Towards a molecular breeding program for Canning Peaches

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Project CF05002

Variety Improvement Program for Canning Peaches

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Variety Improvement Program for Canning Peaches

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The yellow-fleshed canning peach breeding program commenced in 1993. This report details progress from Jan 2006 to Aug 2008.

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Table of Contents

Media Summary

New canning peach cultivars will be progressively released to the canning industry over the next 5 years as commercial trialling progresses. The breeding program, based at DPI Tatura, has been developing a series of peach cultivars over the last 15 years. These new cultivars have characteristics similar to the standard canning peach cultivar 'Tatura 204'. They will provide an even, high quality supply of peaches over the harvest period. The chill requirement of these new cultivars has also been reduced to enable them to adapt to warmer winters.

A large emphasis of the breeding program has been on improving the high productivity standard set by Tatura 204. Productivity evaluations have been made at a range of crop loads to determine the ability of each selection to size fruit. In 2008 a high proportion of selections under evaluation showed equal productivity to Tatura 204 at crop loads from 30 to 50 t/ha. One more year of evaluation will be undertaken at crop loads of more than 50 t/ha to identify the cultivars that can consistently produce the highest canning yields.

Two promising selections have so far been identified with similar quality and yield attributes to Tatura 204 but later ripening dates. The mid February selection will produce a commercial crop of fruit on 6 trial sites next season. It has a more upright growth habit, lighter fruit set and later bloom time than Tatura 204 but fruit quality and productivity are similar. A late February selection has been identified this year in the Tatura 222/Orrvale Queen harvest period. It has a similar bloom time to Tatura 204 but potentially higher productivity and high fruit quality.

After more than 7 decades of DPI research in the development of improved varieties of canning peaches for the Australian industry the breeding program closed in 2008. Over 60% of the cultivars currently grown by the Australian Industry were developed by DPI Tatura, and as newer cultivars are released that proportion is destined to increase. The Canning Industry through SPC-Ardmona will continue to breed peaches for future needs on a private basis and drive the commercialisation of current cultivars released from the DPI program.

Photo: Promising late-February selection for trialling on commercial orchards from 2009.

Technical summary

Consistent supply of high quality, productive fruit throughout the harvest season is an integral part of the maintenance of a vibrant and competitive peach canning industry. The Australian Canning Peach Breeding Program based at the Department of Primary Industries, Tatura has produced over two thirds of the varieties currently used by the Australian Canning Industry, and has been developing a new series of peach cultivars over the last 15 years. A major aim of the breeding program was to maintain and improve upon the high productivity standard set by Tatura 204 and to determine the potential for genetic gain through reliable estimates of heritability. Another aim was to explore the genetic variation in stone tip size and stone weight to determine if improvements in stone traits were possible. Processing peaches require small stone size and short stone tip to increase the volume of flesh available for processing and to prevent stone tip breakage and stone tip splinters left in the canned product. The adaptability of peach varieties to milder winter temperature is also an important component of the breeding program to ensure peach varieties continue to bloom and set fruit normally in spring.

There was genetic variation from Tatura 204 for the range of productivity traits (fruit weight, tree yield), full bloom, fruit set and percentage pre-harvest drop based on their broad sense heritability. Just over a half of the selections had fruit set less than Tatura 204 with half of these with a fruit set too low to sustain commercial yields equivalent to Tatura 204 at a medium crop load. The productive selections had to have both mean fruit weight and gross yield equal or superior to Tatura 204. In 2006 the selections produced their first fruit crop and were thinned to an average of 15 fruit per tree to assess their fruit sizing potential. The gross yield was adjusted using number of fruits as a covariate since not all selections set sufficient fruit to carry a crop of 15 fruit which adversely affected their average gross yields. Of the 280 selections 108 and 142 selections respectively had high productivity based on gross yield and adjusted gross yield. The broad sense heritability was calculated for each of these traits to determine which trait better predicted the genetic variation. Heritability was 26% for gross yield compared to 49% for adjusted gross yield, hence 142 of the selections were deemed high productive. In season 2008 the trees had a median fruit set in November of 100 fruit per tree. All trees with more than 100 fruit were thinned to 100 fruit per tree and those with less than 100 fruit were left unthinned. Based on the combination of average canning yield and fruit weights, 50% of the selections (140) had high productivity in 2008. Of these selections 74% were identified with high productivity in 2006 in their first crop. The other selections from 2006 did not rate highly mainly due to low fruit set.

The original cross of BabyGold 7 x Oom Sarel that produced the industry standard variety Tatura 204 had a high proportion of selections continue to show promise with the highest average fruit size (153g) of all the crosses in 2008. All selections of the Yumyeong x Tatura 215 cross in 2008 rated high for productivity and had one of the highest average canning yields (33.7t/ha) of all the crosses at a medium crop load. The Yumyeong x Tatura 215 cross aims to incorporate the high productive performance, partial brown rot resistance and stony hard trait from the Korean white fleshed peach Yumyeong into the Tatura germplasm. Peaches with the stony hard gene do not soften on the tree or after harvest unless heated or treated with ethylene or 1-Amincyclopropane-1-Carboxylic Acid (the immediate precursor to ethylene). They have the potential to improve the mechanical handling and keeping quality of processed peaches without loss in fruit quality.

The majority of fruit quality traits were measured objectively (stone traits, firmness, sugar and acid levels and flesh colour) and subjective point scales used for evaluation of red pigmentation in the pit and flesh, type of flesh texture and a likeness scale for overall fruit appearance and eating quality. The accuracy of the phenotypic measurement influences the level of heritability (Hansche et al, 1972). There was significant genetic variation for quality attributes within the selections with broad sense heritability of more than 40%. Stone tips had a broad sense heritability of 44% for length and 52% for width at the base of the stone tip. These intermediate levels of heritability suggest there is potential to breed for smaller stone tips. However, there can be a large range in the size if tips found within selections and it's likely that environmental effects also have a major effect on stone tip size.

Once fruit quality was considered with productivity, 77 selections continued to show performance similar or superior to Tatura 204 in 2008. Among these selections is SAB104, harvested mid-February, it has a more upright growth habit, lighter fruit set and later bloom time than Tatura 204 but fruit quality and productivity are similar. It is likely to be the first new variety to be released by the breeding program, with others to follow as they progress through commercial evaluation.

Introduction

1.1 Ripening period

The Australian Peach Canning Industry is principally based in the Goulburn Valley with fruit processed by SPC-Ardmona. The peach canning season extends from late January to late March over a ten-week period. There are two major peaks in supply at the start of the season and mid/late season for the three varieties Tatura 204 and Golden Queen/Taylor Queen respectively. These varieties represent about two thirds of the fruit intake to the canneries, which puts tremendous pressure on them to process as many peaches as possible over short periods. Ideally they would like a series of Tatura 204 type varieties that mature at weekly intervals throughout the season.

1.2 Climate change

The possibility of milder winters occurring in the Goulburn Valley in future years would have a detrimental effect on the fruit industry. The adaptability of peach varieties to their climatic region is an important component of breeding programs. In the Goulburn Valley the winter chill factor has varied erratically between 750 and 1250 chills hours over the last 15 years. The variety Golden Queen has a medium to high chill requirement, which is only just met in some years. It requires 600-800 hours of winter chill (hours below 7.2 degrees Celsius) to foliate and bloom normally in spring (Jerie 1997). Insufficient hours of chill will lead to erratic foliation, bloom and fruit production, and flower bud abscission. Tatura 204 has a medium chill requirement between 400-600 chill hours. Tatura 204 should be adaptable to milder winter temperatures, and be a valuable parent for cross breeding for a medium chill requirement. Time of flowering can be used as an initial guide to chill requirement because early flowering varieties are generally lower in chill requirement whilst later flowering varieties are higher (Hesse 1971). The strategy in the breeding program has been to preferentially select for offspring with a bloom time between Tatura 204 and Taylor Queen. This would give the new varieties a chill requirement between 500 to 700 hours.

1.3 Fruit productivity

Productivity of a peach variety is based on its ability to size a given amount of fruit over a given area. It is dependent upon the age and vigour of the tree and environmental and cultural influences. A fruit variety must also be able to set a crop consistently at or above the optimum crop load to maintain peak production. For a canning peach in the Goulburn Valley, Australia, a tree is defined to be cropped at its optimum load when 90% of its fruit crop at maturity is more than 60 mm in diameter, the minimum size limit for processing. Formulas based on planting density and butt diameter (for the cultivar Golden Queen) have been developed to determine the required thinning levels at pit hardening for optimum productivity (Keatley et al, 1968). Productivity is an essential breeding criterion for the majority of plant breeding programs, for without a threshold level of yield their commercial production becomes non-viable. The heritability of productivity in terms of fruit yields is not known and intermediate for fruit mass in peach (Hansche, 1986, de Souza and Byrne, 1998).

Productivity evaluation is one of the most expensive and labour intensive activity of a breeding program and why quicker and easier measures of fruit size and point scale estimates of crop loads are commonly used. In addition in fresh market breeding where the principal research has been conducted, productivity is less important than in processing fruit breeding. Where productivity is measured it's usually in terms of the amount of fruit per tree (Christensen, 1995), or maximum size of attainable fruit (Topp and Sherman, 1999) rather than a combined rating at which for fruit number and fruit size is maximised (Richards and Issell, 1998). Consequently productive potential of new varieties from the majority of peach breeding programs is inadequately assessed. The size of heritability estimates are influenced by the accuracy of the phenotypic measurements (Hansche et al, 1972) and to determine the potential heritability of productivity more detailed and precise measurements of fruit productivity traits are required. Hansche et al (1972) measured the heritability of crop load on a crude 1 to 9 scale and got a narrow sense heritability estimate of 8%. De Souza and Byrne (1998b) assessed fruit size based on dimensions and mass and found the highest measure of heritability was obtained with fruit mass at 32%. Fruit set was slightly improved at 43% (de Souza and Byrne, 1998a).

1.4 Fruit quality

Stone size and stone tip length are important fruit quality traits in the processing quality of peaches. The highly productive variety Tatura 212 was rejected at the commercial evaluation stage of the previous Tatura breeding program due to problems with stone tip breakage in the cannery. Within the peach germplasm at Tatura there is variation in stone weight and stone tip size that can be potentially used in cross-breeding to improve these traits in future varieties (Richards, 2006).

There is also large variation in textural types within the germplasm, with stony hard and very crisp peaches. The major genes associated with flesh texture, melting and non-melting flesh and stony hard, are simply inherited (Scorza and Sherman, 1996). The stony hard trait is inherited independently of the melting flesh/non-melting flesh trait and is epistatic to this trait (Haji et al., 2005). Peaches with the stony hard gene do not soften on the tree or after harvest unless heated or treated with ethylene or 1-Amincyclopropane-1-Carboxylic Acid (the immediate precursor to ethylene) [Haji et al., 2003]. They have the potential to improve the mechanical handling and keeping quality of processed peaches without loss in fruit quality. The crispness of peach flesh texture has been linked to the amount of calcium bound to insoluble pectin, which are important in cell wall structure (Bassi et al, 1998).

Materials and Methods

Program objectives

The peach breeding program objectives are set by a steering committee consisting of growers, processor representatives and scientists that meet annually to review its progress. The main objectives of the project are:

1. Improved yield
    a) Productivity - trees have high numbers of large uniform sized fruit, an absence of pre-harvest drop, and the ability to size up between picks.
    b) To even out the peaks in fruit supply to the cannery and allow consistent intake for the cannery (ie. Ripening period)

2. Climatic adaptability
    a) Adaptable to global climatic changes due to the greenhouse effect (ie. 500 to 700 chill hours).
    b) Disease resistance - fruit with tolerance or resistance to diseases (ie. Brown rot).

3. Improved quality attributes
    a) Firm fruit - fruit at harvest that does not soften quickly, can withstand bruising and retains its shape and texture after cooking.
    b) Even ripening - preferably a one-pick operation so processors can more easily regulate the intake of peaches into the factory.
    c) High, even fruit colour - fruit has an enhanced and uniform appearance that enables processors to mix batches of fruit together.
    d) Small stone size/stone tip - the amount of flesh in the fruit in proportion to stone size is high, and stones are without a prominent tip that may chip off during stone removal.
    e) Good fruit flavour - new varieties should have good flavour (ie. Sugar/acid balance).

Hybridisation and seedling establishment

Over the last three years the number of annual crosses has been reduced to less than 1000. These latest crosses are being made to introduce new genes into the canning peach germplasm, and/or to make second generation crosses with advanced selections from the current breeding program.

Flower buds are collected at balloon stage and the anthers extracted by lightly rubbing the buds over 2-mm mesh. Pollen is also collected from later maturing varieties by forcing the buds to mature in a constant temperature room set at 30°C. The anthers are dried at 20-24°C following extraction for at least

12 hrs and the dehisced anthers and pollen stored in small glass jars in a desiccator. The parent trees are enclosed in shade-cloth prior to pollination to protect the emasculated buds from extremes of wind and temperature. In the Goulburn Valley, fruit set is very low on hand pollinated trees that are left uncovered (L. Issell, personal communication).

The majority of trees are pollinated twice with a one to two day interval between to improve percentage fruit set (El-Agamy and Sherman, 1987). Flower buds are emasculated at balloon stage when the trees have reached 5-10% full bloom and the buds pollinated the same day. A 4-mm square length of rubber is used to apply the pollen onto the exposed stigmas. Emasculated flowers are sprayed with the fungicide Iprodione following hand pollination to protect the exposed stigmas from disease infection. All flower buds open prior to emasculation or displaying any trace of pollen are removed to prevent self-pollination.

Fruit are harvested at maturity and the seed stratified for at least 5 to 8 weeks to overcome dormancy. When the radicles are 2mm or longer, the seed is planted into a commercially available pasteurised potting mix. The peach seedlings are kept in plastic igloos, and the floor sterilised with copper sulphate. The seedlings are planted into individual seedling pots stacked into a plastic tray and kept off the floor on wire tables. Seedlings are hand-watered, so as to avoid over watering, which can occur under an automated watering system. The peach seedlings are moved from the plastic igloos to a screen house/shade house, when they have 5 to 6 leaves, for hardening off prior to field planting. Liquid fertiliser is applied every two weeks prior to transfer into the field.

Primary and secondary block management

Seedlings are planted in the primary assessment blocks (PAB) at 0.5m x 3.5m spacing (5,700 trees per hectare). They are closely planted to promote rapid growth and early fruiting. Normal cultural practises are applied to the breeding blocks. Pheromones are placed in the blocks for oriental fruit moth (OFM) and OFM are monitored throughout the season. Weed competition on the beds in the PAB is controlled by weed matting and in the SAB by strategic application of pre- and post- emergence herbicide. Water is applied through a micro-jet irrigation system and the soil moisture content monitored using tensiometers. Nitrogen fertiliser is applied in spring and post-harvest in autumn. The traffic lanes and headlands are sown down to ryegrass. The roots of new seedlings are dipped in a biological control agent formulation for the Crown Gall bacterium (ie. No Gall®) when planted into previously used land. PAB seedlings are topped and side trimmed in winter and late spring to maintain height at approximately 1.8 metres. By restricting tree height and regular side trimming, the trees are encouraged to produce more fruiting laterals and are easier to manage. Light penetration and fruit quality is improved by regular trimming. The trees start to crop in their second and third leaf. Management practices are similar in both the PAB and SAB, except the trees in the SAB are annually pruned and the fruit is thinned.

Identification of new selections

Time of flowering is used as an initial guide to winter chill requirement (WCR) (Hesse 1995). The trees that blossom before Tatura 204 are marked to indicate that their WCR is potentially too low for the Goulburn Valley. The trees that bloom the same time as Tatura 204 and up to Taylor Queen are marked as meeting the preferred chill requirement (ie. 500 to 700 hrs). These trees are given a higher priority than those that flower before Tatura 204 or following Taylor Queen. The trees are assessed for fruit quality over one or two successive crops before selection. Progeny are initially assessed in the field for flowering time, maturity date; crop load; fruit size and shape; red pigment in the pit and flesh; stone size and stone tip size; and flesh colour and for eating quality. Those trees showing ideal characteristics are harvested to determine average fruit weight and gross yield and the quality traits of 10 fruit assessed in the lab.

Propagation and evaluation of selections

Progeny selected from the PAB and controls are budded in Autumn or Spring onto virus-tested rootstock (Red leaf Nemaguard) and grown for a year in the nursery. The trees are established on a mini Open-Tatura Trellis system at 1.5 x 4m staggered double row tree spacing. A nearest neighbour experimental design with two blocks and eight single tree replicates was used with 270 selections and ten controls (Tatura 204, Tatura Noon, Golden Queen etc) was established in 2004.

In 2006 and 2008 the amount of fruit set and fruit removed from each tree was counted in November. The percentage re-harvest drop in the week prior to harvest and other fruit drop is recorded. The trees are harvested in two picks when the majority of fruit is a bisque colour. Gross yield is measured and the fruit is graded into six size categories (<$2^{1/4"}$(<56mm), $2^{1/4"}$(56mm), $2^{3/8"}$(60mm), $2^{1/2"}$(63mm), $2^{5/8"}$(66mm) and >$2^{5/8"}$(>66mm)) following each pick. Blemished fruit and fruit less than canning size (≤ $2^{1/4"}$) are removed to determine canning yield.

Fruit quality is assessed on 10 fruit collected from either the first or second pick on similar traits to fruit from the PAB. In addition flesh from each of the ten fruit are sampled and placed in an air sealed plastic bag and frozen for the sugar/acid ratio (soluble solids and percentage titratable acids) to be determined at the end of the season. The frozen fruit is defrosted, pulped and then filtered. The soluble solids content (^{o}Brix) is determined by an Atago digital refractometer PR-1 at 20^{o}C on the filtered juice. Titratable acidity (% malic acid) is determined using a Radiometer Copenhagen ION85 Ion analyser and ABU80 autoburette. Ten millilitres of the filtered juice is mixed with 50ml of distilled water and titrated with 0.1M sodium hydroxide to pH 8.1.

Commercial evaluation

Six commercial evaluation sites for SAB104 were established in 2006. The number of trees per site varies from 140 to 400 trees. The trials sites are all under a vase management system in which within row spacing and between row spacing vary from 2 – 3.3m and 5 – 6m respectively between sites. One commercial evaluation site for SAB145 was established in 2008 of approximately 200 trees. A further 1,200 SAB145 trees will be distributed to commercial evaluation sites in 2009. These trial sites will also be under a vase system, as it's considered the most cost-effective system for growing canning peaches commercially and the system most likely to be adopted by the majority of fruit growers for new canning peach varieties.

Data analyses

The data for each trait were analysed as per trial design using the residual maximum likelihood (ReML). The ReML model included the effects of replicate (B), row-within-replication (R:B), column-within replication (C:B), selection (S) and random residual. All effects were assumed to be random. ReML analysis provided, for each trait, the estimates of genetic variance (GV) among selections, standard error of GV, best linear unbiased prediction (BLUP) of the average performance of selections, and the SEd among selections. The existence of significant GV among selections was assessed from the ratio GV/SE(GV). A trait for which this ratio exceeded 1.96 was considered, assuming asymptotic normality, to possess significant genetic variation among the selections.

Results

Germplasm development and selection

Since the year 2000 the number of annual cross-pollinations was reduced and has focused on the incorporation of new genes/traits into the germplasm such as stony hard for improved mechanical handling and keeping quality (appendix 1 and 2). Over 25,000 trees have been planted in the primary assessment blocks since the commencement of the breeding program and 741 selections identified, of which 87 selections require more than one generation of crossing to incorporate desirable canning traits (table 1).

Cross pollinations in 2005 aimed to create a third generation of Tatura 204 self pollinations using SAB104 and SAB149 to further exploit genetic variation, and to create second/third generations from the superior white fleshed selections. The white fleshed self pollinations were repeated in 2006 to generate sufficient population sizes of yellow non-melting fleshed offspring from their recessive genes. However due to a severe frost event in early October all the cross-pollinated fruitlets were lost and no cross-pollinated seedlings were produced that year. In addition the 2005 cross pollinated trees were subsequently removed in 2008 due to the cessation of the breeding program by DPI.

In 2006, 2007 and 2008 there were 19, 30 and 28 selections respectively taken from the progeny blocks (appendix 1). In 2006 and 2007 a large proportion of these selections were from second generation crosses to incorporate brown rot resistance and stony hard traits into the progeny from white fleshed melting parental germplasm. Some of these selections will require a further generation of crossing to regenerate a yellow firm texture suitable for processing.

Table 1: Number of peach trees established at DPI, Tatura since 1994, and on commercial trials.

Years peach seedlings planted	Total number of trees established	Selections made from that years planting	Select for commercial testing
1994 to 1996	3,680	195	3
1997 to 1998	9,530	146 (26*)	
1999 to 2000	7,552	228 (37*)	
2001 to 2006	4,919	57 (24*)	
Total	25,681	654 (87*)	3

** Selections that require more than one generation of crossing.*

New germplasm has been sourced from overseas breeding programs in the last two years. Three non-melting clingstone varieties were imported in August 2006 and are due for release from quarantine in April 2009. One variety is an almond x peach backcross selection from the Californian canning peach breeding program, F8,5-159. It shows promising levels of brown rot resistance, has good post-harvest keeping qualities and may also have some resistance to plum pox virus (Sharka). The Sicilian breeding program has a couple of late season varieties, Settembrina di Leonforte and Gialla di Moavero which were imported for use in cross breeding to extend the harvest season. They are native Sicilian germplasm with about 700 chill units (Richardson model) and ripen the 4th week of March and the 2nd week of April respectively. Settembrina di Leonforte was detected with apple chlorotic leaf spot virus (ACLSV) in early 2008 and was subsequently removed from quarantine as the other Sicilian variety was virus-free and would provide suitable late season germplasm for breeding purposes without the delay and cost of heat treatment to remove the virus.

Table 2: Chill requirement of some selections and controls for winter 2007 compared to Golden Queen (650 hrs*). Selections in bold are detailed in table 5.

< 70%	70 – 80%	80 – 90%	90 – 95%	95 – 100%
Tatura 207	Tatura 215	Tatura 204	SAB 48	Golden Queen
SAB 32	SAB 74	**SAB 73**	SAB 130	**SAB 104**
SAB 488	**SAB 85**	SAB 125	SAB 250	**SAB 149**
	SAB 92	SAB 133	SAB 263	SAB 251
	SAB 138	**SAB 145**	SAB 377	SAB 287
	SAB 176	**SAB 245**	**SAB 441**	SAB 321
	SAB 373	**SAB 274**	**SAB 471**	SAB 371
	SAB 482	SAB 593	**SAB 521**	SAB 514
	SAB 497		SAB 529	SAB 599
	SAB 674		SAB 531`	

** Hours calculated from 1 May. Two laterals were forced at 20^{o}C, and chill requirement satisfied when 50% buds reached balloon stage.*

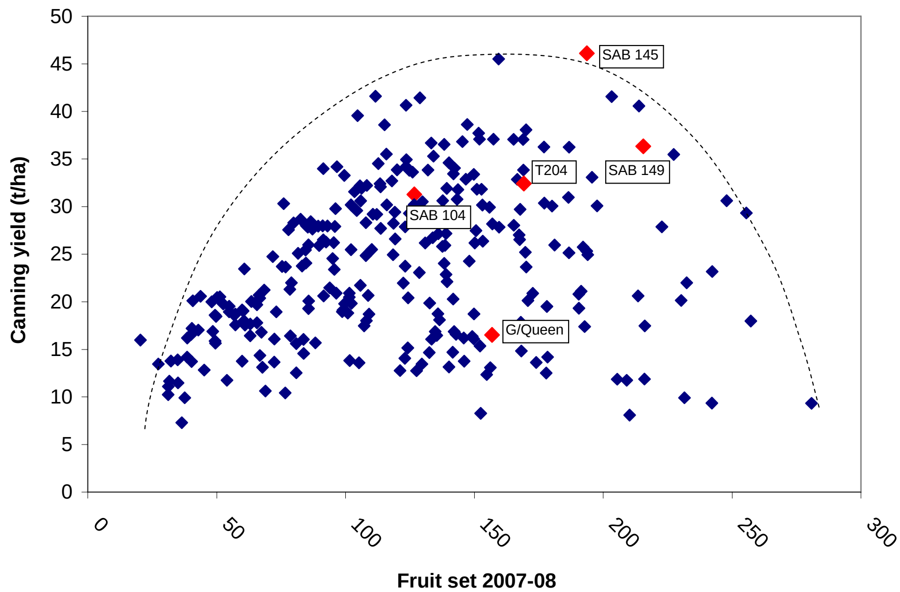
Evaluation of productivity and tree traits

In season 2007 the chill requirement was determined on some of the high productive selections. The amount of hours below 7^{o}C required for Golden Queen to break dormancy was approximately 650 hours. The chill requirement of the selections is expressed as a percentage of the chill requirement of Golden Queen in table 2. The majority of selections are between 70 and 100% of the chill of Golden Queen, as progeny with potentially lower chill were initially not selected for from the progeny blocks based on their full bloom date which is highly correlated to chill requirement (Hesse 1971). Crossing was also principally between medium and medium-high chill parents.

Selections were compared against the control Tatura 204 for productivity and tree traits (tables 3 and 4). There was genetic variation from Tatura 204 for the range of productivity traits (fruit weight, tree yield), full bloom, fruit set and percentage pre-harvest drop based on their broad sense heritability. Just over half of the selections had a fruit set less than Tatura 204 with half of these with fruit set too low to sustain high crop yields. Only 11% of the selections had pre-harvest drop greater than Tatura 204 confirming that previous breeding efforts to reduce pre-harvest drop in the Tatura canning germplasm were successful.

Any new variety must have productivity equal or superior to Tatura 204 otherwise it will not be commercially viable to grow. The productive selections had to have both mean fruit weight and yield equal or superior to Tatura 204. In 2006 the selections produced their first fruit crop and were thinned to an average of 15 fruit per tree to assess their fruit sizing potential. The gross yield was adjusted using number of fruits as a covariate since not all selections set sufficient fruit to carry a crop of 15 fruit which adversely affected their average gross yields. Of the 280 selections 108 and 142 selections respectively had high productivity based on gross yield and adjusted gross yield. The broad sense heritability was calculated for each of these traits to determine which trait better predicted the genetic variation. Heritability was 26% for gross yield compared to 49% for adjusted gross yield, hence 142 of the selections were deemed high productive. When their fruit quality was compared to Tatura 204 there were 100 selections with both productivity and quality equal or better than Tatura 204. The top 20 productive selections are listed in table 3 in comparison to the top productive selections for 2008. These selections are listed in order of maturity date and full bloom dates are expressed as days from Tatura 204 bloom.

Figure1: Range in canning yields of peach selections with fruit set in season 2007-08 showing control cultivars Tatura 204 (T204) and Golden Queen (G/Queen) with the three selections under commercial evaluation.



Due to poor fruit set from frost damage the trial was unable to be evaluated at a higher crop load in 2007 and what fruit remained were re-assessed again at a low crop load (results not shown). The productivity results from 2007 confirmed the previous seasons' results. In season 2008 the trees had a median fruit set in November of 100 fruit per tree. All trees with more than 100 fruit were thinned to 100 fruit per tree and those with less than 100 fruit were left unthinned. Based on the combination of average canning yield and fruit weights, 50% of the selections (140) had high productivity in 2008. Of these selections 74% were identified with high productivity in 2006 in their first crop. The other selections from 2006 did not rate highly mainly due to low fruit set. Conversely 26% of selections in 2008 were selections not previously identified in 2006 as high producers. Once fruit quality was also considered 77 selections continued to show both productive performance and fruit quality similar to Tatura 204. The selections highlighted in bold in table 5, SAB104, SAB176, SAB331, SAB497, SAB521, SAB588 and control Tatura 204 showed consistently high results in both 2006 and 2008.

The range in canning yield with fruit set in 2008 is shown in figure 1, with the selections under commercial evaluation highlighted with the controls, Tatura 204 and Golden Queen. The dotted line represents a potential response curve with a peak in canning yield around a fruit set of 160 fruit per tree. Between fruit set of 120 to 200 the highest canning yields were achieved when the selections were cropped at 100 fruit per tree. At a higher crop load it's expected that this curve will be raised, such that the higher yielding selections will remain those trees with a fruit set between 120 and 200 fruit per tree. There was no obvious relationship between fruit set and yield at the low crop load in 2006 (data not shown). SAB104 had a lighter crop load compared to Tatura 204 in 2008 but produced a similar canning yield with less thinning required. The highest yielding selection for 2008 was SAB145 which set an average of 194 fruit per tree and was subsequently cropped at 130 fruit per tree 33% above the set crop load. This partly explains the very high canning yield compared to the other selections. If it was cropped at 100 fruit per tree it would have yielded at least 33t/ha similar to Tatura 204. The other high yielding selection was SAB383. It set an average of 159 fruit and was cropped at 100 fruit per tree. It produced both a high canning yield of 45.5 t/ha and fruit weight of 174g. It is a melting white fleshed selection between Yumyeong and Tatura 215. The other high yielding and good quality selections above 38 t/ha which were cropped around 100 fruit per tree were SAB274, SAB331, SAB521 and SAB564.

Table 5: Crosses with the highest proportion of selections with high productivity in season 2007-08.

Cross	Number	% *	Average fruit weight (g)	Average canning yield (t/ha)
T211 x T204	12	50	148.3	36.9
Yumyeong x T215	8	100	149	33.7
T204 x T234	6	67	146	31.4
T212 x Oom Sarel	22	73	152	31.0
T204 x T233	7	86	141	30.7
BabyGold 7 x Oom Sarel	19	53	153	30.6
T211 x T215	5	80	138	30.5
BabyGold 7 x Jan Neethling	7	86	145	30.2
T204 self	58	57	145	29.3
T211 x Izac Malherbe	5	80	128	28.5
BabyGold 8 x Oom Sarel	7	57	134	26.3
* *The average percentage of selections from all crosses in the trial with high productivity was 50%.*				

The crosses with the highest proportion of selections with high productivity in season 2007-08 are listed in table 5. The original cross of BabyGold 7 x Oom Sarel that produced the industry standard variety Tatura 204 continues to produce a high proportion of promising progeny (10 selections) and the highest average fruit size (153g). The Yumyeong x Tatura 215 cross aimed to incorporate the high productive performance and brown rot resistance from the Korean white fleshed peach Yumyeong into the Tatura 204 germplasm with the desired chill requirement by combining the lower chill of Tatura 215 with the higher chill of Yumyeong. All (8) selections rated high for productivity with one of the highest average canning yield of all the crosses (33.7 t/ha). The cross Tatura 211 x Tatura 204 had a few high yielding selections, SAB274, SAB331 and SAB572, that lifted the average canning yield of the cross to 36.9t/ha.

Table 3: List of top peach selections with quality and productivity equal or superior to Tatura 204. The 2006 selections were from the 1st crop on Open Tatura trellis thinned to 0-15 fruit/tree, and 2008 selections from the 3rd crop thinned to an average of 100 fruit/tree.

Top Selections 2006	**Parents**	**Ripe date 2006**	**Full bloom** (+- days T204)	**Mean fruit size** (g)	**Adjusted Gross yield per tree *** (kg)	**Top Selections 2008**	**Parents**	**Ripe date 2008**	**Full bloom** (+- days T204)	**Mean fruit size** (g)	**Canning yield (t/ha)**
SAB 441	BG7 x Oom Sarel	6-Feb	9	191	1.44	SAB 444	T204 x Andross	10-Jan	6.3	136	34.0
SAB 176	T204 self	7-Feb	-4.5	176	1.42	**SAB 176**	T204 self	23-Jan	-1.3	148	36.2
Tatura 204	BG7 x Oom Sarel	7-Feb	0	171	1.33	**Tatura 204**	BG7 x Oom Sarel	23-Jan	0.1	142	32.4
SAB 32	T204 self	12-Feb	-3	185	1.41	SAB 462	BG7 x Oom Sarel	3-Feb	4.1	150	35.5
SAB 245	BG6 x Oom Sarel	12-Feb	1	176	1.35	SAB 596	T211 x T215	3-Feb	6.9	145	34.2
SAB 247	2-1-39 x T215	12-Feb	-4.5	195	1.42	SAB 471	T204 x T233	5-Feb	1.4	151	32.1
SAB 73	T204 self	3-Feb	-3	177	1.38	SAB 491	BG8 x Oom Sarel	6-Feb	-1.1	152	33.8
SAB 57	T204 self	15-Feb	-1.5	188	1.46	SAB 274	T211 x T204	7-Feb	2.1	155	38.6
SAB 588	T204 x T233	20-Feb	4	174	1.36	**SAB 588**	T204 x T233	7-Feb	1.8	157	33.4
SAB 451	BG7 x Oom Sarel	20-Feb	9	175	1.39	SAB 480	T212 x Oom Sarel	9-Feb	7.4	163	32.2
SAB 85	T204 self	20-Feb	-9	190	1.40	SAB 529	T204 x T237	11-Feb	-1.1	143	36.8
SAB 128	T204 self	2-Mar	-1.5	187	1.44	**SAB 104**	T204 self	13-Feb	5.0	146	31.3
SAB 521	T204 x Clement	4-Mar	0	191	1.52	**SAB 521**	T204 x Clement	17-Feb	-1.4	146	41.6
SAB 104	T204 self	5-Mar	5	171	1.35	**SAB 497**	T211 x Prof Black	18-Feb	-5.0	153	37.7
SAB 497	T211 x Prof Black	5-Mar	-6.5	177	1.44	SAB 145	T204 self	20-Feb	-1.6	140	46.1
SAB 532	BG7 x Jan Neethling	6-Mar	2	183	1.39	SAB 548	T204 x T235	22-Feb	-0.8	150	34.9
SAB 132	T204 self	10-Mar	-6	202	1.50	SAB 572	T211 x T204	25-Feb	5.1	146	41.4
SAB 140	T204 self	10-Mar	1	196	1.45	SAB 326	BG7 x Oom Sarel	26-Feb	4.5	147	32.4
SAB 545	BG7 x Oom Sarel	10-Mar	-1.5	172	1.32	**SAB 331**	T211 x T204	26-Feb	-0.9	161	38.6
SAB 138	T204 self	13-Mar	-3	192	1.48	SAB 390	T212 x T204	27-Feb	-0.1	147	32.7
SAB 331	T211 x T204	15-Mar	-1.5	195	1.41	SAB 564	T212 x T204	2-Mar	9.5	160	40.6
Trial mean				147	1.16				2.9	135	23.6
Genetic variance				369	26.90				1.276	691	82.2
GV/SE(GV)				9.8	10.22				10.05	10.3	9.56
Heritability (%) **				43	49				43	49	37
Average SEd				11.0	0.085				0.61	13.2	5.63

**Adjusted using number of fruits as a covariate*
*** Heritability = [Genetic Var / (Genetic Var + Residual Var)]*100*
BG = BabyGold

Table 4: Broad sense heritability of fruit quality and tree traits in season 2007-08 of control cultivars Tatura 204, Tatura 212 and Golden Queen with the three selections under commercial evaluation.

Selection	**Average stone tip length** (mm)**	**Average stone tip width** (mm)**	**Average stone weight** (g)	**Red flesh** (1-7 scale)	**Red pit** (1-7 scale)	**Sugar/acid ratio**	**Sugar** (^{o}Brix)	**Titratable acid** (% malic)	**Firmness** (kg)	**Texture** (1-5 scale)	**Flesh Colour ***	**Fruit set** (1-7 scale)	**% Pre-harvest drop**
Tatura 204	2.65	4.02	4.13	6.1	7.0	41.9	14.2	0.31	2.6	3.0	10.7	4.9	8.2
Tatura 212	3.45	4.20	4.03	6.2	6.9	42.0	13.4	0.33	3.2	2.3	13.9	5.9	7.5
Golden Queen	2.94	4.35	4.07	6.8	6.9	47.7	14.2	0.32	3.0	3.1	NA[#]	4.2	5.8
SAB 104	2.64	4.04	4.03	7.0	7.0	34.8	13.3	0.39	2.6	3.0	12.9	4.1	10.1
SAB 145	2.63	3.66	4.47	6.3	7.0	65.6	15.5	0.25	3.2	3.0	14.5	5.1	8.8
SAB 149	2.76	3.58	3.63	6.4	7.0	65.5	16.4	0.25	2.9	3.1	14.4	5.2	6.8
Trial mean	3.00	4.44	4.16	6.5	6.7	44.4	14.2	0.30	3.0	3.0	12.2	3.6	12.3
Genetic variance	0.259	0.486	0.182	0.25	0.53	141	1.94	0.005	0.61	0.63	12.34	1.28	61.90
GV/SE(GV)	6.98	7.82	7.33	7.94	10.09	7.79	6.9	7.72	7.1	9.8	10.2	10.1	8.5
Heritability (%) ***	44	52	48	55	80	53	45	52	45	76	87	43	27
Average SEd	0.464	0.572	0.370	0.40	0.38	9.69	1.15	0.060	0.63	0.45	1.34	0.61	5.82

** Colour(hue) using CIELAB (D65/2^{o}) a value*
*** Stone tip lengths and widths were measured using a 1mm width metal plate with a 10 x 2 mm opening to standardise the point at which the stone tip emerges from the stone.*
**** Heritability = [Genetic Var / (Genetic Var + Residual Var)]*100*
 # NA= not available. Golden Queen usually has flesh colour value a >15 which represents orange fleshed fruit.

Quality evaluation

Quality was measured on a range of fruit traits (table 4). For the processing industry the most critical attributes for a successful canning variety are the absence of red pigmentation inside the fruit, high firmness and a small stone tip along with acceptable flavour and appearance attributes. There were very low or no red pigmentation in the majority of selections due to generations of breeding to eliminate it, except in some crosses used to incorporate new genes that are not traditionally a canning type variety. Similarly the majority of selections had acceptable firmness. There was significant genetic variation in flesh colour (CIELAB a value) with a broad sense heritability of 87%. Ideally the selections require an average value greater than 12 to exhibit a more orange flesh colour. A slight variation in fruit maturity can alter the flesh colour rating. Tatura 204 had a value of 10.7 with a trial average standard error of deviation of 1.2. With a value of 10.7 Tatura 204 had a more yellow-orange flesh colour whereas SAB104, SAB145, and SAB149 were within the 12 to 15 range and exhibited more orange-yellow flesh colours. Data for Golden Queen was not available but it generally exhibits a value greater than 15 representing an orange flesh colour. The trial mean for sugar acid ratio wss 44% which is a typical value for a canning peach and similar to the value for Tatura 204 of 42%. The sugar/acid levels for both SAB145 and SAB149 were 69% and significantly greater than Tatura 204, however previously in 2005-06 they were both about 40%. The combination of a higher level of sugar and lower level of titratable acid contributed to their higher sugar/acid levels in 2008.

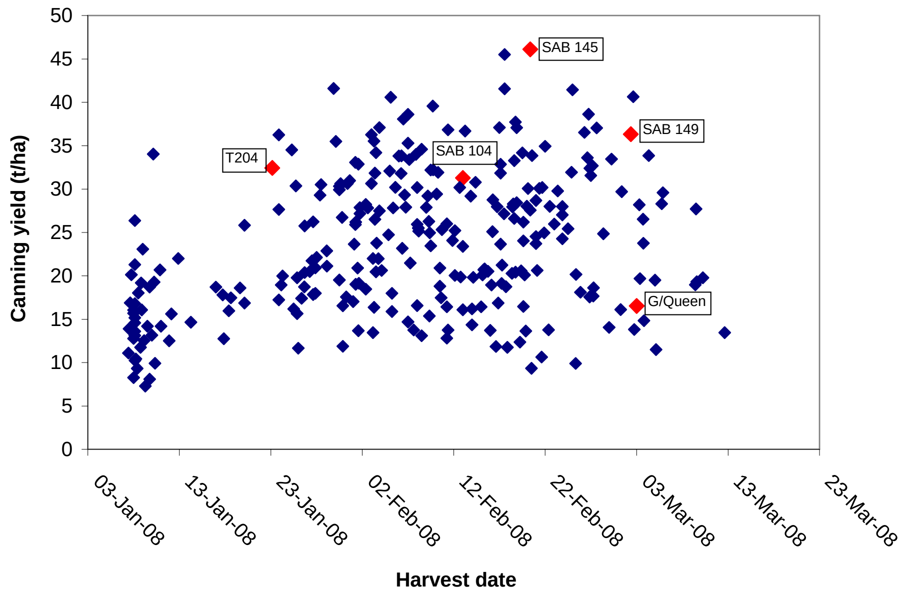
Long stone tip is a serious fault because stone tips (splinters) can break off during stone removal in the cannery. Stone splinters longer than 3mm in length in the canned product pose a potential health risk to consumers. Tatura 204 has a borderline stone tip length with long stone tips being a problem in some years. The highly productive variety Tatura 212 was rejected at the commercial evaluation stage of the previous breeding program due to problems with stone tip breakage in the cannery. From previous research on stone tip lengths it was determined that at least 10 fruit needed to be sampled to detect the presence of stone tips longer than 3mm (Richards, 2006). Tatura 212 had an average stone tip length of 3.45mm compared to 2.65mm for Tatura 204. They were not significantly different based on the average standard area of deviation (SEd) but represent a difference in stone tip length that is commercially unacceptable. The selections under commercial evaluation SAB104, SAB145 and SAB149 had average stone tip lengths of 2.64, 2.63 and 2.76mm respectively which are similar to Tatura 204. One selection SAB163 had an average stone tip length of 1.68mm and could be a potential parent to breed for a reduction in stone tip length (data not shown). It is also desirable to have a smaller stone to enhance the appearance of processed peach halves, and to increase the volume of flesh available for processing into other fruit products. The size of the stone increases with fruit size (Richards, 2006) so all fruit stone weights were only assessed on fruit sampled in the 60-63mm diameter fruit range following grading. There were 10 fruit assessed for 50% of the trees, less than 10 for 30% of the trees and 20% of trees did not have any fruit available of canning fruit size and were not included in the analyses. The average stone weight of Tatura 204 was 4.13g similar to the trial mean of 4.16g. SAB32, SAB189 and SAB598 all had significantly smaller average stone weights than Tatura 204 and could be potential parents to breed for a reduction in stone size (data not shown). SAB149 could also be considered as a potential breeding parent as its stone length was on average 0.5mm shorter than Tatura 204.

Commercial evaluations

The priority for the canning industry is to find superior varieties for the mid February and late February harvest periods between the harvest periods of Tatura 204 and Golden Queen (figure 2). Two selections (SAB104 and SAB149) that met the criteria were established in two small scale commercial trials in 2003, and in 2006 the mid Feb selection SAB104 was progressed to large-scale commercial evaluation. The other selection SAB149 was not recommended because it ripened in the same maturity period as Golden Queen, appeared to have a more yellow than orange flesh colour and ripened unevenly, otherwise it displayed good productivity. An even, high orange or orange-yellow colour is now preferred by the canning industry to fit in with currently grown peach cultivars and market requirements. SAB104 is now being evaluated on 6 commercial orchards on blocks from 140 to 400 trees in size. At their 3rd leaf in 2008 they yielded a small amount of fruit (i.e. 3-8 fruit/tree) and will not produce commercial yields until 2009 for assessment in the cannery. Growers felt that SAB104 was easier to manage because of its more upright growth habit than T204 and T215, and was generally more vigorous. However what fruit that remained on the trees sized well and all growers believe the selection has commercial potential. No obvious issues with pest and disease were reported. The harvest period was a few days after T211 and at a similar time to T215, which is around mid February.

SAB145 was recently recommended for large-scale testing in 2008 after producing the highest canning yield in 2008 of 46.1 t/ha. It is harvested in late February and is a potential superior replacement variety for Tatura 222 and Orrvale Queen. One commercial evaluation site was established in 2008 and seedling trees will be available in winter 2009 to set up further sites.

Figure 2: Range in canning yields of peach selections with harvest date in season 2007-08 showing control cultivars Tatura 204 (T204) and Golden Queen (G/Queen) with the three selections under commercial evaluation.



Discussion

Productivity evaluations

The productivity trial of 280 selections and controls has now been evaluated at both a low and medium crop load. In both years about 50% of the selections and controls had productivity, in terms of average fruit weight and fruit yield, equal or superior to the industry standard cultivar Tatura 204. When fruit quality was considered this reduced suitable selections to between 26 and 36%. One more year of evaluation is required at a high crop load to identify the highest and most consistent performing selections amongst them. The crop load will be set between 150 and 200 fruit per tree dependant on the mean fruit set of the high productive selections in spring 2008. Only selections with quality and productivity equal or superior to Tatura 204 will be evaluated at high crop load along with few low productive high quality selections for comparison across seasons. The most promising selections will be those that show consistent high productivity at the successive crop loads. Within the top 20 selections those that have shown consistency are the early season selection SAB176 which ripens the same time as Tatura 204, the early-mid season SAB588, mid-season selections SAB104, SAB521, SAB497 and mid-late selection SAB331. The mid-late season selection SAB145 which was progressed to commercial evaluation following the 2008 evaluations, also showed promise in productivity testing on the original selected tree pre 2006.

Heritability estimates were made on all the selections and some individual crosses within the productivity trial. Heritability estimates in this report are broad sense and as such estimate how well the phenotypic trait (i.e. average fruit weight) predicts the underlying genetic component compared to other factors such as the environment rather than potential genetic gain in the narrow sense. There are several reports on heritability within peaches on a range of traits such as ripening date, fruit dimensions and soluble solids but little information on productivity except for point scale estimates of crop load (Hansche et al, 1972) and fruit mass (de Souza and Bryne, 1998). Broad sense heritability values of 49% and 37% at low and medium crop load respectively were obtained for fruit yields, whilst average fruit weights were 43% and 49% respectively for all the crosses. These intermediate heritability estimates indicate that the current method of evaluation is a good predictor of productivity potential. Calculation of narrow sense heritability is possible from the data using selections from the BabyGold 7 x Oom Sarel cross as the F1 generation (19 selections) and the T204 x T204 cross as the F2 generation (58 selections) since T204 was originally bred from the BabyGold 7 x Oom Sarel cross. The potential genetic gain in productivity can be determined. Analyses of narrow sense heritability and repeatability estimates will be subsequently published in scientific publications and these analyses are not shown in this report.

One aim of the productivity experiment was determine if the most productive selections could be identified in the first crop if the trees were thinned to a very low level to enable fruit to exhibit their potential sizing ability without any inter- fruit competition for carbohydrate and water resources. If fruit are able to size large fruit at a low crop load then they are more likely to size fruit at a higher crop load where there is competition for resources from other fruits and vegetative parts. Of the 140 high productive selections identified in 2008, 74% of them were previously identified in 2006 in their first crop at a low crop load. The other selections from 2006 did not rate highly mainly due to low fruit set. Although they could still continue to size fruit well they did not set enough fruit per tree to also produce high canning yields. A high producing variety must first have sufficient fruit set and then the ability to size fruit to produce high fruit yields. Table 6a shows some of the correlations in productivity traits between 2006 and 2008. A high phenotypic correlation occurred in both average fruit weight (61%) and fruit set (64%) between 2006 and 2008 but crop yield was slightly lower (0.54) [table 6a]. This supports the idea that potential productivity can be predicted in the first fruit crop in the majority of selections, however fruit set was the main trait that reduced the reliability of the prediction.

Table 6a: Phenotypic correlations between and within fruit traits in season 2007-08 and season 2006-07.

Average fruit weight 2006	Average fruit weight 2008	0.61
Adjusted gross yield 2006	Canning yield 2008	0.54
Fruit set 2006	Fruit set 2008	0.64
Mean fruit weight 2006	Adjusted gross yield 2006	0.93
Mean fruit weight 2008	Canning yield 2008	0.38
Mean fruit weight 2008	Mean stone weight 2008	0.36
Table 6b: Correlations between and within tree traits in season 2007-08.		
Butt area (cm^2) 2008	Canopy size (1-7 scale)	0.85
Butt area (cm^2) 2008	Area shade (m^2)	0.69
Canopy size (1-7 scale)	Area shade (m^2)	0.69
** Two sided test correlations different from zero (n=280, all P values <0.001.*		

Another aim of the productivity experiment was to determine the most accurate measure of tree size as tree size should be used as a covariate in analysis in fruit productivity. Tree size is not accounted for in yield data in this report, and will be reported on in subsequent scientific publications. Traditionally butt circumference or butt area is used in the determination of suitable crop load based on the size of the tree (Keatley et al, 1968). Whist a new method of assessing tree size is by effective area of shade, particularly for setting optimum crop loads (Goodwin and O'Connell, 2004). However the area of shade is normally calculated along a row of trees of the same variety rather than on individual trees. Within this productivity experiment selections were planted as single trees within each replicate. Measurements of shade were made at solar noon and an hour either side before the shadows of neighbouring trees started to overlap and interfere in the measurement. It was also noticed that trees that had a slight lean did not give a reading consistent with tree size that reduced the accuracy of the measurement. A more efficient but subjective measure of tree size is to use a point scale of tree canopy size. Whilst all measures of tree size were highly correlated with each other, the largest correlation of 85% was between butt area and canopy size (1-7 scale) [table 6b]. This indicates that the subjective measure of canopy size (1-7scale) can be used as a reliable alternative to butt area measurement for assessment of tree size because of its strong correlation. It is both easier and quicker to measure than butt area.

Quality evaluations

The majority of fruit quality traits were measured objectively (stone traits, firmness, sugar and acid levels and flesh colour) and subjective point scales used for evaluation of red pigmentation in the pit and flesh, type of flesh texture and a likeness scale for overall fruit appearance and eating quality. The accuracy of the phenotypic measurement influences the level of heritability (Hansche et al, 1972). There was significant genetic variation for quality attributes within the selections with broad sense heritability of more than 40%. Stone tips had a broad sense heritability of 44% for length and 52% for width at the base of the stone tip. These intermediate levels of heritability suggest there is potential to breed for smaller stone tips. However, there can be a large range in the size if tips found within selections and it's likely that environmental effects also have a major effect on stone tips. There is a strong positive correlation between fruit size and stone size within a variety (Richards, 2006). Hence it has been suggested that selection for small stone size may also lead to a reduction in fruit size. All measurements on stone sizes were conducted on fruit of similar size, and the correlation between stone size and fruit size using all crosses was found to be only 36%.

There is significant genetic variation in the type of fruit textures from "rubbery" softer textures typically like Golden Queen to a crisper texture like Tatura 204 and a very crisp texture in SAB176. The firmness of these texture types is very dependant on the stage of maturity that they are assessed and can vary with storage. Golden Queen is typically considered a softer less manageable peach cultivar than Tatura 204. This is likely more due to a greater loss in firmness with storage of the "rubbery" texture types compared to the crisper varieties. After harvest at a similar fruit maturity both Golden Queen and Tatura 204 can have similar levels of firmness and texture as shown in table 4. If these cultivars were assessed after 1-4 weeks in storage it is likely significant differences in firmness and texture would be detectable. The desirability of a selection to have good cool store potential to aide product movement through the cannery indicates the need to assess firmness at both harvest maturity and after 2-4 weeks of storage. However with the development of a high quality series of peaches from this program with strictly controlled commercial production levels, the requirement to store varieties for any period of time before processing may be significantly reduced.

Future opportunities

After more than 7 decades of DPI research in the development of improved varieties of canning peaches for the Australian industry the breeding program closed in 2008. Over 60% of the cultivars currently grown by the Australian Industry were developed by DPI Tatura, and as newer cultivars are released that proportion is destined to increase. The Canning Industry through SPC-Ardmona will continue to breed peaches for future needs on a private basis and drive the commercialisation of current cultivars released from the DPI program. DPI has already put forward an exploitation plan on current canning germplasm (Richards, 2005) and others that may be applicable for fresh market. This plan will be extended to include route-to-market, process to engage nurseries, requirements for production/agronomic support, promotion and international testing, and progressed by the commercialisation sub-committee (PeachCom). Variety information sheets on the new varieties will be provided to growers upon their release to aide adoption (appendix 3). The selection SAB104 is likely to be the first new variety to be released by the breeding program, with others to follow as they progress through commerrcial evaluation (appendix 4). It is recommended that these new selections be used in further cross breeding to continue genetic improvement in fruit productivity. The two varieties to be released from quarantine in 2009 are also recommended for cross breeding to develop brown rot resistance within the Tatura germplasm from the Californian selection F8,5-159, and extension of the season with the Sicilian variety Gialla di Moavero.

The selections developed from crosses with the white fleshed Korean peach variety Yumyeong have the potential to also significantly improve upon the productivity of Tatura 204 and introduce a degree of resistance to brown rot. Italian research found that cultivars from the Eastern countries (China, Japan, and Korea) had a higher proportion of partially resistant cultivars compared to Western cultivars, and Yumyeong was one of the varieties to show a degree of resistance (Richards, 2001). These crosses may also provide a wider range of peach flavours as displayed by the first generation crosses. All the selections of the Yumyeong x Tatura 215 cross rated high for productivity with one of the highest average canning yield of all the crosses (33.7 t/ha). In particular, the Yumyeong x Tatura 215 cross aimed to incorporate the high productive performance and brown rot resistance from the Korean white fleshed peach Yumyeong into the Tatura 204 germplasm with the desired chill requirement by combining the lower chill of Tatura 215 with the higher chill of Yumyeong. One Yumyeong x Tatura 215 selection, SAB383, produced both a high canning yield of 45.5 t/ha and average fruit weight of 174g. With such a high average fruit weight it has excellent potential to produce canning yields much higher than 50t/ha which is a good average yield for a canning peach. It will be either backcrossed to a Tatura canning variety or selfed to regenerate a yellow fleshed firm peach. Some of the selections from Yumyeong crosses may also have potential for fresh market such as SAB376. Selection SAB376 matures late January has excellent sweet, melting texture and a high red blush. SAB692 (SAB365 (Yumyeong x Okubo Late) x T204) produced a high crop of fruit in its first year which all evenly cropped to above canning size without thinning. This is a rare occurrence. This selection is yet to undergo productivity testing but has potential to significantly improve fruit yields based on its first crop performance. Yumyeong also expresses the stony hard gene. The stony hard trait enables fruit to hang on the tree for extended periods because the fruit does not emit ethylene to soften. Some second generation stony hard selections suitable for canning will be evaluated in a new productivity trial to be set-up under the new breeding program managed by SPC-Ardmona (appendix 1). Only one other breeding program is known to using the stony hard gene in breeding for fruit quality. They aim to extend fruit post-harvest life in fresh market peaches (Liveerani et al, 2002).

Technology Transfer

These activities focus on communicating progress rather than the transfer of new technologies *per se*, as no selections have yet reached the commercialisation stage. Two elite selections have progressed to third stage large-scale commercial trials in 2006 and 2008. The program is expecting to release new varieties from 2010 onwards.

Recommendations

Refer future opportunities in the discussion.

Publications

No publications

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The canning peach breeding program is guided by the project steering committee that reviews the project annually, and discusses directions and progress of the program. Their contributions are gratefully acknowledged, along with the technical staff currently employed on the program.

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DPI Vic	Victorian department of Primary Industries, Tatura
FGV	Fruit Growers Victoria
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List of Appendices

Appendix 1: Selections from 2006 and 2007 established in an evaluation trial in 2008 on the new breeding program site managed by SPC-Ardmona.

Appendix 2: Peach germplasm produced by the Tatura canning peach breeding program.

Appendix 3: Draft of a variety information sheet showing the type of information to be provided to growers on new peach varieties released from the breeding program.

Appendix 4: Photos of peach selections that have progressed to commercial evaluation. SAB 149 and SAB104 were recommended for small-scale testing in 2003 and SAB104 progressed to large-scale testing in 2006. SAB145 was recently recommended for large-scale testing in 2008.

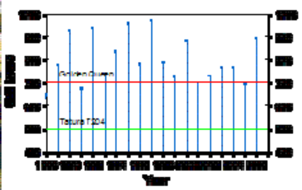
Appendix 1: Selections from 2006, 2007 and 2008 established in an evaluation trial on the new breeding program site managed by SPC-Ardmona.

Female	Male	Harvest day	Number selections	Traits
SAB101	SAB104	14-Feb	1	Yellow canning peach (C)
SAB126	SAB104	14 - 26 Feb	2	C
T/Q	T204	24-Feb	1	C
T204	2-1-39	08-Jan	1	C
T204	7-1-42	7 Feb - 9 Mar	5	C
T204	T212	18 Jan - 2 Mar	11	C
T204	Taylor Queen	29 Jan - 4 Feb	5	C
T212	Andross	13-Feb	3	C
T212	BG7	13 - 28 Feb	4	C
T212	G/Q	29-Jan	1	C
T212	self	14 Jan - 7 Mar	15	C
T212	Taylor Queen	07-Mar	1	C
T212	3-3-42	28-Feb	2	C
T212	4-1-5	4 - 7 Feb	2	C
T212	6-3-8	29-Jan	3	C
T204	SAB382 (Yumyeong x T215)	26-Feb	1	Potential brown rot resistance from Yumyeong (BR), C
T204 x Yumyeong	op	06-Mar	1	Dominant stony hard gene(SH), BR, C
SAB370 (Yumyeong x T215)	op	26-Feb	2	SH, BR, C
SAB379 (Yumyeong x T204)	op	29-Jan	1	SH, BR, C
SAB388 (Yumyeong x T204)	op	14 Feb - 6 Mar	2	SH, BR, C
T204	Jing Yu	08-Jan	1	Potential brown rot resistance from Jing Yu Yellow flesh, melting peach (M)
T204	SAB369 (Yumyeong x T215)	14-Feb	1	White flesh (W), BR
T212	Peentao	3 - 29 Jan	2	Yellow flesh, M, saucer shape
SAB151	op	17-Jan	1	SH, W
SAB336 (7-1-42 op)	op	08-Jan	1	W
SAB365 (Yumyeong x O/L)	T204	7 - 28 Feb	3	W, M, potential recessive SH gene, BR
SAB366 (Yumyeong x O/L)	T204	07-Feb	1	W, M, potential recessive SH gene, BR
SAB376 (Yumyeong x T215)	op	13 - 28 Feb	2	W, M, potential recessive SH gene, BR
SAB388 (Yumyeong x T204)	op	06-Mar	1	SH, W, BR
Total			**77**	

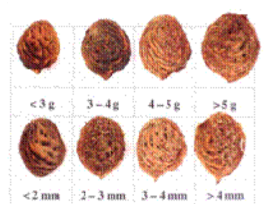
Appendix 2: Peach germplasm produced by the Tatura canning peach breeding program.

The peach germplasm principally consists of high quality and productivity parents, such as Tatura 204, selections SAB104, SAB149 etc for breeding canning peaches. The collection also contains crosses generated from the white Korean peach variety Yumyeong which has partial resistance to brown rot, high productivity and contains the stony hard gene which inhibits the emission of ethylene at fruit ripening enabling the fruit to hang on the tree for a long duration and potentially conductive to a one-pick harvest. Since this peach variety is white fleshed and melting it has required two to three generations of crossing to incorporate its traits onto the canning germplasm to generate yellow non-melting and/or stony hard selections. The germplasm collection also contains a small amount of selections with interesting traits such as semi-freestone (for ease of stone removal), flat shape, eatable seed and low acid/honey gene.

High productivity



Medium chill



Small stone tip

No red flesh/stone

Selection	Female	Male	Status	Comments
T204	B/G	Oom Sarel	1st generation	Parents for breeding canning peaches
SAB104	T204	Self	2nd generation	Selfs of elite selections
Remove Fruit 09	SAB104	Self	3rd generation	
SAB714	SAB101	SAB104		Crosses between high productive & quality selections for next generation of breeding.
SAB149	T204	Self		
SAB176	T204	Self		
SAB130	T204	Self		
SAB250	T211	T215		
SAB377	T211	T204		

Yumyeong

Selection	Female	Male	Status	Comments
SAB370	Yumyeong	T215	1st generation	**Parents for inserting Yumyeong genes into canning peaches for partial resis to brown rot, high productivity & stony hard (SH) gene**
SAB712	SAB370	OP	2nd generation	SAB712 a yellow canning selection with homozygous (?) SH gene
SAB382	Yumyeong	T215	1st generation	
SAB719	T204	SAB382	2nd generation	SAB719 a yellow canning selection
SAB388	Yumyeong	T204	1st generation	
SAB723	SAB388	OP	2nd generation	SAB 723 white fleshed
To cross	SAB723	Self	3rd generation	
SAB365	Yumyeong	Okubo Late	1st generation	SAB365 from white peach breeding program
SAB692	SAB365	T204	2nd generation	SAB692 white melter recessive stony hard with exceptional productivity potential shown first year in primary assessment block
Remove Fruit 09	SAB692	OP	3rd generation	* **Manipulating SH, flesh colour & non-melter/melter genes.**

Peentoa

SAB391

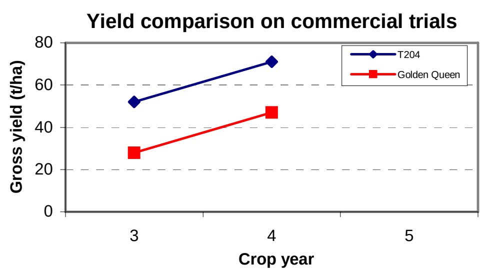
Safira & BR1

Selection	Female	Male	Status	Comments
SAB391	T212	RedGold	1st generation	**Parents for inserting traits of interest into canning selections**
Fruiting	SAB391	OP	2nd generation	Redgold has an **eatable seed** (no cyanide). Self SAB391 to recover gene in homozygous state
SAB636	T204	Safira	1st generation	**Semi-freestone** cultivars are easier to twist pit than clingstones Safira & BR1 are large Brazilian cvs, Oro-A low chill, small Florida cv.
SAB403	T204	Oro-A	1st generation	Selections in productivity trials.
SAB627	T212	Robin	1st generation	Robyn has a **honey gene** (single dominant gene).
To cross	SAB627	Self	2nd generation	Self SAB627 or cross with SAB628 to recover yellow, non-melting flesh types with hony gene.
SAB651	T212	Peentao (Uni W.Sydney selection)	1st generation	**Peentoa** peaches have a flat shape like a donnut (single gene).
To fruit	SAB651	OP	2nd generation	SAB651 yellow fleshed, melter, flat shaped selection, backcross to high productive canning cultivar or self to improve size and recover non-melting flesh with flat (peentao) shape

Appendix 3: Draft of a variety information sheet showing the type of information to be provided to growers on new peach varieties released from the breeding program.

Variety Information Sheet *EXAMPLE*

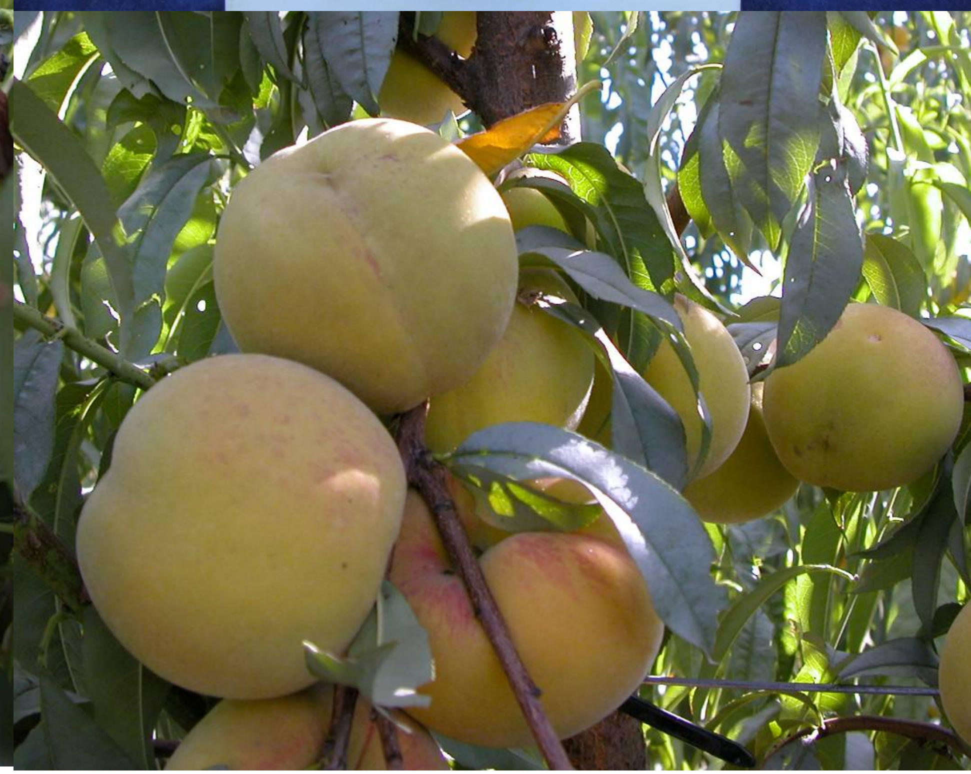
Name: Tatura 204 	**Parentage:** BabyGold No.7 x Oom Sarel **Blossom:** Non-showy, full bloom 10-12 days before Golden Queen, ~2 Aug **Maturity:** 4th week of January **Chill:** Medium-low 400-600 hrs **Tip change:** 2-3rd week of November, ~11 Nov
Description:	
Fruit shape	Medium to large 65-75mm diameter, round to slightly truncate, even suture and even calyx end, very symmetrical, halves equal, moderately deep cavity stem end.
Skin	Even light golden colour, very slight red blush on some fruit exposed to the sun, moderate pubescence.
Flesh	Non-melting, firm but juicy, medium orange-yellow, colours evenly from stone out, no red pigmentation in flesh but a characteristic patch of pink colour in the pit when trees are young, texture slightly coarse, good flavour and aroma, typical °Brix 13-14.
Stone	Clingstone, medium to large size, brown with a medium stone tip, some tip breakage, twist pit clean, low split pit.
Tree architecture and shape	Vigorous long laterals.
Commercial production:	
Establishment (i.e. tree vigour, effects of soil types)	Semi-vigorous, spreading habit.
Pest & disease susceptibility	Highly susceptible to peach leaf curl, rust and brown rot.

Flowering/fruit set (i.e. pattern of fruit set)	Flowers set evenly along laterals, heavy to very heavy fruit set, bears regularly.
Pruning	Laterals vigorous and long, laterals should be tipped during pruning because of heavy fruit set, summer pruning recommended.
Thinning	Need to remove 75-80% fruit by stone hardening at a spacing of 10-15cm to obtain 70mm fruit.
Ripening behaviour	Harvest 2-3 times over a 9 day harvest period, increases in fruit size between fruit picks, low fruit drop.
Other	Thin skin, can suffer from wind rub and brown flecking on skin in some years.
Yields (i.e. crop estimates before & after thinning)	Tatura 204 has the potential to crop 20% greater then Golden Queen. The example below is from data on trials at DPI Tatura in the 1980's. Future yield estimates will give canning yields from large-scale commercial evaluation sites compared to controls established at those sites. 

Appendix 4: Photos of peach selections that have progressed to commercial evaluation. SAB 149 and SAB104 were recommended for small-scale testing in 2003 and SAB104 progressed to large-scale testing in 2006. SAB145 was recently recommended for large-scale testing in 2008.

Selection SAB104
24 Feb 06

Selection SAB149
10 Mar 06



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