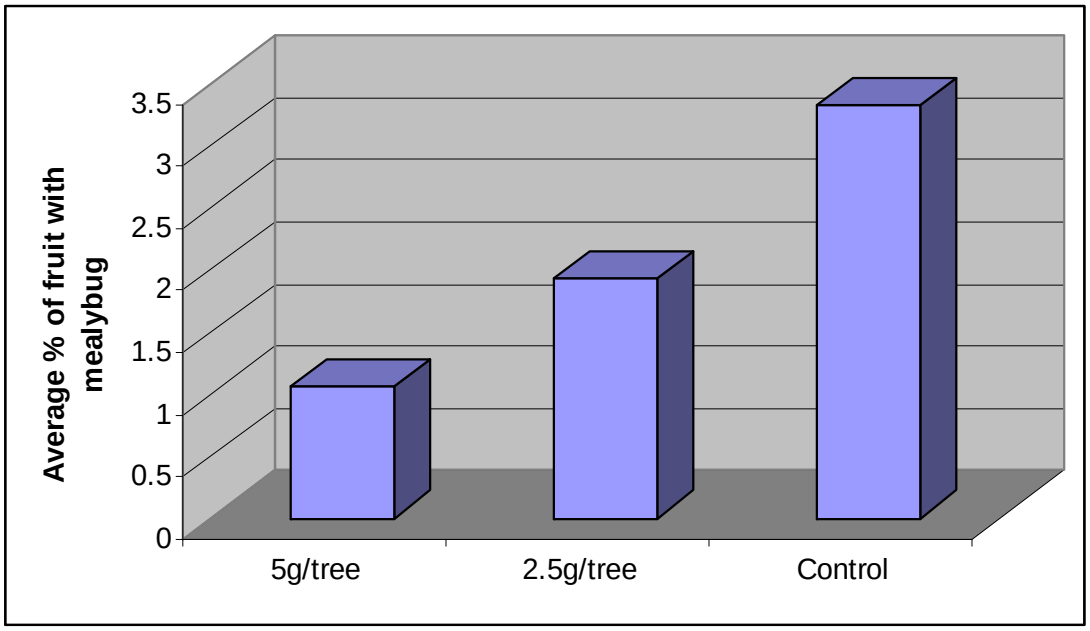

Figure 2. Difference between average percentage of fruit with mealybug infestations for various insecticide treatments (LSD-3.67).

Of the five systemic insecticides trialled Samurai gave the best control, and while the result was not statistically significant it proves that this chemical is effective in controlling mealybug populations in custard apple orchards. The higher concentration of 5g/tree was identified as the best treatment, again not significantly. Higher rates of Samurai may need to be tested on larger trees as custard apples are grown on a variety of tree training systems and tree size can vary considerably. Timing of application will also need to be investigated to allow the most effective use of this insecticide.

TRELLISING CUSTARD APPLES - A COMPARISON OF VERTICAL AND OPEN V TRELLISING SYSTEMS

INTRODUCTION

Trellising of custard apples has been trialled using different growing/training systems to increase productivity and fruit quality while reducing costs associated with harvesting and orchard management. This article will compare the vertical trellis and open V trellis and give an overview of the positives and negatives of each system.

Both the vertical trellis and open V trellis system have the potential to increase early yields because trees are planted at higher densities than conventional plantings and because these systems maximise light interception. The decision on which growing system to use can often be influenced by the level of management a grower is prepared to commit to pruning and tree training, the size and capability of farm machinery and the cost of establishment.

The capital outlay for materials and labour for the trellis structure may be as high as 30% of the total establishment costs. It is estimated that the establishment of the open V trellis may cost between $15 000 to $30 000 per hectare depending on trellis materials and if you erect the trellis yourself. The vertical trellis should cost considerably less because only half the numbers of end and intermediate posts are needed. The trellis should last 20 years with regular maintenance.

Besides the costs of establishing the trellis, there are additional costs of planting an extra 400 trees for vertical trellis systems and up to 800 trees per hectare for the open V trellis system (open V trellis, trees cost $25 each = $10000-20000 extra per hectare).

MATERIALS AND METHODS

We have recently surveyed eight farms which are currently testing either vertical or open V trellis systems. We have summarized the findings of our observations in this final report and we have also asked growers for their opinions on the positives and negatives of the different training systems.

Based on these surveys and experimental findings to date, we are close to setting the best parameters for the optimum design of both types of trellis (Table 1). Up to date details on trellis design, construction materials, erection and pruning are presented in the Custard Apple Pruning Manual which can be purchased from Custard Apples Australia Inc.

TABLE 1.
Trellis design features of the open V and vertical trellises. These specifications may be modified as more findings come to date.

Feature	Vertical trellis	Open V trellis
Trellis height	2.5-3.0 metres	2.5-3.0 metres
Angle of open V	Not applicable	30° to the vertical
Base separation of posts	Not applicable	80cm-1 metre
Height of bottom wire (above mound)	80cm	80cm
No. of wires	3 or 4	3 or 4
Distance between wires	50-70cm	50-70cm
Spacing of intermediate posts*	13-15 metres	13-15 metres
Depth of posts	1m	1m

KEY FINDINGS

High fruit set varieties such as 'KJ Pinks' are well suited to growing systems that incorporate high density plantings (Table 2). Due to the canopy area and tree size (height) being reduced on vertical and open V trellis systems it is essential that these high natural fruit setting types are used. At this stage 'KJ Pinks' is the only variety recommended for high density planting. However, all new selections from the DAFF breeding program will be suitable for trellising. Release of these new selections will hopefully coincide with new trellising systems moving to commercial status rather than being experimental.

TABLE 2.
Characteristics of the different training systems.

Training systems	Trees per hectare	Tree height range (m)	Trellised	Suitability for mechanical pruning	Variety suitability	Status
Vase (traditional)	100-150	6-8	No	No	All varieties	Commercial
Vase (low)	200-300	3-4	No	Yes	All varieties	Commercial
Hedgerow	400-500	2-3	No	Yes	High fruit set types only e.g. KJ Pinks	Commercial
Vertical trellis	600-800	2-3	Yes	Yes	High fruit set types e.g. KJ Pinks	Experimental
Open V trellis	700-1300	2-3	Yes	Yes	High fruit set types only e.g. KJ Pinks	Experimental

Row orientation and length

Rows should run in a north/south orientation as this provides the best sunlight interception to the canopy. Row lengths of 50 to 100m are common. Longer rows >100m may cause problems since this increases the tension to the end posts. These longer rows may also require additional strainers.

Time of trellising

Trellis can be put in before or after planting but young trees will be disturbed by digging and working around them when you choose to trellis them after planting. We therefore recommend that the trellis be established before planting.

Row spacing

Getting the trellis design right from the very start is very important for maximising yield, fruit quality and returns. Since returns are highly correlated with tree density per hectare, determining the appropriate spacing is very important. Based on limited experimental data, the range in spacing presented in Table 3 are a guide only.

TABLE 3.

Row spacing and tree densities for different training systems

Trellis spacing (based on limited experimental data) Training system	**Between row spacing (m)**	**Within row spacing (m)**	**Density (trees /hectare)***
Open vase	6.0-8.0	4.0-6.0	208-417
Vertical trellis	**3.5-5.0**	**3.0-4.0**	**500-952**
Open V trellis	**5.0-6.0**	**3.0-4.0**	**833-1332**

Theoretically row width should be at least 1.2 times the trellis height; otherwise the lower portion of the trellis will be shaded. However, in practice, spacing will be determined by each individual grower based on their equipment type, land availability, labour costs and pruning system.

Most growers are aiming to keep the height of their trellises down to reaching height so that they do not need to use ladders for picking. The first objective of training the open V trellis and vertical trellis systems (Plates 1 and 2) is to produce enough fruiting laterals to produce an economic crop.

Plate 1. The palmette trellising systems trained on a 4 wire vertical trellis. Trees are three-year-old**.**

Plate 2. The open V trellis systems trained on a 4 wire trellis. Trees are three-year-old.

We have calculated that the number of fruit produced per tree will depend on the number of fruiting laterals per tree, which in turn, is governed by the number of sub-leaders and fruiting laterals per sub-leader. The number of sub-leaders per tree is determined by the number of trellis wires, row spacing and pruning system. An example on how to calculate the cropping potential of the open V and vertical trellises to produce a potential yield target is presented in Table 4.

TABLE 4.

An example of how to determine the potential crop load per tree for a vertical trellis to give an economic yield. Yields on the open V trellis will be about 50% higher than the vertical trellis due to the higher planting densities.

No of wires per trellis	**Tree spacing* (m)**	**No of sub-leaders**	**Estimated no. of fruiting laterals per sub-leader****	**Estimated no. of fruit per tree**	**Estimated no of trees per hectare**	**Estimated no. of fruit per hectare**	**Estimated tonnes of fruit per hectare*****
3	3.0	6	10	60	666	39960	24.98
(2.2m high)	3.5	6	11	66	571	37686	22.61
	4.0	6	13	78	500	39000	23.40
4	3.0	8	10	80	666	53280	31.96
(2.9m high)	3.5	8	11	88	571	50248	30.15
	4.0	8	13	104	500	52000	31.20

**assumes an inter-row spacing of 5m; **assumes a spacing of 15cm between laterals*
****assumes an average fruit size of 600g.*

The second objective of tree training on the trellis is to keep the trellis height down to less than reaching height of about 2.5m. Harvesting costs escalate when growers have to use ladders or picking platforms. Given that the bottom wire is 80cm above ground level, the grower can calculate the final trellis height that he wants from the number of wires he intends to use and their spacing (e.g. 50 vs. 70cm).

The third objective is to maximise light transmission through the trellis so that least 20% of full sunlight reaches the fruiting sites. This can only be achieved by restricting the canopy depth to less than 1.2m and to prevent shading of adjacent rows by using the appropriate row spacings.

The vertical trellis and open V trellis growing systems have both achieved good production results. Table 5 gives an overview of some of the positives and negatives growers have experienced with each system.

TABLE 5.

Summary of grower experiences with trellising.

Trellis Type	Positives	Negatives
Vertical	□ Easier and less costly to plant/erect □ Easier to prune □ Easier to harvest □ Easier weed control	□ Less production per hectare □ Increase vigour due to upright growth □ Medium level of management required
Open V	□ More production per hectare □ Less vigorous due to angle of trunk. □ Stronger support in adverse weather (wind)	□ Difficult and costly to erect □ Need to harvest and prune down middle of rows □ Difficult for weed control □ High level of management required

The specifications for design of the trellis systems and the associated training, pruning and management protocols are a ‘work in progress’ and under constant review.

We currently recommend that farmers trial these systems on a limited scale or wait until further evaluations are completed before trialling them on a much larger scale.

EVALUATION OF REFLECTIVE MULCH

INTRODUCTION

Light penetration into the bottom canopy zone of custard apple trees trained on open V trellises may be limited. Custard apple fruit require reasonable light levels and temperatures to reach commercial maturation; these levels are often significantly reduced in the lower canopy.

We have also observed that custard apple fruit that mature in mid- to late-June are very susceptible to fruit splitting and russetting due to the drop in air temperatures below 12°C in June. These problems may be exacerbated on the open V trellis due to the greater exposure of fruit to low temperatures.

We trialled Extenday™ reflective mulch (Plate 1) which is a New Zealand product that increases light reflection, particularly in the lower canopy. Reflective mulch has been shown to increase fruit weight, size and yield in apples (Blanke, 2008; Grout *et al*., 2004), pear (Bertelsen, 2005), kiwifruit (Costa *et al*., 2003) and grapes (Coventry *et al*., 2005).

MATERIALS AND METHODS

Observational trials were conducted on three-year-old and seven-year-old trees 'KJ Pinks' trees trained on open V trellis at Maroochy Research Facility, Nambour, Queensland in 2011 and 2013, respectively.

Two mulch treatments were applied prior to bud break to single rows of 8-10 trees. Treatments were:

- Straw mulch (standard practice, control)
- Extenday™ reflective mulch applied in three strips, 1m wide, per mounded row (two outside strips beneath the sloping trellis and one strip down the open centre (see Plate 1).

Trees were harvested at the normal commercial stage of maturity. Shoot extension growth was recoded on six shoots on each of 8-10 datum trees. Fruit counts made on the bottom two wires were compared with those for the top two wires.

RESULTS AND DISCUSSION

Both observational trials showed that reflective mulch increased fruit set by at least 35% (Table 1). Our findings indicate that light may be limiting carbohydrate production during the flowering period which occurs concomitantly with shoot extension growth. Competition

between developing flowers/fruit and new seasons shoot growth may result in increased flower and fruit drop.

Despite the heavier crop load, reflective mulch has also increased average fruit weight by between 6-12%. The combination of increase fruit set and increased fruit weight has resulted in an overall increase in yield per tree of more than 40%.

TABLE 1.
Effects of reflective mulch on growth and yield of cv. KJ Pinks on open V trellis at Maroochy Research Facility. Data are the means of 8-10 trees.

Trial date	**Treatment**	**Growth and yield variables**			
		Shoot extension (cm)	Average fruit number per tree	Fruit weight per tree (kg)	Average fruit weight (g)
2011	Straw Mulch	29.9	48.3	20.5	424
(3-year-old trees)	Reflective mulch	27	71.8	34.1	475
	% change	-9.7	48.6	66.3	12
2013					
(7-year-old trees)	Straw Mulch	61.6	16.7	5.6	337
	Reflective mulch	70.6	22.8	8.2	358
	% change	14.6	36.5	46.4	6.2

Compared with straw mulch, reflective mulch appears to have increased the percentage of fruit set in the lower canopy (Figure 1) presumably due to better light transmission and interception.

Our findings indicate that reflective mulch may have a significant effect on yield through improved fruit set and fruit size. We suggest that light transmission into the tree canopy may be greatly enhanced when reflective mulch is combined with moderately vigorous trees trained on open V or palmette trellis systems.

Statistical trials should be conducted in a range of regions to validate these promising preliminary findings.

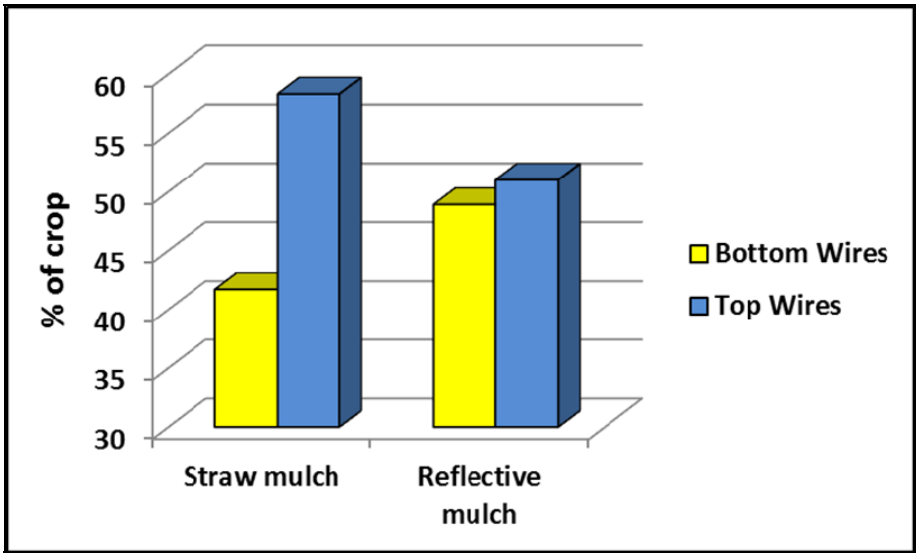

Figure 1. Effects of reflective mulch on crop distribution. Fruit counts for the top two wires were compared with those for the bottom two wires.

Plate 1. Top: Control, trees mulched with straw mulch. Bottom: Reflective mulch - three strips, 1m wide, placed under the outer and centre bands of the open V trellis.

EVALUATION OF POST-HARVEST ATTRIBUTES OF CUSTARD APPLES

INTRODUCTION

Custard apple is a climacteric fruit i.e. the fruit produces ethylene and exhibits a rapid respiratory climacteric rise during ripening. Due to its high respiration rate, custard apples have extremely limited postharvest shelf life making handling, storage and distribution difficult. Ripening is characterized by increased soluble solids, acidity and softening, and the acquisition of aroma and flavour. The mechanism by which this process is induced and controlled is not clear.

The major consideration in postharvest handling is slowing down of the quick ripening process. During postharvest handling and storage the main objective is to maintain a symmetrical, blemish-free and bright green external appearance and firm, bright white internal quality for as long as possible.

MATERIALS AND METHODS

A survey and structured interview of leading custard apple growers was conducted to determine the optimum harvesting and cool storage strategies. Key findings were published in *The Custard Apple*, Summer, 2013.

RESULTS AND DISCUSSION

Maturity (KJ Pinks, Hillary White, Pink's mammoth)

Commercial maturity is determined by creaming between the carpels. Fruit is considered mature when more than 40% of fruit surface exhibits creaming. Fruit harvested immature may fail to ripen properly, have poor eating quality and increased skin blackening when cold stored.

Harvesting and handling

Farmers should keep fruit out of the sun to avoid fruit heating up as this will reduce the potential storage life. To avoid blemish, farmers should handle fruit carefully when transferring into picking boxes. Clip stems to below the shoulders of the fruit to avoid puncturing other fruit. Padded picking box/trays and soft-tyred transport should be used when moving fruit between the field and packing shed. Skin will mark or abrade very easily and damage during harvesting will be exaggerated when cold stored.

Storage methods- refrigeration

Advantages

- Extends shelf life
- Allows fruit to reach market in good condition

Disadvantages

- Expense of operating a cool room
- Increased chance of chilling injury

Storage methods - ambient temperature

Advantages

- No chance of chilling injury

Disadvantages

- Can only access close markets
- Fruit must be sold within a few days
- Fruit quality may deteriorate rapidly

Field heat

Skin temperature in the field can reach 45ºC on hot days. Fruit is cooled by evaporation from the skin and core temperature is usually lowered. After picking, core temperature of warm fruit (field heated) can quickly reach damaging levels. Farmers should avoid leaving fruit in close-stacked boxes.

Custard apples heat up naturally after harvest through respiration which is more pronounced than in any other common fruit. The longer core temperature remains at high levels the more rapidly fruit loses shelf life (Table 1).

TABLE 1.

Relationship between core temperature and days to soft.

Fruit core temperature (°C)	Days between harvest (hard green) and eating soft
35	1.5 - 3 days
30	2 - 5 days
25	2 - 6 days
20	3 - 7 days
15	4 - 9 days
13	6 -15 days

Cold storage options - Storage at 10ºC

Advantages

- Best balance between preventing premature ripening and minimising skin blackening

Disadvantages

- Greater chance of skin blackening and chilling injury if stored for 6 days or longer

Storage above 10ºC (13ºC or higher)

Advantages

- Reduces chances of chilling injury with longer storage times.

Disadvantages

- Field heat not removed quickly
- Greater chance of premature ripening

Storage below 10ºC (8ºC)

Advantages

- Can remove field heat quickly if used for short term storage
- Can be used as a buffer to ensure fruit doesn't heat up during transport

Disadvantages

- Very high risk of chilling injury
- High risk of skin blackening if rain before or during harvesting
- No increase in shelf life

Cold temperature (chilling) injury

Skin blackening is caused by any factor that irritates the fruit skin cells. Fruit secretes a resin on the fruit skin which hardens as a black protective coating which is an effective barrier to microbiological damage. Injury occurs after prolonged exposure to temperatures below 13ºC. Symptoms start with dull slightly brown patches and over time affected areas become brown or black. In severe cases the fruit can become completely black. African Pride is more sensitive to chill injury than 'Pink's Mammoth' or 'Hillary White'.

Cold storage is a balance between fruit darkening when held below 13ºC and fruit going soft from premature ripening at temperatures above 10ºC. Fruit harvested during or soon after rain have a higher risk of damage when refrigerated.

RECOMMENDATIONS FOR COLD STORAGE

There is no single optimum storage temperature for all circumstances. In general, 10ºC is recommended for storage, transport and marketing. Use of higher or lower temperatures depends largely on ambient temperatures. Other influences include weather, season, variety,

handling practices, packing materials and market tolerance for skin darkening. The best options for storage are outlined in Figure1 below.

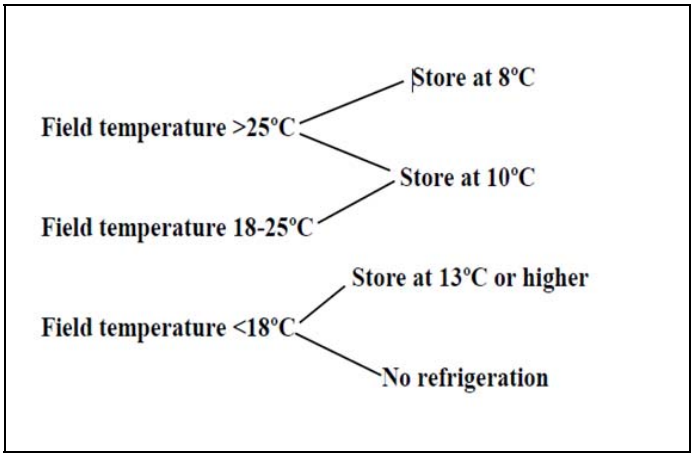

Figure 1. Options for refrigeration of custard apples based on ambient temperature at harvest.

REMOVING FIRELD HEAT FROM CUSTARD APPLES USING HYDROCOOLING

INTRODUCTION

The prompt lowering of internal fruit temperature after harvest can prolong storage life of many fruit commodities. The extremely high respiration rate of custard apples can be slowed by postharvest practices such as forced air cooling, however there is potential to use hydrocooling in the washing and grading process as a quick way to remove field heat. Hydrocooling is the process of immersing produce in circulating cold water cooled by a water chiller, alternatively cold water can be sprinkled or sprayed over produce. Hydrocooling is thought to cool produce quicker than forced air cooling because water comes in direct contact with the fruit and has a higher heat removal capacity. Custard apple growers in north Queensland have expressed interest in using hydrocooling for rapid postharvest heat removal. Small trials were conducted using the cultivar 'KJ Pinks' to evaluate the response of fruit to hydrocooling and possible benefits to postharvest storage.

MATERIALS AND METHODS

Two trials were carried out in Glasshouse Mountains and the Maroochy Research Facility.

Trial 1
Fruit from a commercial grower in Glasshouse Mountains were randomly selected from picking lugs immediately after fruit was transported to the packing shed from the field. Core temperature and fruit weight was measured prior to cooling. Eight fruit per treatment were immersed in a water bath fitted with a cooling element that maintained water temperature at 8ºC (Plate 1). Fruit were hydrocooled for three different durations;

- 5 minutes
- 10 minutes
- 15 minutes

Core temperature was measured after treatment to identify the reduction in temperature caused by hydrocooling.

Trial 2
Fruit were harvested from the field at around 11am. Fruit were randomly selected, weighed and core temperature was recorded. Fruit was immersed in water chilled to 8ºC using the same water bath and durations as trial 1. Core temperature was measured after each treatment. Fruit was then placed in a coldroom set at 8ºC and core temperature was recorded for three hours. Control fruit were placed in the coldroom immediately after harvest.

Fruit were stored for 48 hours in the coldroom (8ºC) and the removed to ripen. Observations on shelf life and skin blemish were recorded.

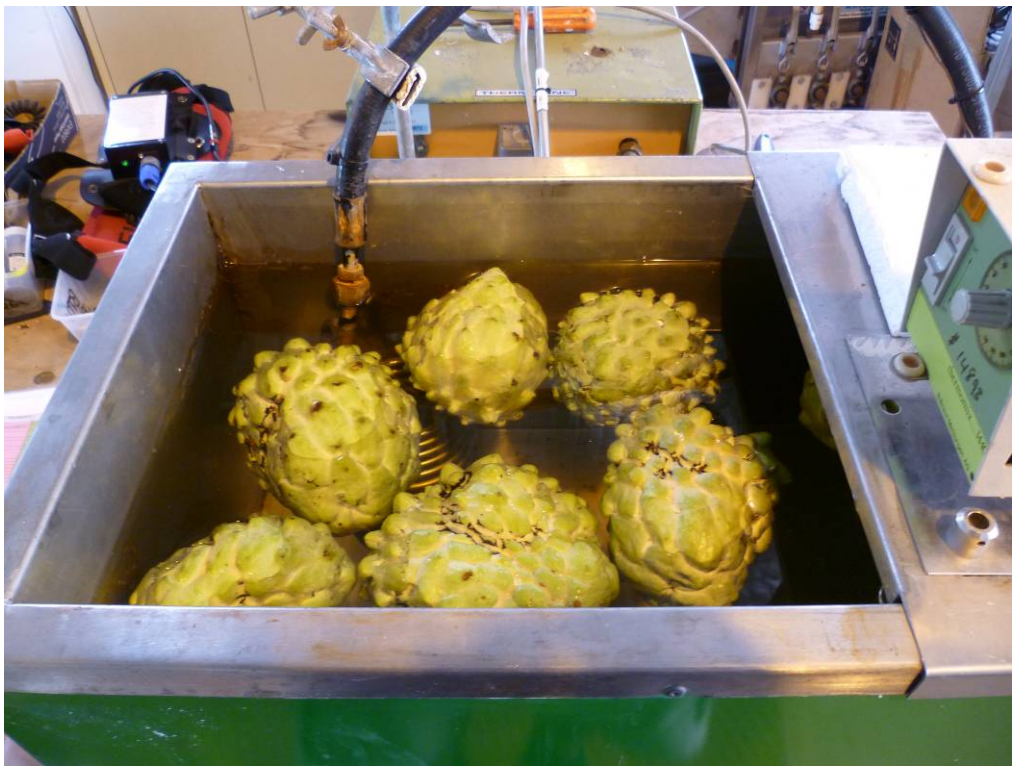

Plate 1. Fruit hydrocooling in water bath set to 8ºC.

RESULTS AND DISCUSSION

Trial 1

A core temperature of around 25ºC was recorded for all treatments prior to hydrocooling (Figure 1). Core temperature of fruit hydrocooled for 5 minutes dropped to an average of 24ºC after treatment. Fruit in the 10 minute treatment dropped to an average of 22.8ºC and fruit cooled for 15 minutes dropped to an average of 18.5ºC

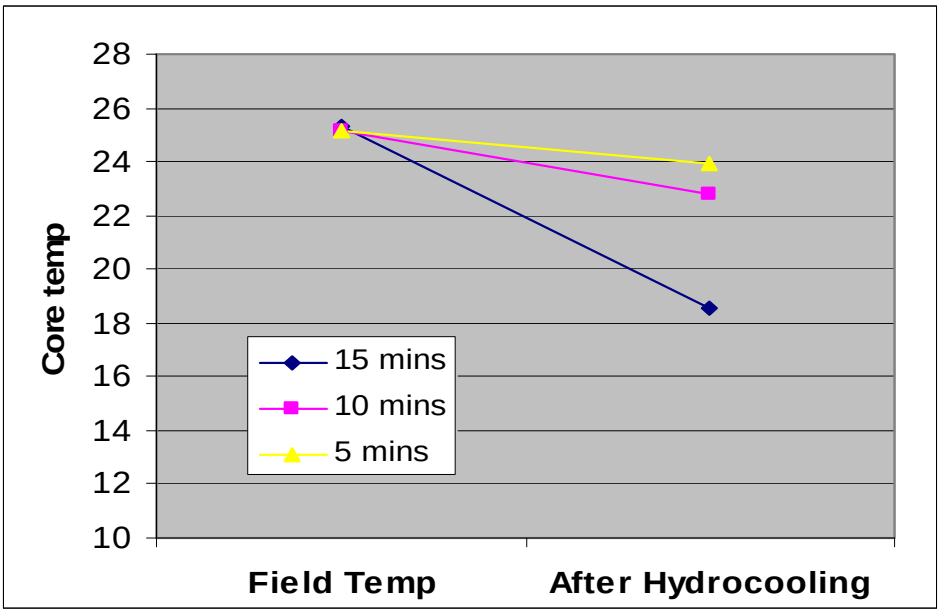

Figure 1. Core temperature of 'KJ Pinks' before and after hydrocooling at 8ºC for 5,10 and 15 minutes.

Hydrocooing for 15 minutes provided a larger reduction in temperature compared to the 5 and 10 minute treatments. Percentage heat reduction from field temperature was largely dependant on the weight (size) of fruit. This difference in heat removal was not observed in the 5 minute treatment (Figure 2), however in the 10 and 15 minute treatments (Figures 3 and 4) smaller fruit had a larger proportion of heat removed than larger fruit.

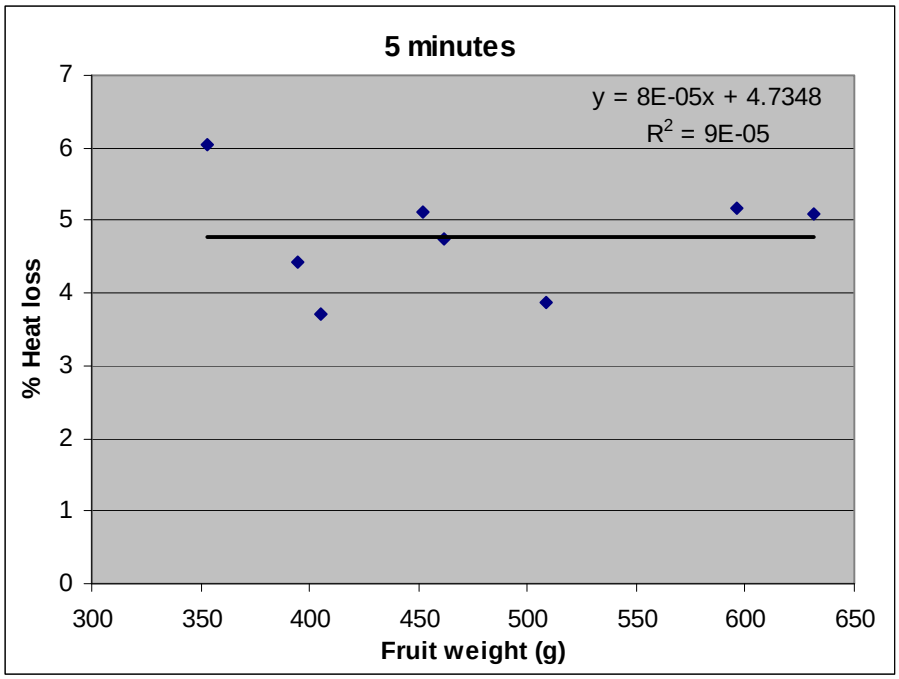

Figure 2. Relationship between fruit weight and percentage of field heat removed after hydrocooling (8ºC) for 5 minutes.

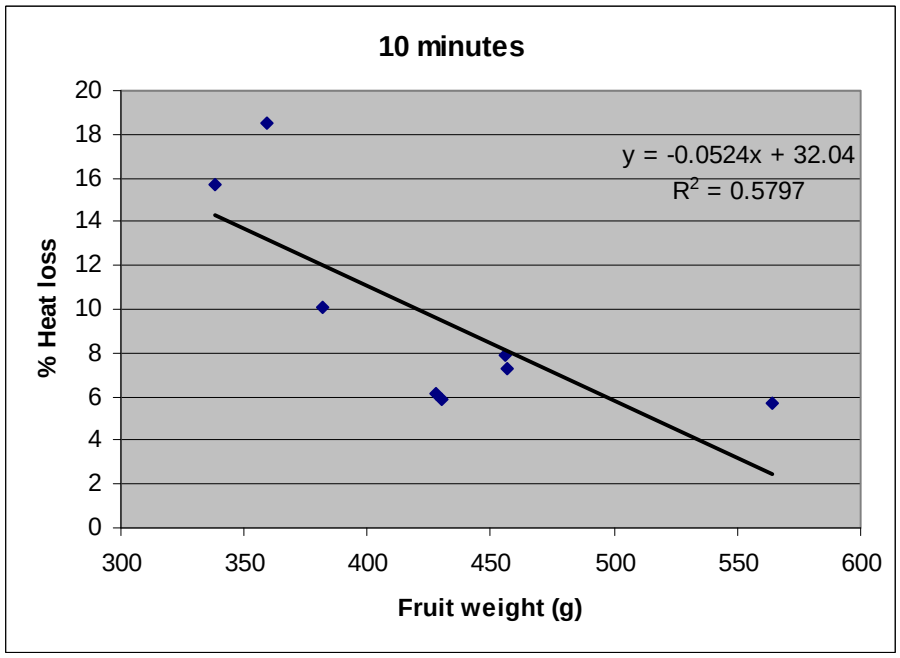

Figure 3. Relationship between fruit weight and percentage of field heat removed after hydrocooling (8ºC) for 15 minutes.

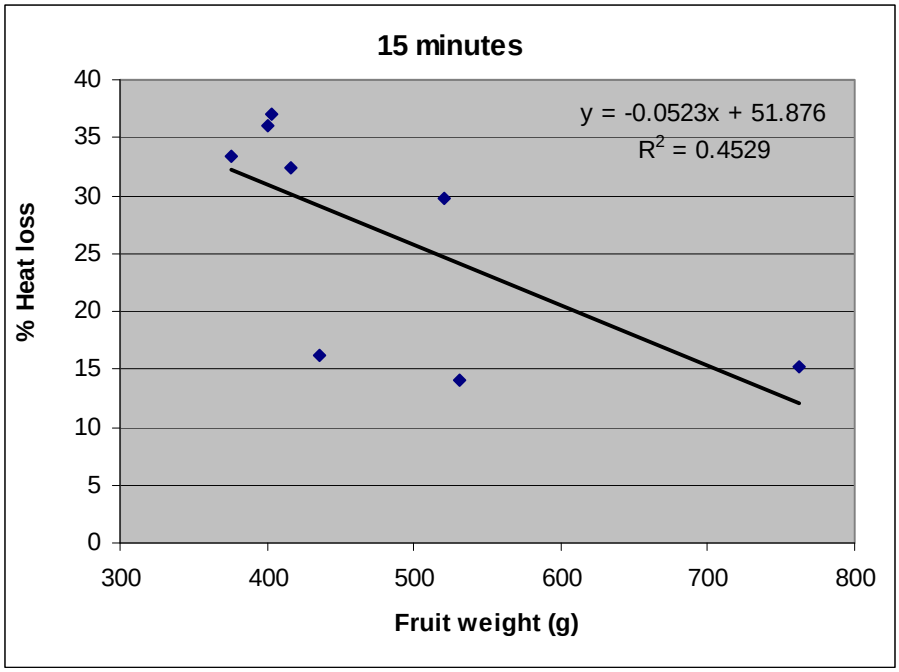

Figure 4. Relationship between fruit weight and percentage of field heat removed after hydrocooling (8ºC) for 15 minutes.

This trial established cooling rates for different hydrocooling durations, however the benefit of hydrocooling was investigated in trial 2 by comparing hydrocooled fruit with fruit immediately placed in the cold room.

Trial 2

All treatments had a core temperature of around 30.5ºC prior to treatment (Figure 5). After 5 minutes hydrocooling average core temperature had dropped to 28.9ºC. 10 minutes hydrocooling reduced core temperature to 27.5ºC and 15 minutes gave the best result with an average of 27.1 ºC. Reduction in core temperature was again dependent on the weight (size) of fruit Figures 6,7,and 8).

After one hour in the coldroom control fruit had an average core temperature of 21.9 ºC compared to 18.3 ºC for the 5 minute, 15.6 ºC for the 10 minute and 14.6 ºC for the 15 minute hydrocooling treatments. After two hours in the coldroom there was a 1.4 ºC difference between the control and the 5 minute treatment and a 0.9 ºC difference at three hours. 10 and 15 minute treatments recorded an average core temperature 3.8-3.9 ºC lower than the control after two hours and 2.4-2.5 ºC lower after three hours.

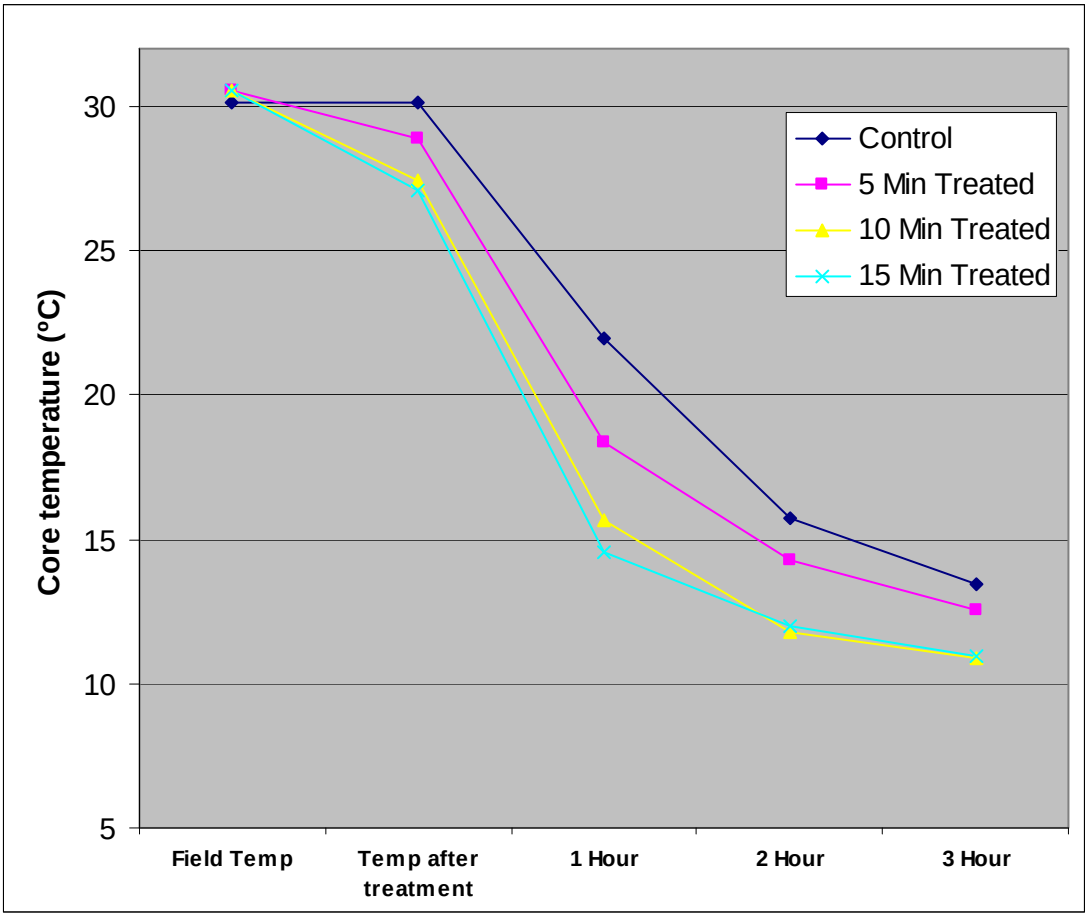

Figure 5. The effect of hydrocooling at 8ºC for 5,10 and 15 minutes and continued cooling in coldroom at 8ºC for three hours.

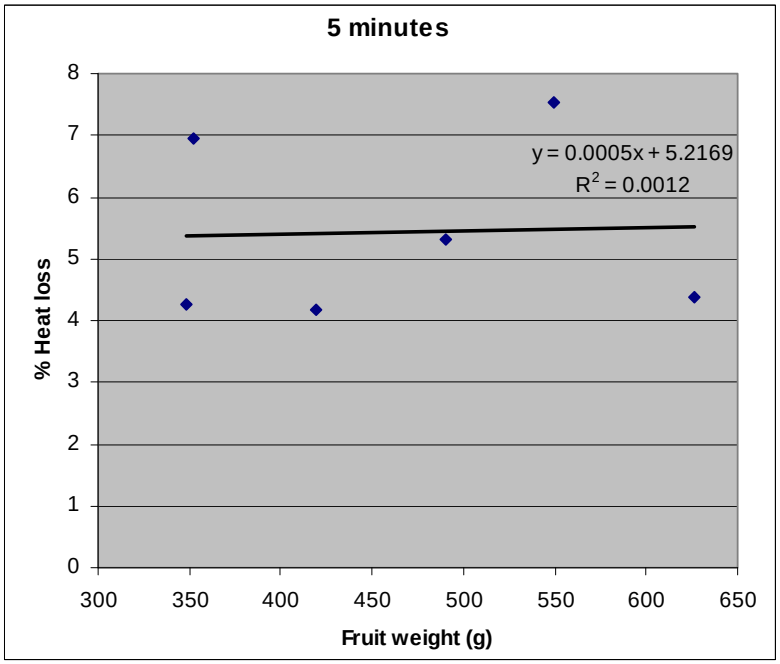

Figure 6. Relationship between fruit weight and percentage of field heat removed after

hydrocooling (8ºC) for 5 minutes.

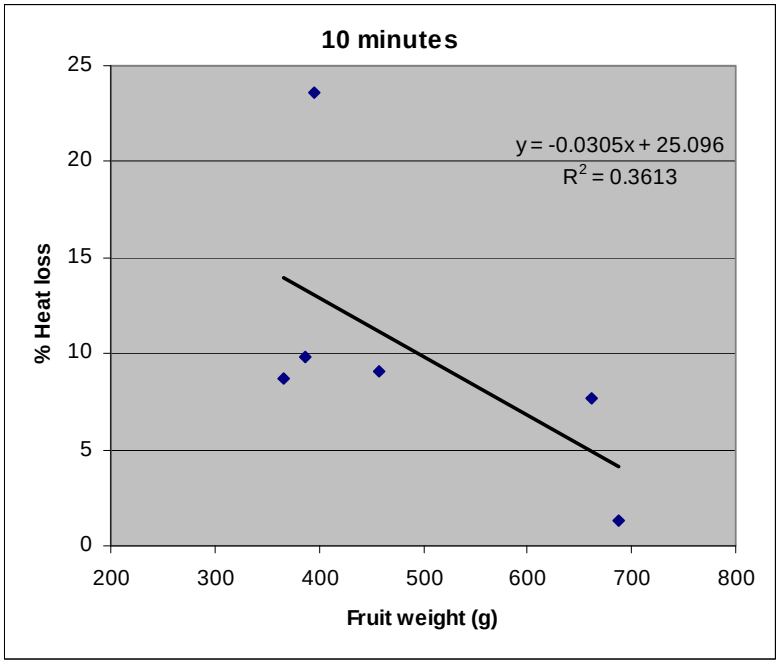

Figure 7. Relationship between fruit weight and percentage of field heat removed after hydrocooling (8ºC) for 10 minutes.

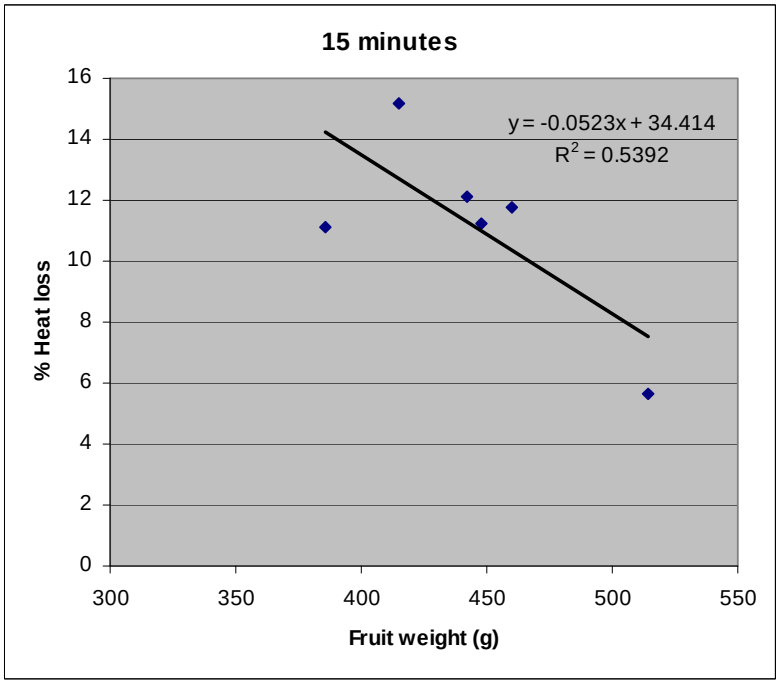

Figure 6. Relationship between fruit weight and percentage of field heat removed after hydrocooling (8ºC) for 15 minutes.

No differences in skin blemish were observed between treatments after removing fruit from the coldroom 48 hours later. Fruit had similar ripening times across all treatments.

While these trials identified that hydrocooling is an effective process to remove field heat quickly, the effects on longer-term storage need to be evaluated. Comparisons with forced air cooling also need to be examined.
Hydrocooling fruit for 10 minutes at 8ºC appears to be the most efficient treatment for rapid cooling of fruit. While hydrocooling for 15 minutes provided the best reduction in core temperature before cool storage, temperatures after three hours in the coldroom were comparable with the 10 minute treatment.

Growers need to decide if hydrocooling is a practical or economically viable technique for removing field heat from fruit. Hydrocooling can be expensive to set up and energy for cooling units can be costly. Growers also need to keep in mind the variable rates of cooling for different size fruit.

TECHNOLOGY TRANSFER

INDUSTRY ADVISORY MEETINGS

- Grant Bignell and David Bruun attended the CAA Annual General Meeting and Industry Advisory Committee meeting held at Glasshouse Mountains between 16 and 17 of February 2012.
- Grant Bignell and David Bruun attended the CAA Industry Advisory Committee meeting held at Glasshouse Mountains on the 25th July 2012. Grant Bignell presented a summary of the project's findings to date.
- Grant Bignell and David Bruun attended the CAA Annual General Meeting and Industry Advisory Committee meeting held at Glasshouse Mountains bteween the 20 and 21 February 2013. Grant Bignell presented a summary of the project's findings to date.
- Grant Bignell and David Bruun attended the Industry Advisory Committee meeting held at Glasshouse Mountains on the 24th July 2013. Grant Bignell presented a summary of the project's findings to date.
- Grant Bignell and David Bruun attended the Annual General Meeting and Industry Advisory Committee meeting between 30 and 31 January 2014. Grant Bignell presented a summary of the project's findings to date.

FIELD DAYS

North Queensland 3-6 February 2012

Approximately 25 people attended a field day/workshop on the 4/02/2012 at Wayne Stewart's orchard in Mareeba. Information on the breeding program, clonal propagation, new chemicals and pest management was delivered by Grant Bignell and David Bruun. Six individual farms were visited to evaluate different growing systems and to deliver advice on tree training, nutrition and pest and disease management. A meeting was also held at Yuruga nursery on the 3/02/2012 to discuss the clonal propagation trial and evaluate early results.

Glasshouse Mountains 17 February 2012

Approximately 30 people attended a field day/workshop on the 17/02/2012 at Peter Cameloto's orchard in Glasshouse Mountains. Grant Bignell and David Bruun presented a summary of findings from farm visits in North Queensland as well as providing information on new elite selections from the breeding program and the clonal propagation trial. David Bruun gave advice on tree training and general orchard management on a field walk.

Alstonville 26 April 2012

Approximately 20 people attended a field day/workshop on the 26/04/2012 at the Bottomley's orchard in Alstonville. Growers were encouraged to bring along any samples of pest or disease damage for discussion and identification. Fruit samples of elite selections from the breeding program were supplied and tasted by all growers.

Alstonville 24th October 2012

Grant Bignell directed discussion and a presentation on custard apple nutrition for over 15 growers as part of a field day on two properties in the Alstonville region. Growers were also given instruction by David Bruun on pruning, fruit thinning and pest and disease management.

Glasshouse Mountains 21 February 2013

Approximately 30 people attended a field day/workshop on the 21/02/2013 at Gary Pike's orchard in Glasshouse Mountains. Grant Bignell presented a summary of findings from farm visits in North Queensland as well as providing information on new elite selections from the breeding program and the clonal propagation trial. A comprehensive presentation was given on the use of predatory insects in integrated pest management.

North Queensland 22-24 February 2013

Approximately 15 people attended a field day/workshop on the 23/02/2013 at Wayne Stewart's orchard in Mareeba. Information on the breeding program, clonal propagation, new chemicals and pest management was delivered by Grant Bignell. Six individual farms were visited to evaluate different growing systems and to deliver advice on tree training, nutrition and pest and disease management. A meeting was also held at Yuruga nursery on the 22/02/2013 to discuss the clonal propagation trial and evaluate results.

Alstonville 17 April 2013

Approximately 20 people attended a field day/workshop on the 17/04/2013 at Phil and Patti Stacey's orchard in Alstonville. Fruit samples of elite selections from the breeding program were supplied and tasted by all growers. A comprehensive presentation was delivered on the use of predatory insects in integrated pest management.

Bundaberg 4 June 2013

Three growers in the Wide Bay/Bundaberg region were visited by Grant Bignell and David Bruun and given advice on pruning, pest and disease management, nutrition, varietal selection and growing systems. These growers represent the majority of custard apple production for this region.

Dunoon 9th October 2013

Approximately 30 people attended a field day/workshop on the 9/10/2013 at two orchards in the Dunoon area. Grant Bignell and David Bruun presented a summary of findings from the current project as well as providing information on new elite selections from the breeding program and the clonal propagation trial. A comprehensive presentation was given on the postharvest management of custard apples.

Maroochy Research Facility 31st January 2014

Approximately 15 growers attended the field day at Maroochy Research Facility in Nambour. Grant Bignell delivered a presentation on postharvest management of custard apples and also updated growers on the latest findings from the project. Growers were taken on a tour of the research blocks and were shown elite selections and trellis trials.

Mareeba 2nd February 2014

Approximately 10 growers attended a field day at a commercial orchard in Mareeba. Grant Bignell gave a presentation on postharvest management of custard apples and made recommendations for storage temperatures for different growing regions. Updates on breeding and clonal propagation trials were also provided. Grant Bignell and David Bruun took growers on a tour of the orchard and demonstrated pruning methods. Elite selections on this orchard were shown to growers.

Alstonville 10 April 2014

Approximately 30 people attended a field day/workshop at Phil and Patti Stacey's orchard in Alstonville. Fruit samples of elite selections from the breeding program were supplied and tasted by all growers. Grant Bignell and David Bruun gave an update on R&D findings and gave a presentation on the management of calcium and associated deficiency symptoms.

Bundaberg 8th May 2014

Two growers in the Wide Bay/Bundaberg region were visited by Grant Bignell and David Bruun and given advice on pruning, pest and disease management, nutrition, varietal selection and growing systems.

WORKSHOPS AND CONFERENCES

- Grant Bignell gave a presentation on the clonal propagation of custard apples at 'The National Australian Custard Apple Conference' on the 15th July 2011.

- Grant Bignell attended the Queensland Harvest Winter Showcase on the 23rd April 2012 which promoted custard apples to some of Sydney's top chefs and food editors. Samples were available for tasting and information on custard apples was provided.
- Grant Bignell and David Bruun attended the Strategic Agrochemical Review Process (SARP) on the 25th July 2012.

- Dr Alan George presented a PowerPoint presentation on Custard apple breeding at the DEEDI Horticulture Plant Breeders Workshop, Twin waters, 3-5 November, 2010.

PUBLICATIONS

- Dr Alan George, David Bruun and Grant Bignell wrote papers that were published in the 2011 Custard Apple conference proceedings. Papers on new varieties and their

potential, clonal propagation opportunities and rootstocks were also presented as oral presentations.

Articles published in Custard Apple Newsletter.

Several articles have been published in the custard apple newsletter including:

George, A. (2011). Sooty mould in custard apples. *The Custard Apple, Dec*, pp.10-11.

George, A. (2011). Leaf stripping. *The Custard Apple, Dec*, pp.12-14.

George, A. (2011). Guidelines for thinning custard apples. *The Custard Apple, Dec*, pp.15-18.

George, A. (2012). Review of pests and control in custard apple. *The Custard Apple*, Autumn 2012, 8-9.

George, A. (2012). The modern approach to disease control – IDM**.** *The Custard Apple* Autumn 2012, pp.14-15.

George, A. (2012). Two Spotted Mites. - Excerpts from IPDM Manual. *The Custard Apple,* Spring 2012, pp.12-15

George, A. (2012). Review of pests and control methods in custard apples. *The Custard Apple,* Autumn, 2012, pp.8-9.

George, A. (2012). Basic concepts of pruning custard apples from the Custard Apple Pruning Manual. *The Custard Apple*, Spring 2012, pp.6-7.

Bignell, G. (2013). Predators of insect pests in custard apple orchards and their use in IPM. *The Custard Apple,* Autumn 2013, pp.10-16.

George, A.and Nissen, R. (2013). Soursap in custard apple. *The Custard Apple,* Winter 2013. pp. 12-14.

Bignell, G., Bruun, D, George, A. and Kilian, A. (2013). Genetic marking aims to speed up custard apple breeding. The Custard Apple Newsletter. October 2013. pp. 1-2.

Bignell, G., Bruun, D., Radke, A., and Tara, J. (2013). Custard apple clonal propagation. The Custard Apple Newsletter. October 2013. pp. 6-7.

Bignell, G. (2013). Postharvest attributes of custard apples. The Custard Apple Newsletter. December 2013. pp. 8-9.

Bignell, G. (2014). New custard apple selections available for large scale test in 2014-2015. *The Custard Apple*, Autumn 2014, pp.10-11.

Bignell, G., Bruun, D., Radke, A. and Tara, J. (2014). Clonal propagation update. *The Custard apple*, Autumn, 2014 pp. 1-4.

TRAINING MANUAL UPDATES

User-friendly manuals were developed during previous HAL projects (CUO4001 and CUO7001). DAFF has updated the various sections and inserted these into the manuals. Information was obtained from grower surveys, feedback from field days, workshops, and desktop and primary research (in-field activities). This is costed as part of this project. Custard Apple Australia Inc. has printed the manuals to recover costs.

Bignell, G., Bruun, D. and George, A. (2013). Custard Apple Varieties Manual. Edition

Bignell, G., Bruun, D. and George, A. (2013). Custard Apple Training & Pruning Manual Edition 8.

Bignell, G., Bruun, D. and George, A. (2013). Custard Apple Pest and Disease Manual. Edition 2.

RECOMMENDATIONS – SCIENTIFIC AND INDUSTRY

- We would strongly recommend that the Australian custard apple industry continue funding the breeding program. This program continues to release superior varieties comparable to or better than the current industry standard of 'KJ Pinks'. Continued selection for red skin should be made a priority.

- Project CU12003 will continue marker development for high productivity traits and red skin. This project will make future custard apple breeding more efficient by moving selection from the field to laboratory.

- Large-scale testing of elite selections from the breeding program initiated in 2014 will generate data on performance in a range of environments. Elite selection 453-1 and 464-1 are recommended to trial on a limited scale. More selections will progress to the large-scale testing phase as further results from on-farm trials become available.

- Excessive tree vigour continues to limit productivity. Greater emphasis needs to be placed on selecting lower vigour and semi-dwarfing rootstock types as moderately vigorous trees exhibit higher yields and better fruit quality. Also smaller trees are easier to manage. This project has already shown that rootstocks of Taiwanese sugar apple and 'African Pride' and cherimoya seedlings of intermediate vigour can reduce scion vigour and tree size. A wider range of semi-dwarfing rootstocks needs to be tested and rootstocks from high yielding trees recovered and cloned.

- The development of a reliable clonal propagation technique by a commercial nursery in north Queensland was a major breakthrough. The clonal propagation technique developed was successful in cloning several rootstock species and elite cultivar selections. Further testing on a wider range of clonal selections and rootstock types, selected specifically for moderate growth and high yield traits, needs to be conducted.

- Monitoring of new training systems for custard apple needs to continue as performance of the Maroochy V-trellis and palmette trellis systems continue to impress. We also recommend that commercial farmers trial these new training systems, initially on a limited scale until they can be fully evaluated.

- Based on the findings of two observational trials at Maroochy Research Facility further testing of reflective mulch on a larger scale is warranted.

- Postharvest quality of custard apples continues to be a problem, especially in warmer production areas. Due to a large number of new growers joining the industry, training workshops on postharvest practices will be required in the future.

ACKNOWLEDGEMENTS

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APPENDIX
APPENDIX 1

ELITE SELECTION ASSESSMENTS FROM GROWER TRIALS

ON-FARM TESTING OF ELITE SELECTIONS
SELECTION NAME: 453-1
Parentage: Cross 22 (A) Unknown x Seedless sugar apple (S)
Date selected: 2008

Tree characteristics: Narrow pointed leaves with a high percentage of sugar apple parentage

Tree vigour: Moderately vigorous (5)

Productivity: High (8)

Fruit size: Medium (6) (500-800g)

Skin colour: Green skin with red flecking in the interstices

Flesh colour: White

Shape: Spheroid

Symmetry: Very symmetrical (9)

Skin type: Mildly tuberculate

Skin thickness: 3.0mm

Flavour: Good (7.2)

Flavour description: Pinks Mammoth type but milder with hint of tang

Texture: Good (6.7)

Seed number per 100g of flesh: 4.5

Disease susceptibility: No (1)

Pest susceptibility: No (1)

Susceptibility to splitting: No (1)

Suitability for trellising: Unknown but likely. Currently under trial

Shelf life: 5.5 days

Overall rating: 8

Comments:

Of the selections from the breeding program evaluated to date, selection 453-1 appears to be the most promising. It has high productivity and excellent appearance. It has a milder flavour than 'Pinks Mammoth' which some people prefer. It has cropped consistently at the Maroochy Research Station over the past 3 years with very attractive fruit.

SELECTION NAME: 450-1

Parentage: Cross 22 (A) (Unknown) x Maroochy Tank (Hillary White (A) x Fino de Jete (C))

Date selected: 2009

Selection 450-1

Tree characteristics: Selection has long pointed leaves indicative of a vigorous sugar apple type. Selection produces numerous laterals.

Tree vigour: Moderate (6)

Productivity: Appears to be moderately high (6)

Fruit size: Medium to large (7) (600-900g)

Skin colour: Lime green with yellow interstices

Flesh colour: White

Shape: Spheroid

Symmetry: Very symmetrical (7)

Skin type: Mildly tuberculate

Skin thickness: Moderate (3.5mm)

Flavour: Good (6-7)

Flavour description: Sweet sugar cane

Texture: Good (6-7)

Seed number per 100g of flesh: 4.47

Disease susceptibility: Does not appear to be susceptible to disease (1)

Pest susceptibility: Does not appear to be susceptible to pests (1)

Susceptibility to splitting: Low (1)

Suitability for trellising: Unknown

Shelf life: 6.3 days

Overall rating: 6.5

Comments:

Selection has great shape and a very attractive lime green skin. Productivity is moderately high but not as good as 'KJ Pinks'. Texture and flavour are reasonable. Selection requires further testing in a wider range of environments to prove its productivity performance.

SELECTION NAME: 464-2
Parentage: Cross 40 (A) (Martin x Maroochy Tank (Hillary White (A) x Fino de Jete (C) x unknown
Date selected: 2009

Selection 464-2

Tree characteristics: Atemoya type

Tree vigour: Moderately vigorous (7)

Productivity: Appears to be high however not precocious (8)

Fruit size: Medium to large (7) (650-950g)

Skin colour: Green with large lime green instices

Flesh colour: White

Shape: Oval

Symmetry: Very symmetrical (7.2)

Skin type: Mildly tuberculate

Skin thickness: Thin (2.0 mm)

Flavour: Good (8)

Flavour description: Mild Pinks Mammoth flavour

Texture: Good (7)

Seed number per 100g of flesh: 2.2

Disease susceptibility: Does not appear to be susceptible to disease (1)

Pest susceptibility: Does not appear to be susceptible to pests (1)

Susceptibility to splitting: No (1)

Suitability for trellising: Unknown

Shelf life: 5.3 days

Overall rating: Very promising (8)

Comments:

Very attractive fruit with nice white flesh. The skin holds its colour after harvesting. Selection requires further testing in a wider range of environments.

SELECTION NAME: 464-1

Parentage: Cross 40 (A) (Martin x Maroochy Tank (Hillary White (A) x Fino de Jete (C) x unknown

Date selected: 2008

Plate 8. Selection I-464-1

Tree characteristics: Atemoya type

Tree vigour: Moderately vigorous (7)

Productivity: Moderately high (7)

Fruit size: Medium (6) (500-600g)

Skin colour: Green with large lime green instices

Flesh colour: White

Shape: Oval

Symmetry: Symmetrical (7)

Skin type: Mildly tuberculate

Skin thickness: Thin (2.0 mm)

Flavour: Good (7)

Flavour description: Mild Pinks Mammoth flavour

Texture: Good (6.5)

Seed number per 100g of flesh: 3.6

Disease susceptibility: Does not appear to be susceptible to disease (1)

Pest susceptibility: Does not appear to be susceptible to pests (1)

Susceptibility to splitting: No (1)

Suitability for trellising: Unknown

Shelf life: 5.6 days

Overall rating: Very promising (8)

Comments:
Selection 464-1 is a very attractive fruit with nice white flesh. Productivity is moderately high but not as good as 'KJ Pinks'. It has a mild Pink's Mammoth flavour. The skin holds its colour after harvesting. This selection and its sibling 462-2 appear very promising. Selection requires further testing in a wider range of environments.

SELECTION NAME: 430-1

Parentage: Cross 76 (A) (Maroochy Gold (A) x Maroochy Tank (A)) x Seedless sugar apple (S)

Date selected: 2008

Selection 430-1

Tree characteristics: Atemoya type but with a high percentage of sugar apple parentage

Tree vigour: Moderately vigorous (6)

Productivity: Moderately high (7)

Fruit size: Medium (6) (550-750g)

Skin colour: Green with cream interstices

Flesh colour: White

Shape: Spheroid

Symmetry: Symmetrical (6.5)

Skin type: Moderately tuberculate

Skin thickness: Thin (2.3mm)

Flavour: Fair (7)

Flavour description: Pinks Mammoth type

Texture: Good (6.5)

Seed number per 100g of flesh: 3.6

Disease susceptibility: No (1)

Pest susceptibility: No (1)

Susceptibility to splitting: No

Suitability for trellising: Unknown

Shelf life: 5.0 days

Overall rating: 6.5

Comments: This selection has fair flavour and texture compared with Pink's Mammoth. Productivity is moderately high. Fruit mature later than other cultivars. Skin is attractive and holds its colour. Selection requires further testing in a wider range of environments.

SELECTION NAME: 430-2

Parentage: Cross 76 (A) (Maroochy Gold (A) x Maroochy Tank (A)) x Seedless sugar apple (S)

Date selected: 2008

Plate 10. I 430-2

Tree characteristics: Atemoya type but with a high percentage of sugar apple parentage

Tree vigour: Moderately vigorous (6)

Productivity: Moderately high (6)

Fruit size: Medium (6) (550-750g)

Skin colour: Green with cream interstices

Flesh colour: White

Shape: Spheroid

Symmetry: Symmetrical (6.5)

Skin type: Moderately tuberculate

Skin thickness: Thin (2.3mm)

Flavour: Fair (7)

Flavour description: Pinks Mammoth type

Texture: Good (6.5)

Seed number per 100g of flesh: 3.6

Disease susceptibility: No (1)

Pest susceptibility: No (1)

Susceptibility to splitting: No

Suitability for trellising: Unknown

Shelf life: 5.0 days

Overall rating: 6.5

Comments: This selection has fair flavour and texture compared with Pink's Mammoth. Productivity is moderately high. Fruit mature later than other cultivars. Skin is attractive and holds its colour. Selection requires further testing in a wider range of environments.

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SELECTION NAME: 470-2

Parentage: KJ Pinks (A) x Seedless sugar apple (S)

Date selected: 2009

Selection 470-2

Tree characteristics: Atemoya type, strongly apically dominant

Tree vigour: Vigorous (8)

Productivity: High (8)

Fruit size: Large (9) (750-1000g)

Skin colour: Green with cream interstices

Flesh colour: White

Shape: Oval

Symmetry: Moderate symmetry (7)

Skin type: Strongly tuberculate

Skin thickness: 2.75 mm

Flavour: Excellent (8.5)

Flavour description: Pinks Mammoth type

Texture: Good (7)

Seed number per 100g of flesh: 4.5

Disease susceptibility: No (1)

Pest susceptibility: Yes, cluster caterpillar (3)

Susceptibility to splitting: High (6) in young trees but appears to reduce as tree matures.

Suitability for trellising: Unknown

Shelf life: 6.8 days

Overall rating: 6.5

Comments: Selection produces very large fruit. It has high productivity with very high fruit set. Flavour is excellent similar to 'Pink's Mammoth'. Fruit may split if they become too large however levels of splitting appear to reduce as the tree matures. Selection requires further testing in a wider range of environments.

SELECTION NAME: 363

Parentage: Maroochy Tank (A) x Seedless sugar apple (S)

Date selected: 2008

Selection 363

Tree characteristics: Atemoya type, moderately apically dominant, numerous laterals

Tree vigour: Vigorous (7)

Productivity: High (7)

Fruit size: Medium to large (9) (600=800)

Skin colour: Green with cream interstices

Flesh colour: White

Shape: Oval

Symmetry: Excellent symmetry (7.8)

Skin type: Strongly tuberculate

Skin thickness: 1.75 mm

Flavour: Good (7.3)

Flavour description: Pinks Mammoth type

Texture: Good (6.3)

Seed number per 100g of flesh: 4.4

Disease susceptibility: No (1)

Pest susceptibility: No (1)

Susceptibility to splitting: No (1)

Suitability for trellising: Unknown

Shelf life: 6.2 days

Overall rating: 6.5

Comments: Heavy cropper. Selection requires further testing in a wider range of environments.

APPENDIX 2

EFFICACY AND RESIDUE TESTING PROTOCOLS

Residue Study Field Trial Report Form
Part A - Treatments

Study number:		
Title: Trials to determine the presence of a taint in custard apples sprayed with prochloraz		
Sponsor: (Name & address)	Robert Vitelli, Bayer Crop Science, PO Box 449, Clayfield QLD	
Study Director:	Grant Bignell- DAFF Peter Dal Santo	
Site Number:	2- Glasshouse Mountains, QLD	
Trial Location:	Glasshouse Mountains	**State:** QLD
Principle Investigator:	Name: Grant Bignell	
	Address: 47 Mayers Road, Nambour Qld 4560	
	Telephone: 07 54535 947	Facsimile: 07 54535 901
	Mobile: 0419 773 206	Email: grant.bignell@daff.qld.go
Study Person(s):	Name: Ros Smerdon	
	Address: 2295 Old Gympie Rd, Galsshouse Mountains 4518	
	Telephone: 07 5493 0268	Facsimile:
	Mobile:	Email: kerryros@bigpond.com
Scheduled Start Date:	16/11/2011	
Scheduled Completion Date:	30/01/2012	
Crop:	Custard Apple *(Annona spp*)	
Variety:	KJ Pinks	
Product Name:	Octave	
Active Ingredient:	Prochloraz 462g/kg	

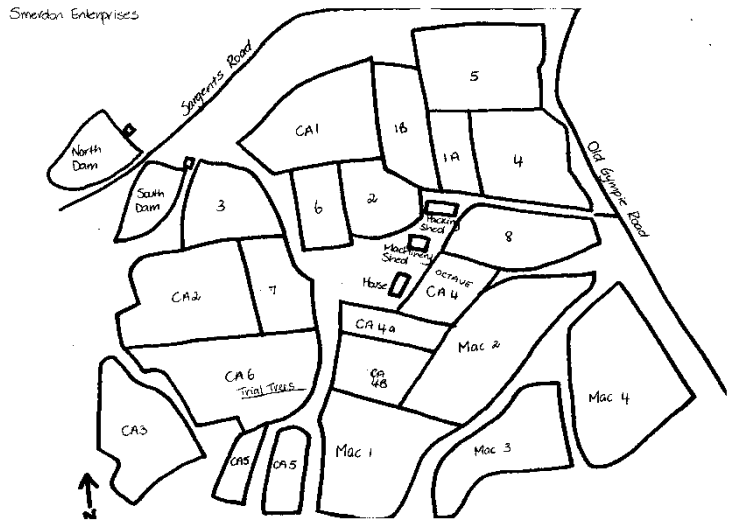
Site Details

Co-operators Name:	Kerry and Ros Smerdon		
Address:	2295 Old Gympie Rd, Galsshouse Mountains 4518		
Telephone:	07 5493 0268	**Facsimile:**	
Mobile:		**Email:**	kerryros@bigpond.com
Paddock ID:			
Soil Type:	Sandy Loam		
Crop:	Custard Apple	**Cultivar:**	KJ Pinks
Date Planted:	2004		
Planting Method: (tick one)	Vase/Hedge		
Plot Size:			
Plot Design:	Trees planted on spacings of 3m in the row and 10m between the rows		
Plot Description:			
Unusual Features of Plot:			

Site Details (cont):

Location Map:

Site Plan:



Test Substance:

Product Name:	Octave
Active Ingredients:	Prochloraz 462g/kg
Formulation & Type:	
Batch Number:	Provided by Bayer
CAS Number:	
NRA NPRIS Record No.:	
NRA Approval Number:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Octave	100g/100L
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:				
Application Date:	16/11/11	14/12/12	12/01/12	
Crop Growth Stage:	Early Flower	Flower/Set	Fruit Set	
Start Time:	8:15am	9:00am	8:45am	
Finish Time:	8:30am	9:15am	9:00am	
Dry Bulb: (^{0}C)	25.5	26.9	27.5	
Relative Humidity: (%)	63	56	58	
Wind Speed: (m/sec)	7km/h	3km/h	9km/h	
Wind Direction:	NNW	ESE	ESE	
Cloud Cover: (%)	30	50	50	
Soil Moisture: 6" Tesiometer	4	6	4	
Rainfall 24 hrs before and after application:	0mm-0mm	0mm-57.2mm	0mm-0.2mm	
Treatment Application Order:	1	2	3	

Type of Application: (eg foliar, band)	Foliar	Foliar	Foliar	
Equipment used:	Hardi Electric 30lt Sprayer			
Nozzle Type:	Adjustable cone jet	Adjustable cone jet	Adjustable cone jet	
Sprayer output: (ml/min)	2.4l/min	2.4l/min	2.4l/min	
Exposure time: (sec/plot)	2min 55sec	3 min 8sec	4 min 48sec	
Application volume: (ml/plot)	7lts	7.5lts	11.5lts	
Application volume: (L/ha)				

Total number of applications:		
Time between applications:	**Application Number**	**Days**
	1	0
	2	28
	3	31
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
	n/a	
Unusual weather or occurrences during the trial:		

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Beerburrum**
Distance from site:	**7km**

Attach photo of trial site:

Photo taken after trial has been pegged and before the first application.

Photo taken immediately after the last application.

Observations of efficacy and crop safety at treatment

Residue Study Field Trial Report Form
Part A - Treatments

Study number:		
Title: Trials to determine the presence of a taint in custard apples sprayed with Prochloraz		
Sponsor: (Name & address)	Robert Vitelli, Bayer Crop Science, PO Box 449, Clayfield QLD	
Study Director:	Phillip Wilk – NSW DPI Peter Dal Santo	
Site Number:	1 – Alstonville NSW	
Trial Location:	Alstonville	**State:** NSW
Principle Investigator:	Name: Phillip Wilk	
	Address: NSW DPI Wollongbar NSW	
	Telephone: 02 66261294	Facsimile:
	Mobile: 0411139567	Email: phillip.wilk@industry.nsw
Study Person(s):	Name: Philip Stacey	
	Address: 145 Victoria Park Rd, Alstonville NSW	
	Telephone: 02 66295333	Facsimile:
	Mobile:	Email:pcstacey@bigpond.com
Scheduled Start Date:	20-12-2011	
Scheduled Completion Date:	15-2-2012	
Crop:	Custard Apples (Annona spp.)	
Variety:	Pinks Mammoth	
Product Name:	Octave	
Active Ingredient:	Prochloraz 462g/kg	

Site Details

Co-operators Name:	Phil Stacey		
Address:	145 Victoria Park Rd, Alstonville NSW		
Telephone:	02 66295333	**Facsimile:**	
Mobile:		**Email:**	pcstacey@bigpond.com
Paddock ID:	KJP vase block		
Soil Type:	Red Kraznos		
Crop:	Custard Apple	**Cultivar:**	
Date Planted:	2004		
Planting Method: (tick one)	Vase trees		
Plot Size:	45 trees		
Plot Design:	Trees planted on spacings of 6m in the row, 7m between the rows		
Plot Description:			
Unusual Features of Plot:			

Site Details (cont):

Location Map:

Site Plan:

Test Substance:

Product Name:	Octave
Active Ingredients:	Prochloraz 462g/kg
Formulation & Type:	
Batch Number:	Product Provided by Bayer
CAS Number:	
NRA NPRIS Record No.:	
NRA Approval Number:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Octave	100g/100Lts
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:				
Application Date:	20-12-2011	11-1-2012	15-2-2012	
Crop Growth Stage:	Early flowering	Flower/early fruit set	Early fruit growth	
Start Time:	9am	9am	9.30am	
Finish Time:	10.30am	10am	10.30am	
Dry Bulb: (^{0}C)	26	28	25	
Relative Humidity: (%)	61	70	65	
Wind Speed: (m/sec)	5km/hr	5/km/hr	<5km/hr	
Wind Direction:	N	SE	SW	
Cloud Cover: (%)	50%	Nil	10%	
Soil Moisture:	Dry	Moist	wet	
Rainfall 24 hrs before and after application:	0	0	5-10mls	
Treatment Application Order:	Only one chemical applied	Only one chemical applied	Only one chemical applied	
Type of Application: (eg foliar, band)	Foliar	Foliar	Foliar	
Equipment used:	Back Pack Sprayer			
Nozzle Type:	Mechanical back pack	Mechanical back pack	Mechanical back pack	
Sprayer output: (ml/min)	2.5l/min	2.5l/min	2.5l/min	
Exposure time: (sec/plot)	45sec.	45sec.	45sec.	
Application volume: (ml/plot)	2lts	2lts	2lts	
Application volume: (L/ha)	750l/ha	750l/ha	750l/ha	

NB – trees are only small and sprayed to point of run off

Total number of applications:	

Time between applications:	**Application Number**	**Days**
	1	0
	2	21
	3	36
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
	n/a	
Unusual weather or occurrences during the trial:		

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Ballina NSW**
Distance from site:	**10kms**

Attach photo of trial site:

Mixing chemical

Photo taken after trial has been pegged and before the first application.

Spraying chemical

Photo taken immediately after the last application.

Observations of efficacy and crop safety at treatment

10kgs mature fruit harvested on 19-6-2012 and sent to Qld DPI for taint tests	

Residue Study Field Trial Report Form
Part A - Treatments

Study number:	QLD –	
Title: Trials to determine the residues of Pyraclostrobin in Custard Apples with skin removed.		
Sponsor: (Name & address)	NUFARM	
Study Director:	Peter Dal Santo, AgAware Consulting Pty Ltd, 21 Rosella Ave., Strathfieldsaye, Vic 3551	
Site Number:	1	
Trial Location:	Glasshouse Mountains	**State:** Qld
Principle Investigator:	Name: Grant Bignell	
	Address: Maroochy Research Station, PO Box 5083, SCMC (Mayers Road), Nambour Qld 4560	
	Telephone: 07 5453 5947	Facsimile: 07 5453 5901
	Mobile: 0419 773 206	Email: grant.bignell@deedi.qld.gov.au
Study Person(s):	Name: Kerry & Ros Smerdon	
	Address: 2295 Old Gympie Road, Glasshouse Mtns 4518	
	Telephone: 07 5493 0268	Facsimile: 07 5493 0924
	Mobile: 0417 612 488	Email: kerryros@bigpond.com
Scheduled Start Date:	16/07/12	
Scheduled Completion Date:	02/08/12	
Crop:	Custard Apples	
Variety:	Pinks Mammoth	
Product Name:	Cabrio	

Active Ingredient:	Pyraclostrobin 250g/l

Site Details

Co-operators Name:	Kerry & Ros Smerdon		
Address:	2295 Old Gympie Road, Glasshouse Mountains Q 4518		
Telephone:	07 5493 0268	**Facsimile:**	07 5493 0924
Mobile:	0417 612 488	**Email:**	kerryros@bigpond.com
Paddock ID:	CA6		
Soil Type:	Sandy loam		
Crop:	Custard Apple	**Cultivar:**	Pinks Mammoth
Date Planted:	February 2006		
Planting Method: (tick one)	Container method trees		
Plot Size:	1.1 ha		
Plot Design:	Hedge row planting		
Plot Description:	Treatments applied to 450 trees in the block. Trees sprayed on both sides using Silvan airblast sprayer		
Unusual Features of Plot:	None		

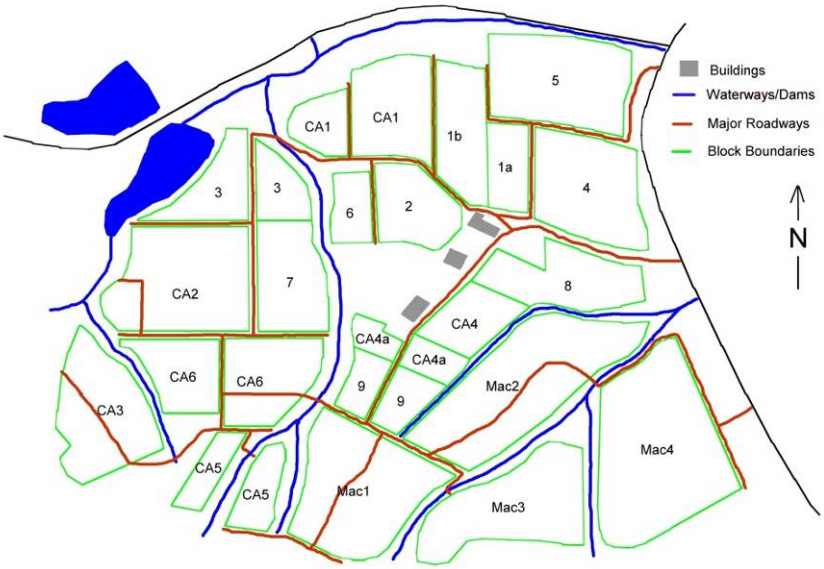
Site Details (cont):

Location Map:

Trees located at 2295 Old Gympie Road, Glasshouse Mountains Q 4518. Rows run east to west.

Site Plan:

Test



Substance:

Product Name:	Cabrio
Active Ingredients:	Pyraclostrobin 250g/
Formulation & Type:	Cabrio liquid
Batch Number:	0004652616
APVMA NPRIS Product No.:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Cabrio	80ml/100L
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:	16/7/12	23/7/12	30/7/12	
Application Date:	16/7/12	23/7/12	30/7/12	
Crop Growth Stage:	Mature canopy	Mature canopy	Mature canopy	
Start Time:	9am	9am	9am	
Finish Time:	10:15am	10:15am	10:15am	
Dry Bulb: (^{0}C)	14.6	15.6	15.9	
Relative Humidity: (%)	58%	69%	50	
Wind Speed: (m/sec)	3km/h	2km	2km	
Wind Direction:	S/SW	SW	W/SW	
Cloud Cover: (%)	20%	25%	15%	
Soil Moisture:	4	4	4	
Rainfall 24 hrs before and after application:	Nil	Nil	Nil	
Treatment Application Order:	Cabrio	Cabrio	Cabrio	

Type of Application: (eg foliar, band)	Foliar	Foliar	Foliar	
Equipment used:	Silvan Air Blast sprayer			
Nozzle Type:	Albuz ceramic cone	Albuz ceramic cone	Albuz ceramic cone	
Sprayer output: (ml/min)	20L/min	20L/min	20L/min	
Exposure time: (sec/plot)	7 sec/tree	7 sec/tree	7 sec/tree	
Application volume: (ml/plot)	3L/tree	3L/tree	3L/tree	
Application volume: (L/ha)	1250l/ha	1250l/ha	1250l/ha	

Total number of applications:		
Time between applications:	**Application Number**	**Days**
	1	0
	2	7
	3	14
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
	Nil	

Unusual weather or occurrences during the trial:	Nil

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Beerburrum**
Distance from site:	**8.5km**

Attach photo of trial site:

Photo taken after trial has been pegged and before the first application.

Photo taken immediately after the last application.

Observations of efficacy and crop safety at treatment

20 pieces of fruit picked on 02/08/12 (3 days after last Cabrio spray) and placed in freezer.	Control fruit harvested from an unsprayed block.

Residue Study Field Trial Report Form
Part A - Treatments

Study number:	NSW - 1	
Title: Trials to determine the residues of Pyraclostrobin in Custard Apples with skin removed.		
Sponsor: (Name & address)	NUFARM	
Study Director:	Peter Dal Santo, AgAware Consulting Pty Ltd, 21 Rosella Ave., Strathfieldsaye, Vic 3551	
Site Number:	1	
Trial Location:	Alstonville,	**State:** NSW
Principle Investigator:	Name: Grant Bignell	
	Telephone:	Facsimile:
	Mobile:	Email:
Study Person(s):	Name: Philip Stacey	
	Address:145 Victoria Park Rd, Alstonville NSW 2477	
	Telephone: 02 66295333	Facsimile: 02 66295422
	Mobile:	Email:pcstacey@bigpond.com
Scheduled Start Date:	2-7-2012	
Scheduled Completion Date:	19-7-2012	
Crop:	Custard Apples	
Variety:	Pinks Mammoth	
Product Name:	Cabrio	
Active Ingredient:	Pyraclostrobin	

Site Details

Co-operators Name:	Philip & Patti Stacey		
Address:	145 Victoria Park Rd, Alstonville NSW 2477		
Telephone:	02 66295333	**Facsimile:**	02 66295422
Mobile:		**Email:**	pcstacey@bigpond.com
Paddock ID:	KJ Pinks Hedge row trees		
Soil Type:	Red Krasnos		
Crop:	Custard Apple	**Cultivar:**	Pinks Mammoth
Date Planted:	Jan 2004		
Planting Method: (tick one)	Container grown trees		
Plot Size:	54 trees planted 6x3.5m		
Plot Design:	Hedge row planting 474 trees/ha		
Plot Description:	Treatments applied to 54 trees in the block. Trees sprayed on both sides using Silvan mister.		
Unusual Features of Plot:	Small trees in size		

Site Details (cont):

Location Map:

Custard Apple Orchard situated on Victoria Park Rd, Dalwood via Alstonville. Rows running north/south.

Site Plan:

Test Substance:

Product Name:	Cabrio
Active Ingredients:	Pyraclostrobin 250g/
Formulation & Type:	Cabrio – liquid
Batch Number:	0004652616
CAS Number:	
NRA NPRIS Record No.:	
NRA Approval Number:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Cabrio	80mL/100L
3		

19-7-2012

Treatment Application Record

Application No.:	1	2	3	
Scheduled Timing:	2-7-2012	9-7-2012	16-7-2012	
Application Date:	2-7-2012	9-7-2012	16-7-2012	
Crop Growth Stage:	mature canopy	mature canopy	mature canopy	
Start Time:	9am	9am	9am	
Finish Time:	10am	10am	10am	
Dry Bulb: (^{0}C)	20°C	18°C	19°C	
Relative Humidity: (%)	65%	60%	70%	
Wind Speed: (m/sec)	1m/sec	nil	nil	
Wind Direction:	North west	nil	nil	
Cloud Cover: (%)	20%	0%	60%	
Soil Moisture:	Field capacity	Field capacity	Field capacity	
Rainfall 24 hrs before and after application:	0mm	0mm	0mm	
Treatment Application Order:	Cabrio	Cabrio	Cabrio	
Type of Application: (eg foliar, band)	foliar	foliar	foliar	
Equipment used:	Silvan mister sprayer			
Nozzle Type:	Mister	Mister	Mister	
Sprayer output: (ml/min)	8L/min	8L/min	8L/min	
Exposure time: (sec/plot)	8.3sec/tree	8.3sec/tree	8.3sec/tree	
Application volume: (ml/plot)	1.1L/tree	1.1L/tree	1.1L/tree	
Application volume: (L/ha)	521L/ha	521L/ha	521L/ha	

Small trees, hedge row plantings, 474 trees/ha

Total number of applications:		
Time between applications:	**Application Number**	**Days**
	1	0
	2	7
	3	14
Additional chemicals used before, during and after applications:	**Date**	**Product**
	Nil	
Unusual weather or occurrences during the trial:		

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Ballina**
Distance from site:	**10kms**

Attach photo of trial site:

Photo taken after trial has been pegged and before the first application.

Spraying Cabrio

Harvesting fruit samples after Cabrio sprays

Observations of efficacy and crop safety at treatment

20 pieces of fruit picked on 19-7-2012 (3 days after last Cabrio spray) and placed in freezer.	Control fruit harvested from an unsprayed block.

Efficacy and Crop Safety Study
Field Trial Report Form

Trial Number: 1	**Site Number: A NSW**	
Title: Efficacy Trials of Fipronil Butt Sprays for Ants on Custard Apple Trees		
Trial Location:	Dalwood, Alstonville	**State:** NSW
Trial operator:	**Name:** Phil Stacey	
	Address: 145 Victoria Park Rd, Alstonville NSW 2477	
	Telephone: 02 66295333	**Facsimile:** 02 66295442
	Mobile:	**Email:** **pcstacey@bigpond.com**
Crop:	Custard Apples	
Variety:	Pinks Mammoth	
Product Name:	Regent 200 sc	
Active Ingredient:	Fipronil	
Trial participants:	Phil and Patti Stacey	

Site Details

Co-operators Name:	Phil and Patti Stacey				
Address:	145 Victoria Park Rd, Alstonville NSW 2477				
Telephone:	02 66295333		**Facsimile:**	02 66295422	
Mobile:			**Email:**	pcstacey@bigpond.com	
Paddock ID:	Custard Apple block				
Soil Type:	Krasnos				
Crop:	Custard apples		**Cultivar:**	Pinks Mammoth	
Date Planted:	2010				
Planting Method:	**Direct seeded**	**Transplant**	**Permanent crop X**	**Trees/vines** X	**Other**
Plant structure:	Trees on vertical trellis				
Irrigation method:	Under tree sprinklers				
Plot Size:	1 ha				
Trial Design:	Trees and posts selected with moderate ant activity		**Replications:**		
Plot Description:	3 year old trees planted on vertical trellises under bird netting. Concrete posts in trellis with wires. Timber support posts for netting.				

Site Details (cont):

Sketch the location of the study site showing plots in relation to main features of property. Indicate on the sketch the direction of spraying.

Location Map:

Site Plan:

Weather Information:

Attach weather data for the period from the first application to last inspection.	
Data location:	Farmers own data
Distance from site:	On site

Product details:

Product Name:	Regent 200 SC
Active Ingredients:	Fipronil
Formulation & Type:	Liquid
Batch Number:	BN 110F 100002 dom. 9-11
Product sourced from:	Nufarm

Treatment Information:

Treatment No.	Product	Rate of product application
1	Regent 200sc	12.5mls/100lt
2	Regent 200 sc	12.5mls/100lt
3		
4		
5		
6		

Adjuvant: **(product & rate if used)**	

Treatment Application Record:

Application No.:	**1**	**2**	**3**	**4**
Application Date:	16-3-2013	30-3-2013		
Crop Growth Stage:	Early fruit set	Early fruit set		
Temperature: (^{0}C)	28 degrees	25 degrees		
Wind Speed: (m/sec)	nil	slight		
Wind Direction:	Nil	Sth east		
Cloud Cover: (%)	30%	100%		
Soil Moisture:	Moist	moist		
Rainfall 24 hrs before and after application:	1.5mls before	8mls before		
Type of application: (eg foliar, band, granule)	Band	Band		
Equipment used:	Silvan Spot Sprayer			
Application volume: (L/ha)	10 lts	10 lts		
Product rate: (mL or L/ha)	12.5mls/100lts	12.5mls/100lts		
Total number of applications:	2			

Time between applications:	**Application Numbers**	**Days**
	1-2	14 days
	2-3	

Treatment Application Record (cont):

Chemicals used before, during and after applications in trial site:	**Date**	**Product**
	Nil	
Standard treatment used in trial:	**Date**	**Product**
Results of standard treatment:		
Unusual weather or occurrences during the trial:	Rainfall 240mm during trial. No heavy rain fell.	

Observations pre and post treatments:

Observations of crop safety at:	Crop stage	Observations
Early March	Early fruit set	Ants active on trees and netting support posts
23-3-13 One week after 1st application	Early fruit set	Some posts have no ant activity, trees still have ant activity
14-4-13 2 weeks after 2nd application	Fruit set	A little ant activity on 1 tree, nil ant activity on other trees and posts. Ants still active on control sites.
28-4-2013 4 weeks after 2nd application	Fruit maturing	No sign of ant activity on treated trees

Efficacy evaluation:

Target pest

Target:	Ants
Crop history:	3 year old trees with active ants on trees and support posts.
Seasonal conditions impact on target:	3 months drought followed by 2 months rain. Ant activity higher than normal during this time

Assessment sample, method and timing

Number of trunks, leaves and nuts at each assessment:	
Assessment method:	Visual
First assessment time:	16-3-2013 10am
Second assessment time:	23-3-2013 10am
Third assessment time:	14-4-2013 10am
Fourth assessment time:	28-4-2013 10am

Observations of efficacy:

Treatment & Product rate	Assessments at:	Size of suckers:	Level of control at 7 days	Level of control at 14 days	Level of control at 28 days
Butt & ground spray of Fipronil @ 12.5mls/100lts	First assessment		**fair**		
	Second assessment			**good**	
	Third assessment				**Very good**
	First assessment				
	Second assessment				
	Third assessment				
No treatments - **Control sites**	First assessment		**Ants active**		
	Second assessment			**Ants active**	
	Third assessment				**Ants active**

Observations of crop safety:

Treatment & Product rate	Assessments at:	Symptoms on bark	Symptoms on leaves	Symptoms on flowers/nuts
	First assessment	**nil**	**Nil**	**nil**
	Second assessment	**nil**	**nil**	**nil**
	Third assessment	**nil**	**nil**	**nil**
	First assessment			
	Second assessment			
	Third assessment			
Standard treatments	First assessment	**nil**	**nil**	**nil**
	Second assessment			
	Third assessment			

DISCUSSION

BUREAU OF METEOROLOGY DATA

Farmers own data

Trial period – 16-3-2013 to 28-4-2013

- Average maximum temperature – 26
- Average minimum temperature – 16
- Total rainfall – 240mm

Efficacy and Crop Safety Study
Field Trial Report Form

Trial Number: 1	**Site Number: B QLD**	
Title: Efficacy of fipronil for controlling ants in custard apple trees		
Trial Location:	Nambour	**State:** QLD
Trial operator:	**Name:** Grant Bignell	
	Address: 47 Mayers Rd Nambour Qld 4560	
	Telephone: 0754535947	**Facsimile:** 0754535901
	Mobile: 0419773206	**Email:** **Grant.bignell@daff.qld.gov.au**
Crop:	Custard Apples (*Annona spp.)*	
Variety:	KJ Pinks	
Product Name:	Regent 200SC	
Active Ingredient:	Fipronil	
Trial participants:	Grant Bignell and David Bruun	

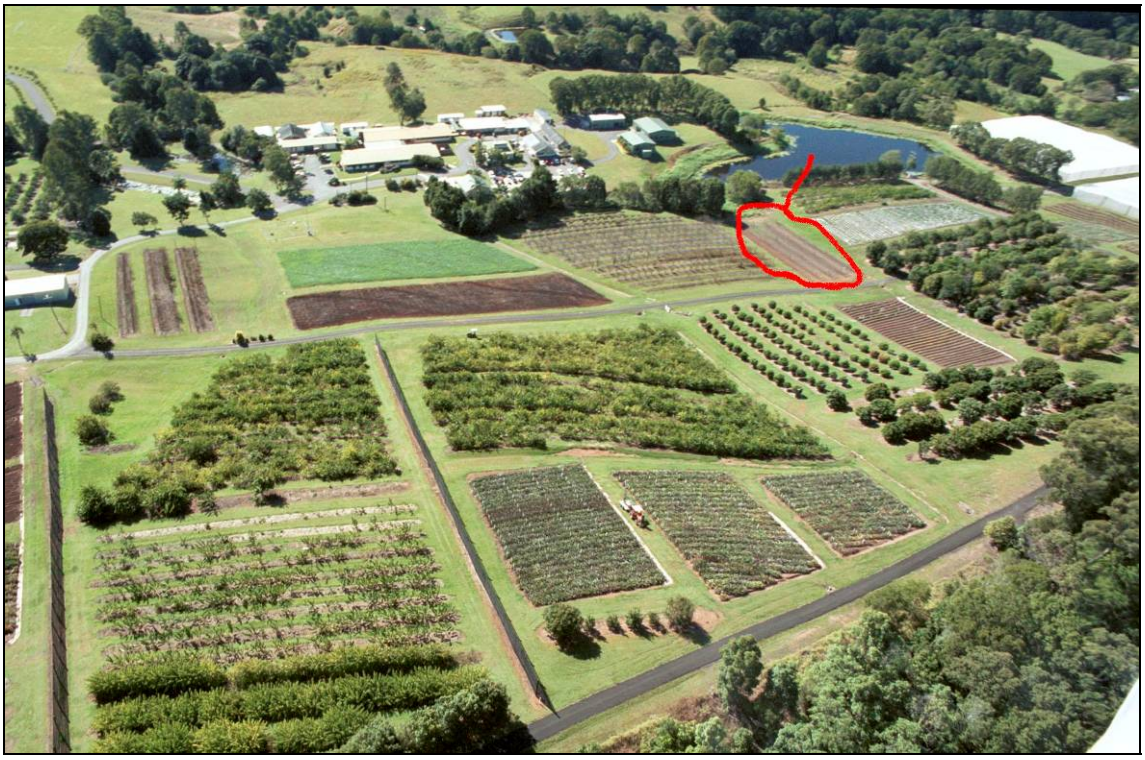
Site Details

Co-operators Name:	Grant Bignell DAFF				
Address:	47 Mayers Road, Nambour Qld 4560				
Telephone:	0754535947		**Facsimile:**	0754535901	
Mobile:	0419773206		**Email:**	grant.bignell@daff.qld.gov.au	
Paddock ID:	C block				
Soil Type:	Clay Loam				
Crop:	Custard Apples		**Cultivar:**	KJ Pinks	
Date Planted:	2009				
Planting Method: **(tick one)**	**Direct seeded**	**Transplant**	**Permanent crop** **X**	**Trees/vines**	**Other**
Plant structure:	Trellis				
Irrigation method:	Overhead sprinklers				
Plot Size:	0.25 Ha				
Trial Design:	Non-randomised Trees and posts selected with ant activity		**Replications:**	6	
Plot Description:	4 year old KJ Pinks planted on V-trellis.				

Site Details (cont):

Sketch the location of the study site showing plots in relation to main features of property. Indicate on the sketch the direction of spraying.

Location Map:



Site Plan:

Weather Information:

BUREAU OF METEOROLOGY DATA Trial period – 29/11/2012 to 13/01/2013 • Average maximum temperature – 30.2 • Average minimum temperature – 19.3 Total rainfall – 7.6ml	
Data location:	Nambour
Distance from site:	1km

Product details:

Product Name:	Regent
Active Ingredients:	Fipronil
Formulation & Type:	Liquid
Batch Number:	BN 110F 100002 dom. 9-11
Product sourced from:	Nufarm

Treatment Information:

Treatment No.	Product	Rate of product application
1	Regent 200SC	12.5ml/100L
2	Regent 200SC	12.5ml/100L
3		
4		
5		
6		

Adjuvant: **(product & rate if used)**	

Treatment Application Record:

Application No.:	**1**	**2**	**3**	**4**
Application Date:	29/11/2012	13/12/2012		
Crop Growth Stage:	Fruit set	Fruit Set		
Temperature: (^{0}C)	28	25.6		
Wind Speed: (m/sec)	15km/h	15km/h		
Wind Direction:	ENE	ESE		
Cloud Cover: (%)	30	40		
Soil Moisture:	Moist	Moist		
Rainfall 24 hrs before and after application:	0.0-0.0	0.0-5.0		
Type of application: (eg foliar, band, granule)	Butt and radial band	Butt and radial band		
Equipment used:	Solo Backpack Sprayer			
Application volume: (L/ha)	10L	10L		
Product rate: (mL or L/ha)	12.5ml/100L	12.5ml/100L		
Total number of applications:	2			

Time between applications:	**Application Numbers**	**Days**
	1-2	14

Treatment Application Record (cont.):

Chemicals used before, during and after applications in trial site:	**Date**	**Product**
	NIL	
Standard treatment used in trial:	**Date**	**Product**
Results of standard treatment:		
Unusual weather or occurrences during the trial:	NIL	

Observations pre and post treatments:

Observations of crop safety at:	Crop stage	Observations
28/11/2012	Flowering and fruit set	Some ant activity observed on branches and trunks of trees and support post of trellis in C block
6/12/2013 One week after first application.	Flowering and fruit set	No ant activity on treated posts and trees. Some ant activity on control trees
27/12/2013 Two weeks after second application	Fruit set	No ant activity on treated posts and trees. Some ant activity on control trees.
10/01/2013 Four weeks after second application	Fruit growth	Treated trees had no ant activity after treatments were applied compared to control trees which had some minor ant activity in most trees.

Efficacy evaluation:

Target pest

Target:	Ants
Crop history:	Ant activity has been observed over several seasons on this block
Seasonal conditions impact on target:	Very dry conditions during this trial until early January followed by significant rain in January/February.

Assessment sample, method and timing

Number of trunks, leaves and nuts at each assessment:	6 trunks of control trees and 6 trunks of treated trees
Assessment method:	Visual
First assessment time:	28/11/2012
Second assessment time:	6/12/2012
Third assessment time:	27/12/2012
Fourth assessment time:	10/1/2013

Observations of efficacy:

Treatment & Product rate	Assessments at:	Size of suckers:	Level of control at 14 days	Level of control at 28 days	Level of control at XX days
Fipronil	First assessment		**Trees have no ant activity**		
Fipronil	Second assessment			**All trees have no ant activity**	
Fipronil	Third assessment				**All trees have no ant activity**
Treatments Control	First assessment		**Minor ant activity in all trees**		
Control	Second assessment			**Minor ant activity observed in most trees**	
Control	Third assessment				**Some ant activity observed in 4 of six trees**

Observations of crop safety:

Treatment & Product rate	Assessments at:	Symptoms on bark	Symptoms on leaves	Symptoms on flowers/fruit
	First assessment	**nil**	**nil**	**nil**
	Second assessment	**nil**	**nil**	**nil**
	Third assessment	**nil**	**nil**	**nil**
Standard treatments	First assessment	**nil**	**nil**	**nil**
	Second assessment	**nil**	**nil**	**nil**
	Third assessment	**nil**	**nil**	**nil**

Residue Study Field Trial Report Form
Part A - Treatments

Study number:	1 - NSW	
Title: Residue study field trial report on Fipronil butt and ground sprays on Custard Apple trees to control ants.		
Sponsor: (Name & address)	Grant Bignell – Queensland DAFF	
Study Director:	Phil Stacey	
Site Number:	1-NSW	
Trial Location:	Dalwood, Alstonville	**State:** NSW
Principle Investigator:	Name: Grant Bignell	
	Address:Maroochy Research Station, Nambour Qld	
	Telephone:07 54535947	Facsimile:
	Mobile:0419773206	Email:grant.bignell@daff.qld.gov.au
Study Person(s):	Name: Phil & Patti Stacey	
	Address: 145 Victoria Park Rd, Alstonville NSW 2477	
	Telephone: 02 66295333	Facsimile:02 66295422
	Mobile:	Email:pcstacey@bigpond.com
Scheduled Start Date:	18-4-2013	
Scheduled Completion Date:	23-5-2013	
Crop:	Custard Apples	
Variety:	Pinks Mammoth	
Product Name:	Regent 200sc	
Active Ingredient:	Fipronil	

Site Details

Co-operators Name:	Phil & Patti Stacey		
Address:	145 Victoria Park Rd, Alstonville NSW 2477		
Telephone:	02 66295333	**Facsimile:**	02 66295422
Mobile:		**Email:**	pcstacey@bigpond.com
Paddock ID:	Main Custard Apple block		
Soil Type:	Krasnos		
Crop:	Custard Apples	**Cultivar:**	Pinks Mammoth
Date Planted:	2004		
Planting Method: (tick one)			
Plot Size:	1ha		
Plot Design:	Trees planted on 3.5m x 6m spacings		
Plot Description:	9 year old custard apple trees grown in open goblet form.		
Unusual Features of Plot:	Nil		

Site Details (cont.):

Location Map:

Site Plan:

Test Substance:

Product Name:	Regent 200 sc
Active Ingredients:	Fipronil
Formulation & Type:	Liquid
Batch Number:	BN 110F 100002 DOM 9/11
APVMA NPRIS Product No.:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Regent	12.5ml/100lt water
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:	9am	9am		
Application Date:	18-4-13	2-5-13		
Crop Growth Stage:	Fruit set	Fruit set		
Start Time:	9am	9am		
Finish Time:	9.15am	9.15am		
Dry Bulb: (^{0}C)	26	24		
Relative Humidity: (%)	65%	75%		
Wind Speed: (m/sec)	Nil	nil		
Wind Direction:	Nil	nil		
Cloud Cover: (%)	0%	50%		
Soil Moisture:	Moist	Moist		
Rainfall 24 hrs before and after application:	Nil	nil		
Treatment Application Order:				
Type of Application: (e.g. foliar, band)	Butt & soil application	Butt & soil application		
Equipment used:	Silvan Spot Sprayer			
Nozzle Type:				
Sprayer output: (ml/min)	100mls/min	100mls/min		
Exposure time: (sec/plot)	30sec	30sec		
Application volume: (ml/plot)	10lts	10lts		
Application volume: (L/ha)				

Total number of applications:		
Time between applications:	**Application Number**	**Days**
	1	
	2	14 days
	3	
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
	nil	
Unusual weather or occurrences during the trial:		

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Farmer's data used – average max. Temperature 24 degrees, min temp 16 degrees. Rainfall - 120 mm**
Distance from site:	**At site**

Attach photo of trial site:

Mixing Fipronil

Application of Fipronil to butts

Applying Fipronil to ground

Observations of efficacy and crop safety at treatment

	Efficacy and crop safety reported on another sheet

Residue Study Field Trial Report Form
Part A - Treatments

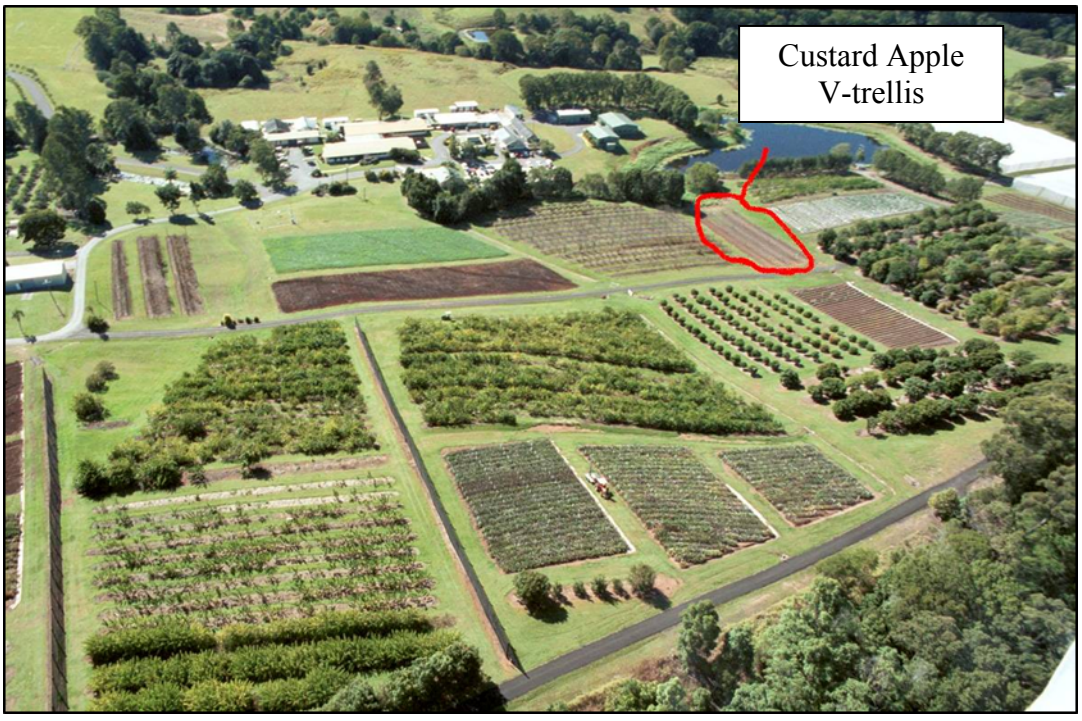
Study number:	2-QLD	
Title: Residue study field trial report on Fipronil butt and ground sprays on custard apple trees to control ants		
Sponsor: (Name & address)	DAFFQ	
Study Director:	Grant Bignell	
Site Number:	2-Qld	
Trial Location:	Nambour	**State:** QLD
Principle Investigator:	Name: Grant Bignell	
	Address: 47 Mayers Rd Nambour Qld 4560	
	Telephone: 0754535947	Facsimile: 0754535901
	Mobile: 0419 773 206	Email: grant.bignell@daff.qld.go
Study Person(s):	Name: as above	
	Address:	
	Telephone:	Facsimile:
	Mobile:	Email:
Scheduled Start Date:	13/03/2013	
Scheduled Completion Date:	27/03/2013	
Crop:	Custard Apple	
Variety:	Pinks Mammoth	
Product Name:	Regent 200sc	
Active Ingredient:	Fipronil	

Site Details

Co-operators Name:	Grant Bignell- DAFFQ		
Address:	47 Mayers Rd Nambour Qld 4560		
Telephone:	07 54535947	**Facsimile:**	0754535901
Mobile:	0419773206	**Email:**	grant.bignell@daff.qld.gov.au
Paddock ID:	C Block		
Soil Type:	Clay loam		
Crop:	Custard apple	**Cultivar:**	Pinks Mammoth
Date Planted:	2009		
Planting Method: (tick one)			
Plot Size:			
Plot Design:	V Trellis		
Plot Description:	4 year old trees espaliered on an open V-trellis.		
Unusual Features of Plot:	NIL		

Site Details (cont):

Location Map:



Test Substance:

Product Name:	Regent 200sc
Active Ingredients:	Fipronil
Formulation & Type:	Liquid
Batch Number:	BN 110F 100002 DOM 9/11
APVMA NPRIS Product No.:	

Treatment Information

Treatment No.	Product	Rate of Application
1	Control	---
2	Regent 200sc	12.5ml/100L
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:	13/03/2013	27/03/2013		
Application Date:	13/03/2013	13/03/2013		
Crop Growth Stage:	Fruit Growth	Fruit Growth		
Start Time:	14:30	14:15		
Finish Time:	14:40	14:20		
Dry Bulb: (^{0}C)	26.3	25.6		
Relative Humidity: (%)	49%	64%		
Wind Speed: (m/sec)	1km/h	13km/h		
Wind Direction:	ESE	ESE		
Cloud Cover: (%)	30	20		
Soil Moisture:	Moist	Moist		
Rainfall 24 hrs before and after application:	8.6-0.0	0.2-1.0		
Treatment Application Order:	1	2		
Type of Application: (e.g. foliar, band)	Butt and soil radial band	Butt and soil radial band		
Equipment used:	Solo backpack sprayer			
Nozzle Type:	cone	cone		
Sprayer output: (ml/min)	750ml/min	750ml/min		
Exposure time: (sec/plot)	35sec	45sec		
Application volume: (ml/plot)	2.3litres on 5 trees	3 litres on 5 trees		
Application volume: (L/ha)				

Total number of applications:		
Time between applications:	**Application Number**	**Days**
	1	0
	2	14
	3	
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
Unusual weather or occurrences during the trial:	NIL	

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Nambour** **Average temperatures from 13/03/2013-17/04/2013** **Av. Min- 18.3ºC** **Av. Max- 26.8 ºC** **Total Rainfall- 252mm**
Distance from site:	**1km**

Attach photo of trial site:

Photo taken after trial has been pegged and before the first application.

Last application to soil and butts

Residue Study Field Trial Report Form
Part A - Treatments

Study number:	QLD –	
Title: Trials to determine the residues of Sunny in Custard Apples with skin removed.		
Sponsor: (Name & address)	Sumitomo	
Study Director:	Peter Dal Santo, AgAware Consulting Pty Ltd, 21 Rosella Ave., Strathfieldsaye, Vic 3551	
Site Number:	1	
Trial Location:	Glasshouse Mountains	**State:** Qld
Principle Investigator:	Name: Grant Bignell	
	Address: Maroochy Research Station, PO Box 5083, SCMC (Mayers Road), Nambour Qld 4560	
	Telephone: 07 5453 5947	Facsimile: 07 5453 5901
	Mobile: 0419 773 206	Email: grant.bignell@deedi.qld.gov.au
Study Person(s):	Name: Kerry & Ros Smerdon	
	Address: 2295 Old Gympie Road, Glasshouse Mtns 4518	
	Telephone: 07 5493 0268	Facsimile: 07 5493 0924
	Mobile: 0417 612 488	Email: kerryros@bigpond.com
Scheduled Start Date:	22 November 2011	
Scheduled Completion Date:	14 March 2012	
Crop:	Custard Apples	
Variety:	Pink's Mammoth	
Product Name:	Sunny	
Active Ingredient:	Uniconazole	

Site Details

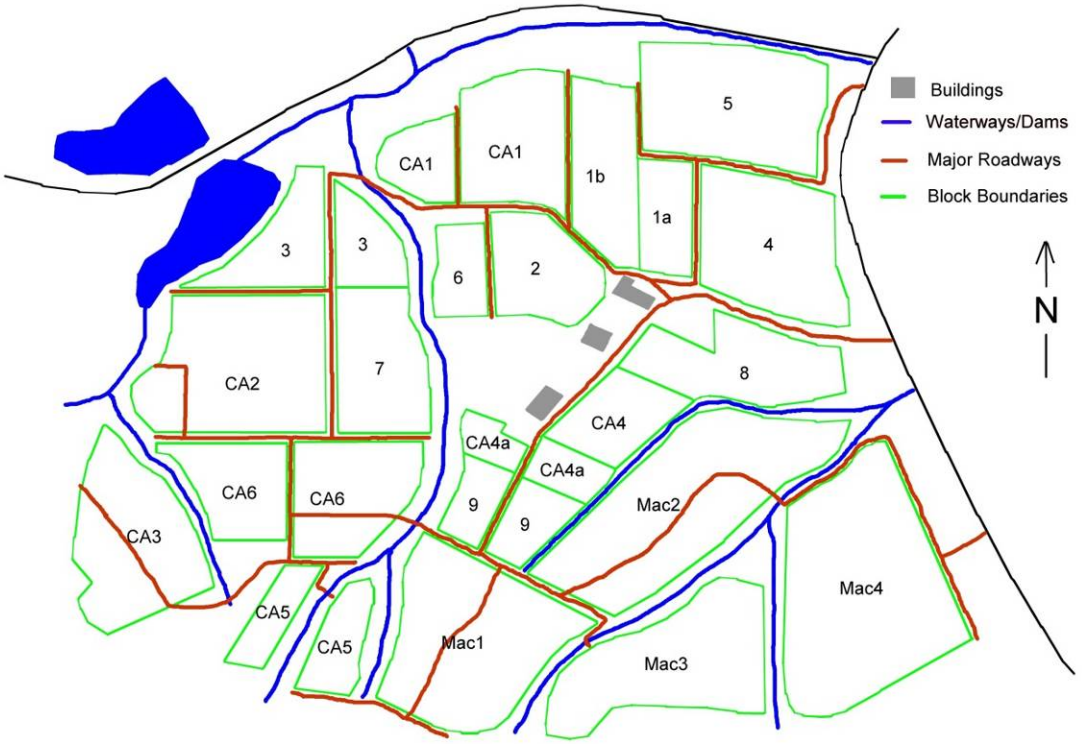
Co-operators Name:	Kerry & Ros Smerdon		
Address:	2295 Old Gympie Road, Glasshouse Mountains Q 4518		
Telephone:	07 5493 0268	**Facsimile:**	07 5493 0924
Mobile:	0417 612 488	**Email:**	kerryros@bigpond.com
Paddock ID:	CA1		
Soil Type:	Sandy loam		
Crop:	Custard Apple	**Cultivar:**	Pinks Mammoth
Date Planted:	2002		
Planting Method: (tick one)	Container method trees		
Plot Size:	1.2ha		
Plot Design:	Hedge row planting		
Plot Description:	Treatments applied to 440 trees in the block. Trees sprayed on both sides using Silvan airblast sprayer		
Unusual Features of Plot:	None		

Site Details (cont):

Location Map:

Trees located at 2295 Old Gympie Road, Glasshouse Mountains Q 4518. Rows run north to south.

Site Plan:



Test Substance:

Product Name:	Sunny
Active Ingredients:	Uniconazole 50g/l
Formulation & Type:	Sunny liquid
Batch Number:	10088163

APVMA NPRIS Product No.:	

Treatment Information

Treatment No.	**Product**	**Rate of Application**
1	Control	---
2	Sunny	1%
3		
4		
5		

Treatment Application Record

Application No.:	1	2	3	4
Scheduled Timing:	21/11/11			
Application Date:	21/11/11			
Crop Growth Stage:	Mature canopy			
Start Time:	10.20am			
Finish Time:	11:35am			
Dry Bulb: (^{0}C)	26.5			
Relative Humidity: (%)	52%			
Wind Speed: (m/sec)	2km/hr			
Wind Direction:	N			
Cloud Cover: (%)	20%			
Soil Moisture:	4			
Rainfall 24 hrs before and after application:	Nil			

Treatment Application Order:	Sunny			
Type of Application: (eg foliar, band)	Foliar			
Equipment used:	Silvan Air Blast sprayer			
Nozzle Type:	Albuz ceramic cone			
Sprayer output: (ml/min)	7 sec/tree			
Exposure time: (sec/plot)	3L/tree			
Application volume: (ml/plot)	650L per block			
Application volume: (L/ha)	540L/ha			

Total number of applications:	1	
Time between applications:	**Application Number**	**Days**
	1	0
	2	
	3	
	4	
Additional chemicals used before, during and after applications:	**Date**	**Product**
	21/11/11	Agral

Unusual weather or occurrences during the trial:	

Attach weather data for the period from the first application to the last sampling.	
BOM data location:	**Beerburrum**
Distance from site:	**8.5km**

Attach photo of trial site:

Photo taken after trial has been pegged and before the first application.

Photo taken immediately after the last application.

Observations of efficacy and crop safety at treatment

	15 custard apples harvested off control trees
	15 custard apples harvested off trees sprayed with Sunny