

Development of Australian passionfruit hybrids to improve quality and disease tolerance

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Summary

Alternata Spot (*Alternaria alternata*) and other fungal diseases cause major problems in commercial passionfruit. Plantations have to be sprayed at fortnightly intervals throughout the year to prevent defoliation and fruit spotting. Control often fails during prolonged wet weather. A local selection, known as Toms Special, (a possible hybrid of *Passiflora edulis* f. *flavicarpa*) displays tolerance to leaf diseases but yields poorly. In 1985, crosses were made between this selection and the three main commercial hybrids (23-E, 3-1 and Lacey), to produce alternative hybrids with improved fruit quality and disease tolerance. These hybrids were grafted on commercial sources of rootstock and planted in January, 1986.

From an initial 237 F1 hybrids planted, seven vines were selected for commercial evaluation. The yield, fruit quality and disease resistance rating of each selection are given. These selections were released for commercial 'on farm' evaluations in December 1988. These vines were inspected on five properties after they had set two crops. The fruit quality of six of the seven selections were compared against standard hybrids (23-E, Lacey). Commercial evaluation indicated that four F1 selections performed extremely well in different growing areas. Vegetative vigour gave selections superior disease tolerance compared to the standard hybrids. Further F2 hybrids produced from these selections did not give promising results. Hybrid selections 14 and 146 are now being grown commercially on the north coast of NSW.

Introduction

Numerous species of *Passiflora*, are grown in Australia (Bodkin 1986). The most common edible species are; *P. edulis* Sims. (black or purple passionfruit), *P. edulis* Sims. f. *flavicarpa* Degener (golden or yellow passionfruit) and *P. quadrangularis* L. (granadilla). Fruit of *P. edulis* are small (40 - 60 mm long, 30 - 50 mm wide), having a thick (3 - 6 mm), leathery, rind which is deep purple when ripe. *P. edulis* f. *flavicarpa* has large (60 - 120 mm long, 40 - 70 mm wide) yellow, fruit. The rind is thick (3 - 10 mm) with an orange, sweet

tasting pulp. The yellow passionfruit is more vigorous than the purple variety and there are numerous selections of both species. *P. quadrangularis* has very large fruit (100 - 130 mm long, 100 - 150 mm wide) with pale coloured, sweet pulp. Skin colour is yellowish green at maturity with a pinkish tint at the blossom end.

Compatibility between species is high in *Passiflora*, and many first generation hybrids have been produced (Ruberte-Torres and Martin 1974, Beal 1975). However, few if any, have better commercial properties than selections based on *P. edulis* or *P. edulis* f. *flavicarpa*. Breeding and selection to improve agronomic characteristics in these species have been undertaken previously. Ito (1978), reported selection for tolerance to brown spot (*Alternaria passiflorae*, Simmonds) and fusarium wilt in *P. edulis* f. *flavicarpa*. Hybrids between *P. edulis* and *P. edulis* f. *flavicarpa* combining high production, tolerance to passionfruit woodiness virus, and fusarium wilt were bred by the Queensland Department of Primary Industries at Redland Bay in the early 1960s, (Beal and Farlow 1984). Hybrids used in the Australian passionfruit industry today viz; 3-1, 23-E and Lacey are cloned selections from that breeding programme, however their exact pedigree is not clear (Farlow 1979). These hybrids have purple or plum-coloured fruit, crop more heavily over a longer period than *P. edulis* and although their flavour varies it is generally more acid than purple passionfruit. Selection 3-1 has fruit which is medium in size and somewhat triangular in cross-section. The vine is not as vigorous as the other commercial hybrids. Selection 23-E has large, oval to round fruit and is also somewhat triangular in cross-sections. The Lacey hybrid is similar to 23-E. Farlow (1979), made further crosses between selected hybrids of *P. edulis* × *P. edulis* f. *flavicarpa* and other species of *Passiflora* namely; *P. caerulea* and *P. incarnata* to obtain greater resistance to passionfruit woodiness virus. Although resulting hybrids and back crosses to 23-E produced symptom-less fruit, (Farlow 1979), commercial quality was unacceptable.

Peasley and Fitzell (1981) were able to reduce the spread of severe strains of

passionfruit woodiness virus within commercial plantings by an annual accreditation of mothervines. This scheme identified a hybrid known as Tom's Special which displayed commercial field tolerance to leaf and fruit diseases but was not grown widely due to poor yields of pale coloured fruit. This selection has many of the morphological features of *P. edulis* f. *flavicarpa*.

In 1979, a new disease called alternata spot *Alternaria alternata* (Fr.) Keissler [A. tenuis]) seriously affected Queensland hybrids, (Hutton 1988). Alternata spot is more virulent than brown spot and induces rapid leaf defoliation especially during wet, showery weather. Numerous, small (1-5 mm diameter) spots with characteristic dark green, greasy margins developed on fruit. This disease was initially controlled by iprodione, however, the emergence of strains resistant to iprodione (Hutton 1988), heightened industry demands for improved hybrids with disease tolerance. The aim of this breeding programme was to incorporate the vegetative vigour, disease tolerance and fruit size and flavour of hybrid Tom's Special into the three main commercial hybrids; 23-E, 3-1 and Lacey.

Materials and methods

Pollen transfers using the method of Beal (1975), were made between the hybrids Lacey, 23-E and Tom's Special in February 1985 and between Lacey, 3-1 and Tom's Special in March 1985. Flowers of both parents were covered with paper bags one day before opening. Pollen was transferred between 7 am and 9 am each morning, when anther dehiscence occurs. Bags were replaced over the artificially pollinated flowers and not removed until fruit were harvested. Hand pollination yielded 5-10 fruit of each cross and these were harvested between May and July. Seedling progeny of the crosses were raised in hot houses during June and July. Rootstocks (*P. edulis* f. *flavicarpa*), ex Queensland Department of Primary Industries, Redlands Bay, were also raised from seed in June and were grafted with F1 scionwood in December 1985.

Two hundred and thirty seven F1 crosses were planted into the field at the NSW Agriculture and Fisheries Tropical Fruit Research Station, Alstonville in January 1986 at a commercial planting density of 6 × 3 m. Due to constraints on land, labour and management costs, F1 crosses were not replicated nor were standard hybrids planted to act as controls. Available resources were used to screen as many progeny as possible. These vines were inspected on a two month basis by a joint committee comprising NSW Agriculture Officers and growers. Vines which did not reach commercial standards for growth habit, fruit

size and yield, skin colour and thickness, disease tolerance and processing criteria, were culled. Disease tolerance of vines was assessed by rating the incidence of leaf disease on a scale of 0 to 4 (0, 80 - 100% defoliation; 4, 0 - 20% defoliation) leaf drop. The processing evaluations were performed by Tweed Valley Fruit Processors Ltd. These were based on skin to pulp (wt:wt) ratio (% pulp); sugar content ($^{\circ}$ Brix at 20 $^{\circ}$ C); acid content (% acidity); sugar to acid ratio and pH of juice using techniques similar to Seal and Sherman (1960).

Seven F1 selections (see results) were released for commercial 'on farm' evaluation in December, 1988. Growers were provided with all seven selections, each on three different strains of *P. edulis* f. *flavicarpa* rootstock viz; 1) open pollinated Nambour, 2) open pollinated Redlands, 3) open pollinated Hawaiian ex Kershaw. These vines were inspected on a sample of five properties in the Richmond/Tweed district (NSW) during winter 1989 prior to harvesting their first winter crop and again in January, 1990 during their first major summer crop. Growers were questioned about the performance of each vine and which they considered commercially acceptable or unacceptable.

Ten fruit from six of the seven F1 selections, and standard hybrids 23-E and Lacey, were harvested on a monthly basis (January to April, 1990) from a commercial planting at Kyogle, (Richmond district, NSW). Fruit were evaluated for flavour (panel of 10 tasters), sugar content ($^{\circ}$ Brix at 20 $^{\circ}$ C), and pulp recovery (% pulp as ratio of fresh weight of fruit to fresh weight of pulp).

From the 18 F1 vines which remained in March, 1987 (see results), 13 were used to produce a total of 15 different F2 crosses; 3 within 23-E types, 3 within 3-1 types and 9 within Lacey types. Parents were chosen by ranking vines then crossing the best vine with second best, third best and fourth best. The F2 progeny of these

crosses were collected during July/August, 1987. These crosses were grafted onto *P. edulis* f. *flavicarpa* rootstock as described previously. One hundred and sixty nine F2 progeny from fifteen crosses viz; 14 x 11; 14 x 39; 14 x 8; 78 x 99; 78 x 73; 78 x 100; 193 x 154; 193 x 179; 193 x 151; 193 x 213; 193 x 209; 14 x 209; 78 x 209; 179 x 213 and 179 x 154 were planted out in December, 1988 in the area previously occupied by F1 vines. These were field evaluated similarly to the F1 progeny.

Results

F1 Programme

The number of F1 vines remaining after each inspection were; November 1986, 230; January 1987, 41; February 1987, 24; March 1987, 18; August 1987, 16; January 1988, 15; and March 1988, 11. From the 11 F1 vines which remained in March 1988, seven were selected for commercial evaluation. A brief description of the agronomic features of each vine is given below. The description is based on two seasons evaluation of a single vine.

Selection 11. Began producing earlier than all other selections (November after planting in January). Main cropping period is November to March then again from May to August.

Selection 14. Produced fruit in January after planting in the previous January. Production periods are during January to March and May to July with distinct low periods during April and September to December. This selection was the most vigorous and produced the largest, sweetest fruit but was considerably lacking in skin colour.

Selection 22. Produced fruit in January after previous January planting. It was slow to yield during the first 12 months of fruiting but set an exceptionally large crop during the following December to January period. Displayed good tolerance to leaf disease.

Selection 78. Produced fruit in December

after planting in January. It yielded more fruit in the first 12 months of fruiting than any other selection. Main cropping period is from January to March and May to September.

Selection 146. Fruited in December after planting in January and has an even cropping pattern with no real distinct "on" or "off" periods. This selection had exceptionally large fruit.

Selection 151. Began fruiting in December after planting in January, was slow to begin but like selection 22 produced a heavy crop in the following January (two years after planting). Displayed good tolerance to leaf disease.

Selection 193. Began quickly, producing a large crop in December to March after planting in January. Had an "off" period before producing a large crop in the following December.

The yield, fruit quality and disease resistance rating of each of the seven F1 selections are given in Table 1.

Commercial evaluation of F1 selections

Vine performance and grower comments are presented in Table 2. Selection 11 performed poorly on all farms and was dropped from further commercial evaluation. All other selections performed as well as standard hybrids in one or more locations with the exception of Terranora 1. On this property vines grew too vigorously under grower's high fertilizer management, yielded poorly and had little colour. There were no visual differences between the performance of the three types of rootstock used on any farm.

Commercial evaluations of six F1 selections and standard hybrids 23-E and Lacey from the Kyogle farm are shown in Table 3. Fruit from all F1 selections had significantly higher pulp recoveries and taste panel scores than either 23-E or Lacey standards. Selection 14 had the highest pulp recovery and 146 had the highest Brix reading and was favoured most by the taste panel.

F2 Programme

Ninety three vines were culled during the July 1989 inspection and a further 68 were taken out after inspection of the first summer crop (December, 1989). Four more vines were removed after harvesting the second summer crop (January, 1991). The four F2 vines remaining were 78 x 73; 78 x 100(a), 78 x 200(b) and 193 x 151. The most promising of these is 78 x 100(a), having extremely large fruit (average 103.6 g), a pulp content of 53%.

Discussion

One or more of the desirable agronomic features of each parent e.g., purple coloured fruit, good yields (standard hybrids) and vigour, disease tolerance and large, sweet fruit (Toms Special selection)

Table 1. Fruit characteristics and disease tolerance for the best seven F1 vines grown at NSW Department of Agriculture, Alstonville. (Figures are mean values for each vine's production from November 1986 to November 1988).

Selection Number	Production per year (kg)	Fruit wt. (g)	% pulp	Sugar content $^{\circ}$ Brix	% Acidity	Sugar:Acid Ratio	Ph	Disease ^a Tolerance
11	51	60	37	12.2	1.6	7.6	3.5	2
14	79	83	50	13.8	2.1	6.6	3.1	2
22	53	67	34	14.0	2.0	7.0	3.7	3
78	56	66	43	11.8	2.0	5.9	3.0	1
146	48	72	35	13.2	1.3	10.2	3.7	2
151	64	67	34	13.2	1.1	12.0	3.5	3
193	54	58	45	13.0	1.5	8.7	3.4	2

^a Disease tolerance on a rating scale of 0 - 4 (0, 80 - 100% leaf defoliation; 4, 0 - 20% leaf defoliation).

Table 2. Commercial evaluation of seven F1 selections after 13 months on five properties in the Richmond/Tweed district of NSW.

Locality	Commercial Grower Evaluation		Growers Comments
	Acceptable	Unacceptable	
Burringbar	146	11, 14, 78, 151, 193	Selection 146 had larger, sweeter fruit with more disease tolerance than standard hybrids
Newrybar	14, 146, 193	11	Selection 14 fruit had excellent size and taste but lacked colour
Terranora (1)	NIL	All seven	Selections were too vigorous and did not suit high fertilizer management. Selections yielded poorly but required less spraying. Selections lacked colour. Fruit of all selections were sweeter than standard hybrids.
Terranora (2)	78, 193, 146	11, 22	Selections were vigorous and needed fewer fungicide sprays than standard hybrids. All selections sweeter than standard hybrids. Selection 193 yielded better than standard hybrids.
Tyalgum	14, 78, 193	11, 151	Selection 78 had excellent colour. Selection 14 was large and sweet but lacked colour.

Table 3. Mean taste score, sugar content and pulp recovery of fruit of six F1 selections and standard hybrids 23-E and Lacey during second summer crop at Kyogle NSW.

Selection	Taste Score ^A (mod. av.)	Sugar Content Brix ^o	Pulp Recovery %
14	6.44 ^b	15.5 ^b	55.4 ^a
22	6.19 ^b	15.3 ^b	53.9 ^{ab}
78	4.69 ^c	14.7 ^c	47.2 ^b
146	8.25 ^a	16.6 ^a	48.2 ^b
151	5.60 ^{bc}	14.9 ^{bc}	48.6 ^b
193	7.75 ^{ab}	16.1 ^{ab}	49.9 ^b
23-E	3.13 ^d	13.2 ^d	38.7 ^{cd}
LACEY	4.13 ^c	14.1 ^{cd}	41.6 ^c

^A Score scale 1 - 10 (1, poor; 10, excellent) using modified average (lowest and highest scores excluded).

^B Means followed by the same superscript were not significantly different ($P < 0.05$).

were found in all F1 selections. Unfortunately a segregant of these hybridizations did not arise possessing all desirable features. This may have been due to the small number of seedlings arising from each cross.

Selections 22 and 151 had more disease tolerance but slightly poorer fruit characteristics than other F1 selections. Selection 14 was a consistent producer of large (83 g) fruit, with excellent taste, skin to pulp ratio and processing characteristics. The vine had moderate disease tolerance, however skin colour was poor. This characteristic may jeopardize its acceptance on the fresh fruit market. Selection 78 produced smaller (66 g) fruit, had low disease tolerance, however it did have a darker skin colour. Selections 146 and 193 both had moderate disease tolerance; 146 had large, pale fruit similar to the Toms Special parent while 193 had smaller,

darker fruit resembling the standard hybrids.

Commercial growers criticized selection 14 for lack of colour, however, considered it an excellent choice for processing. Selections 78, 146 and 193 performed well in different areas. This emphasized the environment, genotype interaction and importance of releasing a group of selections instead of one or two of the very best from a particular test site. The Burringbar area is warm and sheltered thus favouring vines with *P. edulis* f. *flavicarpa* characteristics such as 146. The Tyalgum site was the coldest and favoured more vigorous vines (14, 193) and those with *P. edulis* characteristics (78). Comments from three growers all indicated that vegetative vigour had given selections better disease tolerance compared to the standard hybrids but at the expense of yield and fruit colour. Criteria for com-

mercial assessment of passionfruit can be ranked in descending order of colour, fruit size, yield, cropping time and taste. This criteria reflects attention paid to visual appearance of wholesale markets.

The only F2 crosses which showed potential were those between selections 78, 100, 151 and 193. The single most promising cross will be repeated to enable screening of greater than 100 progeny.

Several commercial blocks of selections 146, 193 and 14 have been established in the Tweed region of NSW. Fruit from these selections are now appearing in major wholesale markets in eastern Australia and have been commercially named AV1, AV2 and AV3 respectively.

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