VG97064

Assessment of Tomato and Capsicum Cultivars and Production Techniques for Export to Japan and Taiwan and Demonstration of IPM for Botrytis cinerea for local and export crops

Ray Hart et al
Department of Primary Industries Water and Environment

Know-how for Horticulture™

VG97064

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Assessment of Tomato and Capsicum Cultivars and Production Techniques for Export to Japan and Taiwan and Demonstration of IPM for *Botrytis cinerea* for local and export crops.

Ray Hart *et al*

FINAL REPORT
TO
HORTICULTURE AUSTRALIA LIMITED

Horticulture Australia

Tasmania
DEPARTMENT of PRIMARY INDUSTRIES, WATER and ENVIRONMENT

TasTom

field fresh
Tasmania

Project No. VG 97064

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Purpose:

The purpose of this report is to detail the conduct of this three-year project to Horticulture Australia and to provide new and existing hydroponic greenhouse growers and industry investors with the outcomes of this study. These outcomes are intended to assist the expansion and market options for *Solanaceous* crops in Tasmania by providing new production and investment information gathered, trialed and collated in this report and associated publications.

Acknowledgments:

Project partners

Horticulture Australia Limited (HAL) was the major funding organisation, matching industry contributions dollar for dollar. Horticulture Australia was formerly known as the Horticultural Research and Development Corporation (HRDC).

Department of Primary Industries Water and Environment (DPIWE) provided "in kind" support to the project as project manager and with supply of administration overheads. The project funded one officer for three days a week.

Tasmanian Greenhouse Tomato and Vegetable Growers Association (TGTVGA) representing the interests of greenhouse vegetable growers provided funding and 'in kind' support.

Field Fresh Tasmania contributed financially towards the project and by 'in kind' support through its excellent marketing skills and contacts, Interstate and Overseas.

Project sponsors

J. and A. Brandsema – Seedlings, capsicum greenhouse, maintenance, supply of water, nutrients, management of nutrients and environmental control.

Tasmanian Institute of Agricultural Research (TIAR) – provided "in kind" support to the project principally with plant nutrition advice during the project and collaboration in writing the nutritional topics in the guide.

Aurora Energy – contributed towards the heating bill for the capsicum house and for monitoring the energy input. Heating is one of the main expenses of hot house growing.

Air Liquide – gas and equipment for the capsicum demonstration house.

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Editing

H. Watkins (hw: editing) – Final edit and layout of this report and the production and investors guides.

Date of Report: 31 March 2001.

Disclaimer:

Contents

Media Summary

Tasmania has an ideal environment in which to produce greenhouse vegetables. Its cool summers favour the production of high quality produce.

When Tasmania was granted area freedom from Tobacco Blue Mould (TBM) in November 1996, it presented greenhouse growers with an opportunity to export tomatoes, capsicums and eggplants to Japan.

This three-year project investigated a range of greenhouse tomato, capsicum and eggplant cultivars and their production techniques. The project also confirmed the New Zealand experience that *Botrytis cinerea*, which can be a major problem with these crops, can be controlled by managing the environment in greenhouses.

This work has generated knowledge that is a sound basis for decision-making by both existing greenhouse growers who wish to expand production and new entrants to the greenhouse vegetable industry.

Early on the project identified capsicums as the main market opportunity. The project also identified the cultivars Mazurka and Spirit (both red), Fiesta (yellow) and Nassau (orange) as suitable for both Tasmanian greenhouse production and for the Japanese market.

A production guide, "Greenhouse Capsicums: A guide to growing export quality hydroponic greenhouse capsicums in Tasmania", has been published. An investors guide, "Greenhouse Capsicums: Investors guide to export quality hydroponic capsicums in Tasmania", also has been published to help investors decide whether or not to invest in the capsicum industry.

Towards the end of the project, Korean imports of capsicums into Japan had a profound effect on price, making it uneconomic to export this crop to Japan. Fortunately, investigations showed that opportunities existed for high quality capsicums on the Tasmanian and interstate markets.

As a direct outcome, this project has encouraged two industry partners, with support from Horticulture Australia, to begin a semi-commercial joint venture to trial the knowledge learned in this initial study and test the market for capsicums on the local and mainland markets.

Technical Summary

Tasmania was granted area freedom from Tobacco Blue Mould (TBM) in November 1996. This presented Tasmanian greenhouse tomato and vegetable growers with the opportunity to export a range of *Solanaceous* vegetables, such as tomatoes, capsicums and eggplants, to Japan. In 1997, the supply of these crops into Japan was lowest and the prices highest during the peak Tasmanian harvest period from December to late March.

Botrytis cinerea can be a major disease problem with these crops. Experience from New Zealand (NZ) showed that appropriate management of the greenhouse environment would prevent this disease becoming a problem. This Integrated Pest Management (IPM) technique eliminates or minimises the use of fungicides.

The Tasmanian Greenhouse Tomato and Vegetable Growers Association (TGTVGA), Field Fresh Tasmania (FF), and the Department of Primary Industries, Water and Environment (DPIWE) developed a joint industry/Horticulture Australia-funded three-year project to investigate this opportunity and to trial the NZ method of *Botrytis* control in Tasmania.

The initial work involved growers from the TGTVGA and the DPIWE screening a large number of cultivars and FF exploring the export market opportunities. After the first year of broad investigation, the project partners selected the most promising cultivars on agronomic, export quality and market potential for more intensive trials.

The project confirmed early that greenhouse capsicums had the most potential of the *Solanaceous* crops for export. In consequence, world best practice production methods would need to be determined. A small greenhouse containing a computerised environmental control system was leased. In addition, a specialist consultant in capsicum husbandry was contracted to advise on all aspects of crop management.

The project identified that the greenhouse capsicum cultivars Mazurka and Spirit (both red), Fiesta (yellow) and Nassau (orange) were suitable for greenhouse production in Tasmania and for the Japanese market. A production guide, "Greenhouse Capsicums – A guide to growing export quality hydroponic capsicums in Tasmania", was compiled and published as a direct result of this Horticulture Australia project. This publication has been produced for greenhouse growers in Tasmania. However, it could be adapted to suit the needs of any greenhouse growers throughout Australia. A supplementary investors guide also has been written to help potential investors decide whether or not to develop greenhouse capsicum operations.

Unfortunately as the project neared completion, imports of capsicums from Korea had a profound effect on the price received for capsicums in Japan. Fortunately, opportunities exist on the mainland to market high quality Tasmanian capsicums, although it may be necessary to trial different cultivars.

Preliminary trials comparing capsicums grown using Nutrient Film Technique (NFT) with those grown in sawdust bag culture suggested that NFT could be used for early production of coloured fruit without affecting total production. This potential economic advantage is worth verifying.

The work with tomatoes identified two new cultivars, Darita and AX 701-7, that were more adaptable than the cultivars in present use to the wide range of existing greenhouse facilities in Tasmania. The long shelf life (LSL) type Ipsilon, which is widely grown in Tasmania, was found to require the higher temperatures sustained in the more modern greenhouses to produce to its potential.

This work has generated knowledge and information about three *Solanaceous* crops that could provide a sound basis for decision-making by both existing greenhouse growers wishing to expand and new entrants to the greenhouse vegetable industry.

As a direct outcome, this project has encouraged two industry partners, with support from Horticulture Australia, to begin a semi-commercial joint venture to trial the knowledge learned in this initial study and test the market for capsicums on the local and mainland markets.

Introduction, including review of literature

In November 1996, Japan granted Tasmania area freedom from Tobacco Blue Mould (AQIS 1994). This gave Tasmania an opportunity to export *Solanaceous* fruits such as tomatoes, capsicums and eggplants to Japan. In addition, Tasmania's cool temperate climate is ideal for greenhouse production as it favours the production of high quality produce with relatively low incidences of pests and diseases.

DPIWE began a project in 1997 to explore this export opportunity by assessing tomato, capsicum and eggplant cultivars and the best available production techniques for these crops.

Production of greenhouse tomatoes has been extensively researched in Australia and elsewhere. Many cultivars have been tested for their suitability to specific markets that need certain sizes, shapes, colours, tastes, food quality and dates of maturity. Some cultivars, such as Ipsilon, show potential for export to Japan. However, they need to be tested to see whether or not tomatoes of acceptable quality for the Japanese market can be produced economically in Tasmanian greenhouses. Hydroponic tomato production methods are well understood by Tasmanian growers.

Capsicums, *Capsicum annuum*, have had a lucrative market in Japan. However, Australia, and especially Tasmania, has little or no previous experience in exporting this vegetable to Japan. In Addition, Tasmanian greenhouse growers have not attempted to grow hydroponic capsicums. Technical information is lacking on techniques of production, including solid media versus nutrient film technique (NFT), environmental requirements, nutrient management and economic feasibility of production.

Sawdust as a greenhouse growing medium has been used to grow many vegetable and ornamental crops (Cheng 1987, Adamson and Mass 1976, Morgan and Lennard 2000), but has not been trialed in Tasmania for capsicum.

NFT has been comprehensively reviewed by Graves (1983) and shown to be superior to other media in most cases. Under the same environment and management, tomatoes yielded up to 26% more than when grown on soil or peat media (Spensley *et al.*1978). However, Norman (1981) observed up to 6% lower tomato yields in two consecutive years with NFT. No comparable results are available in Australia for comparing NFT with alternative media.

Environmental conditions have significant effects on yield, quality and pest and disease management of capsicum crops (Morgan and Lennard 2000, Moreshet *et al.* 1999, Rylski and Spigleman 1982, Bekker 1989). Anecdotal evidence shows that capsicums may need higher temperatures than tomatoes but this has not been verified experimentally.

A wealth of information is available on the composition of nutrient solutions used for growing tomato, lettuce and many other crops. However, little is available for capsicums or eggplants. The recent book on hydroponic capsicum production (Morgan and Lennard 2000) describes nutrient solutions for different stages of growth of capsicum but neither reveals the source of this information nor indicates whether or not the solution has been used successfully in commercial environments.

Blossom-end rot that causes soft watery rots on the fruit of capsicums has been a major problem in Australia and other countries. This disorder is linked to environmental factors and imbalances in nutrient solutions (Wien and Zhang 1991, Tadesse *et al* 1999).

Eggplants have rarely been grown in Tasmania and little is known of present cultivars, production methods or the economics of this crop.

Botrytis cinerea (grey mould) is a common disease for all greenhouse *Solanaceous* crops. It produces grey to brown coloured fluffy lesions on leaves, fruits and stems and causes severe rot in fruit and flower buds (Kim *et al.* 1996). For the infection to occur, the spores must

germinate and penetrate the plant foliage and fruits. The grey mould spores like hot and humid conditions for germination. When temperatures are above 20°C and humidity above 95%, spores germinate rapidly, especially when free water is present on the plants (Elad *et al.* 1992).

Many fungicide sprays have widely been used to control *Botrytis* infection in greenhouses. Spraying alone is not the answer as this disease can build resistance against many fungicides (Faretra *et al.* 1989) and the method is very costly. In consequence, controlling environmental conditions to make them unsuitable for spore germination is crucial (Elad *et al.* 1992).

An integrated pest management strategy (IPM) for *Botrytis* has been successfully applied in New Zealand by combining minimal pesticide use and taking measures to reduce the presence of free water on crops. There is no information about whether or not the NZ experience could be extended to Tasmania. This project aimed to include a demonstration of this methodology under Tasmanian conditions. An IPM strategy is needed to reduce the economic damage of the disease to the production and quality for export.

This project needed to gain technical production knowledge and document this to ensure potential investors and growers confidently can undertake the production of high quality fruit that meets export standards.

Tasmania has a relatively small domestic market for *Solanaceous* crops. Export would greatly increase the opportunities existing growers to expand production and for new growers to enter the industry.

As Tasmanian growers have no previous experience of exporting *Solanaceous* crops, this would be a major challenge for them without trial shipment experience. Trial exports from this project would allow the many components required for an export program to be assessed.

Objectives

1. To assess greenhouse tomato, capsicum and eggplant cultivars to meet yield, quality and fruit characteristics for export.
2. To gain best practice knowledge on how to economically produce greenhouse crops that meet export requirements.
3. To use this knowledge to produce a comprehensive guide for greenhouse hydroponic production of high quality fruit suitable for export.
4. To demonstrate that IPM control methods will work for *Botrytis* under Tasmanian conditions.

Materials and Methods

This was exploratory research where the direction of the work and the methodology was developed after the project partners reviewed the results each year. This section of the report is described chronologically to make it clear how this project developed. However, in the results and discussion sections, the information is clearer when presented on an objectives and crop basis.

All trial crops were grown hydroponically using bag culture or NFT, depending on the site.

1997–1998

In 1997–98 tomatoes, capsicums and eggplants were evaluated by greenhouse growers around the State and by the DPIWE at the Stoney Rise Centre (SRC) at Devonport.

Ten sites were established throughout Tasmania, six trialing tomato cultivars, four capsicum cultivars and three eggplant cultivars. In total, 28 tomato cultivars, 25 capsicum cultivars and nine eggplant cultivars were planted for evaluation. Greenhouse structures and methods of production varied with sites. Seed was sourced from a range of commercial companies. All seedlings were grown by a commercial propagator and distributed to growers for inclusion with their own plantings. At this initial evaluation stage, no statistical design was employed and the specific data gathered varied with sites and plant types grown. Appendix 1 shows which species were trialed at the ten sites in Tasmania.

Tomatoes – Seed of cultivars that would have the potential to be suitable for the Japanese market were sourced from a range of seed companies. The 25 new cultivars were compared with three standard cultivars, Amfora, Vemone and Ipsilon. Commercial growing methods were used at all sites. Regular records were kept at each site. Fruit were photographed and assessed for size, number per truss and appearance. In addition, one grower recorded yield by date and the DPIWE recorded individual fruit weights, truss details, grade, appearance and brix at the SRC. A taste test that involved locals and expatriate Japanese was conducted by one grower. In addition, anecdotal data was gathered about cultivating tomatoes in Tasmanian conditions.

Capsicums – Blocky cultivars that are preferred by the export market were grown at all sites. In this first season, all the capsicum crops were grown in tomato greenhouses alongside tomato plants. This meant that capsicums were grown with feeding and environmental management that was set for commercial tomato crops. In consequence, the growing conditions were below the optimum for capsicums. Detailed information on yields was not recorded. Capsicum plants were trained to two leaders as described by Smith (1986) and Nederhoff. E. (1998). Only one fruit per node was allowed to grow. Regular observations were made at each site and fruit were photographed and assessed for size and shape.

Eggplants – Growing conditions for this crop also were dictated by the requirements of tomatoes. Plant habit and the size and shape of fruit were the only details considered worth recording at this stage. The training method followed was one leader trained up a string to the crop wire. Side shoots were pruned at the first leaf junction, usually after allowing fruit to set at this point. Some cultivars had very large leaves and some needed to be removed during the growing season. Indicative fruit weights were recorded at SRC. In addition, photographs were taken of all cultivars throughout the season.

Market investigations – Because of business connections and trade with Asian markets, Field Fresh Tasmania, an industry partner in this project, used its business connections and trade with Asian markets to conduct this component of the project during overseas visits and other meetings with importers from these countries. The organisation continued this role during the life of the project.

IPM of *Botrytis cinerea* – Due to a major restructuring and planned partial sale of the Hydro-Electric Corporation (HEC) by the State Government, the anticipated HEC funding for demonstrating that *Botrytis* disease can be controlled by managing the environment in commercial greenhouses did not eventuate.

In consequence, a small demonstration was developed at the SRC where the relative humidity (RH) in the greenhouse was kept below 85% by controlling temperature and ventilation. The intact skin and fresh wounds of tomato fruit and stems were inoculated with high concentrations of *Botrytis* spores. The RH was monitored and logged by Tinytag™ equipment.

1998–1999

Following a seasonal review by the project partners, further evaluation of eggplants was not considered worthwhile and only tomatoes and capsicums were progressed.

Market research in 1997–98 identified capsicums as having the greatest economic export potential to Japan. In consequence, the project partners decided that this crop should be evaluated thoroughly. A small, 184 square metre greenhouse that contained a computerised environmental control system was leased at Turners Beach to ensure optimum growing conditions for capsicum plants could be established. A specialist consultant was contracted to advise on all aspects of crop husbandry. He made fortnightly visits to the crop for most of the season.

As a consequence of the withdrawal of HEC support and the successful suppression of *Botrytis* in the small first year demonstration at the SRC, the proposed large scale *Botrytis* IPM demonstration was not pursued.

Tomatoes

In a statistically designed trial, a total of nine tomato cultivars were compared with the industry standard, Ipsilon, in larger greenhouse trials at Kindred and Ulverstone in the north-west, Launceston in the north and Lauderdale in the south. About 50 plants of each cultivar were grown at each site. A random sampling technique was used for each pick. All cultivars were grown according to commercial practices and included the leading cultivars AX 701-7 and Darita from the 1997–98 trials.

Due to a shortage of local tomatoes in March, it was not possible to test the market for tomatoes in Japan for the 1998–99 season.

Capsicums

Four cultivars, Spirit, Fiesta, Mazurka and Nassau, were transplanted on 29 June 1998 into a replicated block trial in a leased, environmentally-controlled greenhouse at Turners Beach in north-west Tasmania. A further three cultivars were transplanted on 30 June and eight cultivars on 3 August in unreplicated observations. All cultivars were grown in run to waste sawdust bags and the first two flushes of fruit were picked green, beginning in the week ending 9 October 1998. Harvest of coloured fruit began in the week ending 11 December 1998 and was completed on 10 May 1999.

The growing method used was two leaders per plant trained on strings attached to overhead wires and fastened to the base of plants with tomato clips. The plants were pruned and trained (twisting) as needed over the growing season. This was about every two to three weeks. The density of plants was 3.8 plants/m^2. The plots in the replicated trial consisted of 12 plants, each set out in six blocks. For the initial pruning, the first or crown flower and flowers from the next two nodes were removed along with lateral shoots in excess of the two leaders. However, to allow the plants to develop further and recover from pruning, it also was decided to remove flowers from the fourth node. Further pruning consisted of leaving up to five

leaves on laterals past the node supporting the fruit. Bumblebees were introduced, under special permission, to observe the effect they had on fruit set and shape.

The mature green fruit harvest began in the last week of September and continued twice a week for seven weeks. This consisted of the green fruit from the first two flushes, which were harvested to allow further development of the plants. After this green harvest, fruit was left until it developed its mature colour. The harvest for coloured fruit began in mid December, continuing twice a week until mid March, then once a week until the end of the crop in early May.

A small trial shipment of about 200 kg was sent to Japan to coincide with Foodex 1999.

1999–2000

Again, following a seasonal review, the project partners decided to put all resources into confirming the previous season's good results for capsicums and to increase the knowledge base of how to grow high quality hydroponic greenhouse capsicums for potential export markets. No further tomato trials were conducted because the potential export income from this crop was assessed as not being viable at the time the trials were conducted.

Capsicums

Six capsicum cultivars, including the four from 1998–99, were grown at a density of 3.8 plants/m^2 in a replicated trial at Turners Beach in sawdust bags. The seed was sown on 9 April 1999 and transplanted into sawdust bags on 8 June 1999. The trial included two red maturing cultivars, Spirit and Mazurka, two yellow maturing cultivars, Sirtaki and Fiesta, and two orange maturing cultivars, Emily and Nassau. Also included for observation in the greenhouse were a number of additional cultivars grown in unreplicated plots for observation.

In addition to the sawdust bags, a small area of NFT was established in the greenhouse. Four single plots of 10 plants each were grown. The two growing systems were compared. Both systems were established using two leaders trained up a string attached to the top wire. Plants were pruning and trained at intervals of two to three weeks throughout the growing season.

Fruit grown in sawdust bags were harvested at the green mature stage for the first two flushes, which lasted about eight weeks. Fruit grown in NFT were harvested at the mature green stage for the first flush only, which lasted about four weeks. This meant that the fruit was allowed to reach colour maturity earlier, which meant the first coloured harvest from the NFT system was about a month earlier than from the sawdust bags. Fruit were harvested twice a week until mid December and then once a week until the end of March when the trial was terminated.

Results

Objective 1: Export potential of *Solanaceous* cultivars.

Eggplants

1997–1998

Eggplants were evaluated in the first year only because financial analyses showed that the potential returns from eggplant exports to Japan were poor. Yield data was not collected. However, the amount of first grade fruit was well below commercial expectations in all cases. Some cultivars performed very poorly but growers and the DPIWE considered three would be suitable for commercial trials if demand became economic. The cultivars N6204, Abrivado and Bonica were selected on plant vigour and the attractiveness of the fruit. Table 1 shows the cultivars grown in the 1997–98 trials. The data collected will serve as a base for selecting cultivars in line with any future market requirements for shape, size and colour. Problems were experienced with mites, aphids, mealy bugs and white flies.

Table 1 Eggplants grown at the SRC in 1997–98.

Cultivar	Habit	Size of fruit	Shape of fruit
Long Tom	upright, small leaf, purple stem	170 x 50 mm	semi-long slender, purple/black
Summer Bird	upright, small leaf, purple stem	150 x 45 mm	cylindrical/oval, dull purple/black
LV 9732	upright, vigorous, large leaf, green stem	180 x 90 mm	elongated/oval, purple/black
LV 9733	upright, vigorous, large leaf, green stem	170 x 90 mm	oval, glossy dark black
Money Maker No. 2	purple stem	180 x 60 mm	long cylindrical, dull purple
Sendai Naga Nasu	pickling type, small leaf, purple stem	70 x 20 mm	very small, cylindrical, dull purple
Bonica	upright, vigorous, large leaf, green stem	155 x 110 mm	round/oval/bell, glossy dark purple
Abrivado	upright, vigorous, large leaf, green stems	240 x 70 mm	long cylindrical, glossy purple
N6204	upright, vigorous, large leaf, green stem	240 x 80 mm	long cylindrical, glossy purple

Tomatoes

Experienced greenhouse tomato growers evaluated tomatoes over two seasons in various types of greenhouses.

1997–1998

In the first year, 28 cultivars were evaluated across six sites. Table 2 collates all the information collected.

Table 2 Performance of tomato cultivars at several sites in 1997–98.

Cultivar	* Performance and appearance rating (grower mean)	# Blind taste test (total score)	Fruit/truss (range)	1st grade fruit – SRC (% of total)	Yield (kg/plant)	Typical average. weight of 1st grade fruit – SRC (g)	Brix ex TB
AMFORA	10	NT	7–9	76	5–8.7	130	4.9
Darita	9	16	3–6	90	5.3	157	4.8
Roulette	9	11	4–6	88	6.7	166	3.7
Toga	9	14	5–9	87	6.1	123	4.4
AX701-7	9	NT	4–6	92	6.6	140	5.8
No. 59	7	12	3–4	62	4.2	170	5.5
Ramos	7	13	4–7	90	6.1	128	5.0
Kasha prie	7	6	5v6	79	5.4	115	5.2
Red bluff	7	14	4–7	85	4.6	127	5.5
Burswood	7	14	4–7	93	5.3	137	5.0
Vemone	7	20	5–6	72	4.9–7.9	118	5.7
974548	7	12	4–5	85	6.0	143	5.0
974527	7	NT	5–6	75	3.6	118	4.5
LV9570	7	NT	3	30	2.0–6.1	190	6.5
954K	6	12	4–6	75	5.1	138	3.7
Crown	6	8	5–6	88	4.6	139	5.2
Regal red	6	7	3–6	91	5.2	128	5.2
No. 57	6	15		56	2.9–7.3	150	5.4
Ipsilon	6	15	4–8	66	3.2	131	4.9
AX701-9	5	NT	3–5	73	4.6–4.8	202	3.5
T93	5	NT	4–7	61	2.0	156	5.0
HTB	5	NT	2–3	57	2.7–4.3	130	6.0
Jupiter	4	7	4–8	90	4.5	130	4.8

* Performance and appearance rating: based on scores for yield, size and shape of fruit and plant habit and management characteristics.

Total score: High = Good, NT = Not available to test at this site.

Overall, Darita and AX701-7 were considered the most promising tomato cultivars for yield, quality and desirable characteristics for export in 1997–98 by the commercial collaborators and the DPIWE. The performance of other cultivars was more variable across sites.

1998–1999

In 1998–99, the best cultivars from 1997–98 were grown at four commercial sites using a random sampling technique at each picking. Data from one of the sites was lost. Table 3 shows the results that were recorded.

Table 3 1998–99 total yield of tomato cultivars

Cultivar	Total yield of fruit (kg/plant)			# Mean	
	Grower A	Grower B	Grower C		
	21 Picks	9 Picks	12 Picks		
	25 Nov—18 Jan	6 Nov—31 Dec	16 Dec—13 Feb		
AX-701-7	8.11	7.10	5.35	5.99 ab	
Darita	6.96	5.80	4.27	5.01 bc	
Ipsilon	7.98		4.40	5.54 b	
Toga		7.87	6.92	7.24 a	
Roulette		6.08	2.76	4.06 c	
Trediro	7.50				
Daniela		6.49			
Regal Red		6.08			
Ramos			5.75		
Kasha-Prie			4.91		

Cultivar means that are followed by the same letter are not significantly different (pr.<0.05).

Appendix 2 shows the weight of fruit at each picking.

AX 701-7 and Darita again performed well against the industry standard Ipsilon at two sites. Again due to the variability in cultivar performance, which depended on location and greenhouse environment, it is evident that growers need to conduct their own on-site tomato cultivar evaluations.

Due to a shortage of local tomatoes in March it was not possible to test the market for tomatoes in Japan for the 1998–99 season.

Both the NFT and sawdust bag culture methods were successful. However, anecdotal evidence suggested that bag culture would provide growers with a higher safety margin. Some LSL cultivars required more heat than other cultivars, while some performed well in older-style greenhouses that did not have modern environmental controls. The cultivar Ipsilon, the present LSL standard, produced abnormally small fruit in the 1999 spring crop, probably due to cooler than normal outdoor temperatures.

Capsicums

1997–1998

In the first year, capsicums proved more difficult to grow than tomatoes, hampered by insufficient control of temperatures and the presence of root disease in the main trial site at Stoney Rise where an old glasshouse was used. Other trial sites produced limited data due to commercial pressures. Appendix 3 provides information of the observations made at SRC.

Results showed that conditions suitable for growing tomatoes were far from optimal for capsicums. In addition, it was clear that specialist experience and expertise was required to rapidly assess the potential of capsicums and to gain local experience and knowledge. Market evaluation by FF suggested that out of the *Solanaceous* species, capsicums were the major export opportunity.

The trial experience indicated that capsicum plants would require modern environmental controlled greenhouses where temperatures could be kept at 18–24°C to ensure good fruit set and shape. From the trial observations and other industry advice, the four most promising cultivars, Mazurka, Spirit, Fiesta and Nassau, were selected for further intensive assessment. A suitable greenhouse was leased to trial and demonstrate capsicum production and a consultant was retained to speed up acquisition of best practice technology.

Results indicated that bumblebees greatly improved pollination, which lead to substantial increases in export grade fruit. A separate project proposal was submitted to Horticulture Australia to progress a Commonwealth decision to introduce fresh genetic stock of bumblebees to Australia to help develop a bumblebee pollination service in Tasmania. (See HRDC Project No. HG 631.1997.)

1998–1999

Significant progress was made in the second year. The plants grew well, with only minor problems, and yields and grade of fruit were up to world best standards. Table 4 shows the yields of fruit and Table 5 shows the average weight of fruit and the percentage of first grade fruit. Damage by rodents and thrips reduced the first grade yield. The effect of bumblebees was considered to help fruit set and shape and also ensured flower separation, lessening the risk of *Botrytis*.

Table 4 1998–99 Yield of capsicum fruit (kg/m^2)

Cultivar	Green		Coloured		Combined	
	Total	* 1st grade	Total	* 1st grade	Total	* 1st grade
Fiesta (yellow)	9.1 a	6.7 a	25.2 a	14.8 b	34.3 a	21.8 a
Mazurka (red)	9.0 a	7.0 a	22.1 b	15.9 a	31.1 b	23.0 a
Nassau (orange)	7.5 b	6.2 b	18.5 c	14.4 b	26.0 c	20.3 b
Spirit (red)	7.9 b	5.9 b	19.9 c	14.2 b	27.8 c	19.9 b
Lsd 5%	0.74	0.61	1.78	1.06	2.14	1.24

*adjusted for covariate (total weight).

Figures that are followed by the same letter are not significantly different (pr.<0.05).

Table 5 1998–99 Average fruit weight (g) and percentage first grade fruit.

Cultivar	Green		Coloured		Combined	
	Average weight	% 1st grade.	Average weight	% 1st grade.	Average weight	% 1st grade.
Fiesta	136	77	163	68	154	70
Mazurka	139	81	177	74	163	76
Nassau	124	76	152	68	142	71
Spirit	134	72	170	67	158	68

Of the other 11 cultivars evaluated on a limited basis, Emily (yellow) and Sirtaki (red) were considered worthy of inclusion in 1999–2000 trials, along with the above four that more than met expectations.

Capsicum fruit samples were appraised on a number of occasions by visiting Japanese importers and exporters and at Foodex in Japan in March 1999. The Japanese importers and exporters suggested that fruit were of similar standards to Dutch products. This was supported by feedback on the trial samples displayed at Foodex. Some problems were experienced with packaging and a small number of fruit were found to be bruised and punctured on arrival in Japan.

1999–2000

In the final year, the six main cultivars grown in sawdust culture performed reasonably well although they did not perform up to the very high yield and grade of the previous season. Combined fruit yields were 30–50% lower in 1999–2000 than in 1998–99 and the average weight of first grade fruit was 5–15% less in 1999–2000. Table 6 shows the yields of fruit and Table 7 shows the average weight of fruit and the percentage of first grade fruit.

Apart from seasonal factors, the project partners felt that the following management practices may have influenced the lower yields in 1999–2000. Inadequate pruning, which allowed extra laterals to develop and set fruit, resulted in increased fruit load; once a week harvesting from mid December 1999; and the absence of bumblebees to assist pollination. In addition, the difficulty of maintaining sufficient humidity on clear hot days and over vigorous plant growth resulted in plants reaching the top wire and being stopped earlier than in the 1988–99 season.

Table 6 1999–2000 Yield of capsicum fruit (kg/m^2)

Cultivar	Green		Coloured		Combined	
	* Total	** 1st grade	* Total	** 1st grade	* Total	** 1st grade
Fiesta	7.1 a	5.1 a	12.3 d	6.4 b	19.4 c	11.8 b
Mazurka	7.1 a	5.2 a	14.3 a	8.3 a	21.3 a	13.1 a
Nassau	6.1 b	4.1 b	11.6 e	5.9 c	17.6 d	9.8 c
Spirit	6.4 b	4.4 b	13.1 c	6.8 b	19.6 c	11.4 b
Emily	5.5 c	3.6 c	10.9 f	5.7 c	16.5 e	9.2 c
Sirtaki	7.0 a	5.2 a	14.0 b	7.9 a	20.4 b	13.3 a
Lsd 5%	0.30	0.24	0.20	0.34	0.50	0.43

*adjusted for covariate (total number). **adjusted for covariate (total weight)

Figures that are followed by the same letter are not significantly different (pr.<0.05).

Table 7. 1999–2000 Average fruit weight (g) and percentage first grade fruit.

Cultivar	Green		Coloured		Combined	
	Average weight	% 1st grade.	Average weight	% 1st grade.	Average weight	% 1st grade.
Fiesta	149	78	146	50	147	61
Mazurka	147	79	159	62	154	68
Nassau	132	57	149	50	143	52
Spirit	141	67	141	55	139	59
Emily	135	53	141	45	145	48
Sirtaki	147	80	155	66	152	70

Appendix 4 shows the raw yield data from each picking for the 1998–99 and 1999–2000 seasons.

NFT in 1999–2000

In the small-unreplicated NFT trial, quality advantages were recorded. Combined first grade yield was similar to the sawdust bag trial but coloured fruit made up a higher percentage of total yields. The yield of first grade coloured fruit was up to 30% higher and average weight of first grade fruit for both green and coloured was 10% higher than from sawdust bags. In addition, the percentage of first grade fruit was 10% higher than from sawdust bags. However, it must be stressed that these results were from small-scale unreplicated plots. More rigorous trials would be needed to test these results thoroughly. Table 8 shows the yields of fruit and Table 9 shows the average weight of fruit and the percentage of first grade fruit.

Fruit were harvested at the green mature stage for the first two flushes for the plants in the sawdust bags, lasting about eight weeks, whereas for the NFT, only one flush was picked green, lasting about 4 weeks. This meant that the fruit from the NFT system reached coloured maturity about a month earlier than from the sawdust bags with no obvious detrimental effect on the plants from earlier coloured fruit load.

Table 8. 1999–2000 Yield of capsicum fruit (kg/m^2)

Cultivar	Green		Coloured		Combined	
	Total	1st grade	Total	1st grade	Total	1st grade
Fiesta	3.5	3.1	17.8	8.5	21.2	11.7
Mazurka	1.5	1.3	17.8	11.7	19.3	13.0
Spirit	3.5	3.1	12.3	8.1	15.9	11.2
Emily	2.9	2.1	12.3	7.1	15.2	9.2

Table 9. 1999–2000 Average fruit weight (g) and percentage first grade fruit.

Cultivar	Green		Coloured		Combined	
	Average weight	% 1st grade.	Average weight	% 1st grade.	Average weight	% 1st grade.
Fiesta	164	89	150	48	153	55
Mazurka	168	90	159	66	160	68
Spirit	165	87	156	66	158	71
Emily	155	71	156	58	155	60

Objectives 2 and 3: Gaining best practice knowledge and incorporation into a grower guide.

As capsicums became the prime focus of the project, detailed cultural information was gathered and this was developed into a comprehensive production guide, "Greenhouse Capsicums: A guide to growing export quality hydroponic greenhouse capsicums in Tasmania". The knowledge gained for Objective 2 is presented in this guide and not in this report. This published guide is submitted as a major outcome of the project. Economic information for establishment of a new capsicum dedicated greenhouse also was gathered during the project and has been compiled in the supplementary investors guide, "Greenhouse Capsicums: Investors guide to hydroponic greenhouse capsicums in Tasmania."

In addition, the detailed environmental monitoring/control and nutrient monitoring/control data collected for the capsicum house at Turners Beach has been collated in a separate case study document available from the DPIWE as a reference for new growers, "Case Study: Technical Information from the 1998-99 and 1999-2000 Greenhouse Capsicum Trials".

Objective 4: IPM of *Botrytis cinerea* of greenhouse tomatoes.

Work overseas has successfully demonstrated that applications of fungicides to control *Botrytis* are not needed if the greenhouse environment is controlled to prevent free moisture building up on the plants.

To demonstrate this control measure in Tasmania, tomato fruit still on the plant were exposed to *Botrytis* spores. Table 10 shows the results of the *Botrytis* trials.

Table 10. Results of *Botrytis* spores placed on skin and in fresh wounds

Date inoculated	Number infected/Number inoculated (% infected)	
	Spores on skin	Spores on wounds
27/2/98	0/55 (0%)	* 74/87 (85%)
6/3/98	0/82 (0%)	98/98 (100%)
10/3/98	0/78 (0%)	77/78 (98.7%)

*Possible resistance in some cultivars detected in this inoculation round.

The results from Table 10 demonstrated that *Botrytis* could not infect tomatoes except when the fruit was freshly wounded. The failure of spores to infect unwounded tomatoes were attributed to the dry conditions in the DPIWE greenhouse, which resulted in no free water being deposited on the fruit.

Although the humidity was high on several occasions, the periods were not long enough to demonstrate infection in the absence of wounds. These results highlighted that *Botrytis* can be controlled successfully by manipulating the greenhouse environment.

Each inoculation round had a different concentration of spores applied. The first round on 27 February 1998 had the lowest concentration and two cultivars showed high levels of resistance to infection even though the spores were placed in fresh wounds.

Freshly wounded stems also were inoculated with spores. The failure of the spores to infect the stems again emphasised the importance of controlling the environment to prevent *Botrytis* infection. This result suggested how the growers would benefit from being particularly diligent in providing dry conditions during and after the practices that damage plants, such as de-leafing, pruning and harvest.

Discussion

Eggplants

Although only a preliminary evaluation was undertaken in tomato greenhouses, it was clear that eggplants would need more heat and specific environmental conditions for this crop to reach its potential for yield and quality.

Market enquires found that the likely export returns for this crop would not warrant the high production costs that would be necessary under Tasmanian conditions at this point in time. The study on eggplants stopped after the first year of trials.

Tomatoes

A small domestic greenhouse tomato industry has operated in Tasmania for many years. At present, there is a wide range of grower experience and levels of sophistication of greenhouse infrastructure, environmental control and production methods.

A local grower association and partner in this project, the TGTVGA, facilitates information exchange. This project has provided the impetus and opportunity for association members to explore the requirements and potential for export through cooperation in trials, field days and meetings.

From the evaluations conducted over two seasons, only two cultivars Darita and AX701-7 performed well at all sites. Although local evaluations of fruit quality were positive for export suitability by visiting importers and exporters, this was not tested by trial shipment.

Export market investigations found that market-suitable cultivars would need to be grown by a number of growers to obtain economic volumes of best quality fruit. In turn, the project partners assessed that more modern or upgraded greenhouses would be required by new or existing growers to produce export volumes.

Enquiries indicated that the likely export returns for this crop might be economic but at some risk because the Japanese market was well supplied and highly competitive.

For these reasons, the project partners considered that further cultivar and market assessment is required before growers make large-scale investments into greenhouse tomatoes for export.

Capsicums

Evaluations of capsicums in the first year were limited. However, the export market investigations were significantly favourable for the project partners to direct the main project effort into this crop.

Although starting from a base of little practical experience, leasing a modern greenhouse specifically to grow this crop and contracting a specialist consultant enabled the project to produce a small commercial crop up to world class standard for yield and quality.

The small trial shipment of about 200 kg sent to Japan to coincide with Foodex 1999 confirmed the quality of the product. Valuable experience was gained in testing the procedures required for packing and exporting capsicums.

Spirit and Mazurka were confirmed in two seasons as red capsicum cultivars suited to both greenhouse production in Tasmania and the Japanese market. The suitability of Fiesta (yellow) and Nassau (orange) also were confirmed. Sirtaki (red) and Emily (yellow) showed similar potential in the final season.

Strict attention to all aspects of crop production was shown to be critical and this knowledge is now available to growers in the production guide developed from the project. Some variations in the production methods in the third season highlighted the sensitivity of capsicums to timely and optimal management methods.

The project showed that, unlike tomatoes, capsicums must be grown with more management and cost inputs and with greater control over temperature and humidity. This can only be achieved in modern greenhouses that have all the ancillary infrastructure needed to achieve this control.

Initial market intelligence suggested that capsicums were a major market opportunity for export to Japan. However, an influx of capsicums from Korea in 2000 lowered prices and no fruit was exported in 2000. The Korean imports reduced prices enough to make export to Japan an uneconomic proposition. However, the potential in the local and interstate markets appears to be promising for Tasmanian greenhouse capsicums.

On the completion of this project, a semi-commercial capsicum trial sponsored by Horticulture Australia and industry partners began to test lessons learned from this initial three-year study. The opportunity exists to update initial findings as the results from this commercial trial come to hand.

As the main focus of the project shifted to capsicums in the second year, the production of a technical guide for this crop became a priority, especially as there was little local experience or expertise in this crop. The use of a specialist consultant was considered the most significant factor in gaining the expert knowledge required. The project partners believe the production guide, "Greenhouse Capsicums: A guide to growing export quality hydroponic greenhouse capsicums in Tasmania", has captured this knowledge in sufficient detail to allow new growers to confidently, and at minimal risk, grow this crop under Tasmanian conditions.

IPM control of *Botrytis cinerea*

With the failure of commercial support, a commercial-sized demonstration was considered too expensive. However, a smaller trial of IPM control of *Botrytis cinerea* confirmed the NZ experience that controlling the greenhouse environment to avoid high humidity and associated surface wetness will control the disease. A number of growers who adopted the environmental control measures achieved considerable success in limiting *Botrytis cinerea* infection in their greenhouses and reduced their use of fungicides.

IPM control measures are keenly sought and taken up by growers as they become more aware and concerned for their own health. Growers see a distinct market benefit in supplying the growing demand for produce grown with less use of pesticides.

Recommendations - Scientific and Industry

This project has confirmed that a number of cultivars of tomatoes and capsicums can be grown in Tasmanian greenhouses to produce export quality fruit. However, further evaluation will be needed for eggplants.

Capsicums have the potential for the highest returns for high quality fruit. To achieve this quality and the consequent economic returns, modern, automated and dedicated greenhouses using best practice management are needed. The production guide developed from the project gives growers most of the knowledge needed to grow hydroponic greenhouse capsicums in Tasmania. The project partners recommend that growers who are unfamiliar with hydroponic cropping should employ consultant agronomists who have experience with growing greenhouse capsicums.

Market intelligence varied over the course of this project. At the time of writing, the prospects for exporting capsicums to Asian markets were less favourable than they were at the beginning of the project. However, interstate markets for high quality, well presented fruit has been found to be strong. The project partners believe that the interstate markets should be evaluated further and that new cultivars should continue to be evaluated. The demand in the Tasmanian market for high quality greenhouse capsicums also is increasing. Both these markets could confidently be pursued, with the option to divert some produce into overseas markets when the demand becomes economic again.

It is recommended that a semi-commercial sized greenhouse be established by industry partners to:

1. carry out a more comprehensive assessment of the market potential for greenhouse capsicums;
2. confirm the methods of production and input costs referred to in the production and investors guides; and
3. further develop a local skills base for growing greenhouse capsicums before any decisions are made to establish a substantial area of greenhouse production that would be needed to generate export volumes.

The small trial using NFT indicated that coloured fruit could be produced earlier than was the case using sawdust bag culture. More comparative trials of both techniques would be worthwhile.

The performance of tomato cultivars varied depending on location, greenhouse environment and grower. Due to this variability, the project partners recommend that growers continue to conduct their own on-site tomato cultivar evaluations.

Some tomato cultivars, such as Ipsilon, an industry standard, only performed in greenhouses that maintained higher base temperatures, whereas some of the new cultivars trialed, such as Darita and AX 701-7, seemed to be adapted to wider temperature ranges. The latter types are worth further evaluation because they would be cheaper to produce than those needing higher temperatures. These types could be grown by more growers, which would be useful if the industry contemplates cooperative supply of larger markets, in the future. In addition, it is now recommended that Ipsilon be grown at temperatures that do not drop below 17°C. This is best achieved economically in heated, twin skin polythene greenhouses.

As found in NZ, managing greenhouse humidity was confirmed as a successful method for controlling *Botrytis cinerea*. In conjunction with good greenhouse hygiene, the project partners recommend that all growers adopt this method of control because *Botrytis* is the most common disease and cause of downgraded fruit. As this IPM method involves precise control of temperature and ventilation, growers who have older facilities should consider upgrading to

at least some form of automated heating. In addition, they would be wise to incorporate some form of automated ventilation. The automated systems must be set to prevent free moisture forming or remaining on plants.

Technology Transfer

The information gained through this three-year project has been passed on to industry through field days, meetings with various industry bodies, articles in the local media and by publishing production and investors guides for capsicums.

A photographic album has been compiled for all the cultivars examined in this project. The album and the results of trials are available for scrutiny at meetings. Posters explaining the project were produced and displayed often.

Field Days

1997–98, Stoney Rise Centre on the 24 February 1998. About 35 growers and industry people viewed and tasted samples, discussed project results and listened to the project marketing partner Joe Gayton, of Field Fresh Tasmania, speak on market prospects.

1998–99,Turners Beach site on 4 December 1998 and 18 February 1999. About 60 growers and industry personnel attended on each occasion.

1999–00, Turners Beach site on 18 February 2000. About 60 growers and industry personnel attended.

Those who attended each of the field days were given handouts that updated progress on the trials and acknowledged the project partners and sponsors.

Each field day was well attended by local media who provided good coverage through radio interviews and newspaper articles. Articles on the project were printed in Tasmanian Country on 27 February 1998, The Advocate on 4 March 1998, Agriculture Tasmania on 14 October 1998, Tasmanian Country on 18 December 1998, The Examiner on 11 February 1999, The Advocate on 17 February 1999, The Advocate on 6 March 1999 and Tasmanian Country on 12 March 1999.

Meetings

Presentations were made at the annual Potato and Vegetable Agricultural Research and Advisory Committee (ARAC) forum to growers and industry processors, exporters, researchers and service providers. The meetings were held on 25 May 1998, 11 March 1999 and 10 August 2000.

Meetings were held twice a year, in March and August for the three years of the project, with members of the TGTVGA and its R&D committee to update progress and review the course of the project. Other meetings were held with key members as required.

Production and Investors Guides

Production and Investors guides have been produced and are available to industry.

The production guide, "Greenhouse Capsicums: A guide to growing export quality hydroponic greenhouse capsicums in Tasmania", contains all the cultural knowledge on capsicum production acquired during the project, covering both the basic and finer details. It has been written as a comprehensive reference manual for experienced hydroponic greenhouse growers and new growers. In addition, the daily details of the environmental and nutrient monitoring have been presented in a separate case study booklet for technically-minded operators. It is called, "Case Study: Technical Information from the 1998–99 and 1999–2000 greenhouse Capsicum Trials".

The investors guide, "Greenhouse Capsicums: Investors guide to hydroponic greenhouse capsicums in Tasmania", is based on typical overhead costs and a gross margin assessment for a new 2,000 square metre twin-skin environmentally controlled greenhouse as a base economic unit for a single owner operator. A 20,000 square metre model also is presented for corporate investors. This scale of enterprise is suited to export on a stand-alone basis.

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Appendices

Appendix 1

Species of *Solanaceous* crops grown at 10 sites in Tasmania

Trial Sites	Greenhouse type	Cultivars	Data collected
Ulverstone	Older houses NFT	All tomato cultivars.	Size and visual rating Gross yield
Turners Beach	New twin skin Bag culture	Most tomato cultivars. plus extras Some capsicums Eggplants	Size and visual rating
Kindred	New twin skin NFT	Most tomato cultivars.	Size and visual rating Blind taste test
Stoney Rise Centre	Older house NFT	All tomato cultivars Some capsicums All eggplants	Size and visual rating Gross yield and storage Size and shape Size and shape
Prospect	Older twin skin Box culture	All eggplants	Size and shape
Pipers Brook		Some capsicums	Photos only
Mowbray	Older houses NFT	Some tomatoes	Visual, brix, pH and taste
Kingston	New twin skin NFT	Most tomato cultivars.	Size and visual rating
Lauderdale	Older twin skin NFT	Some capsicums	Visual report

Appendix 2

Tomato Harvest 1998–99

Grower A: Yield data from six random plants – fruit picked by grower

Cultivar	Trediro			Ipsilon			AX-701-7			Darita		
Date	No. of Fruit	Weight	Avg Fruit Wt	No. of Fruit	Weight	Avg Fruit Wt	No. of Fruit	Weight	Avg Fruit Wt	No. of Fruit	Weight	Avg Fruit Wt
		(kg)	(g)		(kg)	(g)		(kg)	(g)		(kg)	(g)
prior 25/11	5	0.9	172	30	6	200	2	0.5	250	5	0.8	160
25-Nov	5	0.9	172	10	2.1	205	7	1.8	257	2	0.3	140
30-Nov	9	1.5	167	6	1	167	6	1.3	223	4	0.7	183
02-Dec	8	1.3	163	9	1.3	139	3	0.7	233	8	1.2	150
04-Dec	12	1.5	125	14	1.8	129	8	1.8	225	9	1.2	133
07-Dec	9	1.5	167	11	1.6	145	1	0.2	200	6	0.7	117
09-Dec	10	1.4	140	10	1.9	190	11	1.8	164	10	1.3	125
11-Dec	11	1.8	164	12	1.8	146	13	2.0	155	16	2	125
14-Dec	9	1.6	178	15	2.5	167	20	4	200	11	1.6	145
16-Dec	11	2	182	13	2	154	9	2	222	10	1.5	150
18-Dec	12	2.2	183	15	2.5	167	14	2.8	200	14	2	143
21-Dec	16	3.1	194	10	2	200	13	2.8	215	17	2.2	129
23-Dec	8	1.6	200	8	1.9	238	4	1.2	300	8	1.5	188
26-Dec	14	3	214	29	4.6	159	18	3.5	194	13	2.2	169
29-Dec	14	2.8	200	11	3	273	20	3.4	170	14	2.8	200
31-Dec	12	2.5	208	10	1.5	150	9	1.8	200	15	2.8	187
04-Jan	30	5	167	13	1.9	146	20	3.9	195	18	2.7	150
07-Jan	9	1.5	167	12	1.7	142	12	2.5	208	21	3.1	148
11-Jan	19	3	158	3	0.5	167	10	1.9	190	19	2.9	153
14-Jan	10	1.8	180	13	1.9	146	8	2.5	313	20	3.2	160
18-Jan	30	4.2	140	35	4.5	129	35	6.2	177	28	5.1	182
TOTAL	263	45.0		289	47.9		243	48.7		268	41.7	
mean/plant	44	7.5	173	48	7.0	169	41	8.1	214	45	7.0	154

Grower B: Yield data from six random plants – fruit picked by grower

Cultivar:	Toga				Roulette:				AX-701-7			
Date	1st grade	Small	Reject	Total	1st grade	Small	Reject	Total	1st grade	Small	Reject	Total
	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
06-Nov	2.04	0.00	0.61	2.66	0.79	0.00	0.00	0.79	1.19	0.11	0.18	1.48
13-Nov	0.93	0.19	0.00	1.12	1.45	0.00	0.80	2.25	1.05	0.00	0.29	1.34
20-Nov	3.32	0.42	1.20	4.94	1.87	0.00	0.66	2.53	3.24	0.57	0.97	4.77
27-Nov	4.00	1.28	0.90	6.18	2.30	0.79	1.17	4.26	2.36	0.53	0.35	3.24
04-Dec	5.20	0.57	0.79	6.56	4.30	0.56	0.42	5.28	4.77	0.67	1.19	6.63
11-Dec	4.95	0.75	0.90	6.60	2.00	0.85	1.90	4.75	6.00	1.05	1.40	8.45
18-Dec	7.55	0.95	1.50	10.00	1.25	0.00	1.45	2.70	3.95	1.35	2.55	7.85
24-Dec	2.25	1.05	1.10	4.40	3.70	0.65	3.35	7.70	2.05	0.90	1.90	4.85
31-Dec	2.35	0.90	1.50	4.75	1.70	0.30	4.20	6.20	2.40	0.75	0.85	4.00
Total (kg)	32.59	6.11	8.50	47.20	19.35	3.15	13.95	36.45	27.00	5.93	9.68	42.60
kg/plant	5.43	1.02	1.42	7.87	3.23	0.53	2.33	6.08	4.50	0.99	1.61	7.10
Total marketable (kg)				6.45				3.75				5.49

Cultivar:	Daniela				Regal Red				Darita			
Date	1st grade	Small	Reject	Total	1st grade	Small	Reject	Total	1st grade	Small	Reject	Total
	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
06-Nov	0.99	0.00	0.23	1.22	0.77	0.00	0.00	0.77	1.17	0.00	0.00	1.17
13-Nov	1.79	0.18	0.23	2.20	1.73	0.11	0.38	2.21	1.41	0.13	0.86	2.41
20-Nov	1.37	0.40	0.40	2.17	2.29	0.42	0.25	2.97	2.99	0.38	0.96	4.34
27-Nov	4.90	0.74	0.46	6.10	3.20	0.88	0.43	4.51	2.50	0.00	2.00	4.50
04-Dec	4.56	0.44	0.33	5.33	2.11	0.59	0.60	3.29	1.80	0.57	1.62	3.99
11-Dec	3.45	0.45	1.25	5.15	3.65	0.75	0.50	4.90	3.65	0.75	1.10	5.50
18-Dec	5.85	0.85	0.65	7.35	5.00	1.20	1.25	7.45	4.10	0.70	0.65	5.45
24-Dec	2.60	1.50	1.85	5.95	3.10	1.60	2.10	6.80	3.10	0.35	0.60	4.05
31-Dec	1.10	1.00	1.40	3.50	2.25	0.49	0.85	3.59	2.10	0.35	0.95	3.40
Total (kg)	26.61	5.55	6.79	38.96	24.09	6.03	6.36	36.48	22.83	3.24	8.74	34.81
kg/plant	4.44	0.93	1.13	6.49	4.02	1.01	1.06	6.08	3.80	0.54	1.46	5.80
Total marketable (kg)				5.36				5.02				4.34

Grower C: Yield data from six random plants or yield data from three random plants – fruit picked by grower

Cultivar:	* AX701-7	* Ipsilon	* Darita	# Ramos	# Roulette	# Kasha-Prie	# Toga
Date	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)
16-Dec	3.18	0.79	2.04	1.02	0.23	0.91	1.36
23-Dec	2.27	2.27	1.81	1.36	0.91	1.59	1.81
30./12	3.40	2.49	2.27	1.59	0.68	2.04	1.59
05-Jan	2.95	2.04	2.27	1.59	0.68	2.04	1.36
10-Jan	2.49	3.86	2.27	1.81	1.13	1.36	1.36
17-Jan	3.29	4.08	2.72	1.70	0.68	1.36	2.72
21-Jan	3.40	3.40	2.27	1.81	1.13	0.68	2.49
26-Jan	2.95	2.27	2.95	1.36	0.57	1.13	1.59
31-Jan	2.72	1.36	1.59	0.91	0.68	0.68	1.36
05-Feb	2.27	2.27	1.36	0.91	0.45	0.23	1.47
10-Feb	1.81	0.91	2.72	1.36	0.23	0.45	1.81
13-Feb	1.36	0.68	1.36	1.81	0.91	2.27	1.81
Total	32.09	26.42	25.63	17.24	8.28	14.74	20.75
kg/plant	5.35	4.40	4.27	5.75	2.76	4.91	6.92

Appendix 3

Capsicums Cultivar Observations SRC 1997–98

Cultivar	Seed line	Fruit shape	Fruit size
Canape	Sakata	good shape, small	95 x 60mm
LV 96216	Lefroy Valley	good shape, short blocky	70 x 90mm
Top Star	Takii	slender, very small fruit	50 x 35mm
Kyounami	Takii	long slender	90 x 50mm
Jericho HF1	Graines Gautier	good shape	90 x 70mm
Mogador HF1	Graines Gautier	yellow, good shape	130 x 80mm
Catalan HF1	Graines Gautier	good shape	100 x 50mm
Blockade F1	S&G	good shape, even set	80 x 70mm
Bonanza F1	Fairbanks	uneven shape	120 x 70mm
Merlin	SPS	variable shape, some good blocky	90 x 80mm
Toledo	SPS	reasonably shaped fruit	110 x 85mm
Monza	SPS	variable shape, some distorted	110 x 80mm
Rialto	Hendersons	reasonably shaped fruit	100 x 75mm
Sylvia	Hendersons	poor shape, short blocky	70 x 90mm
971241	Hendersons	reasonable shape, large blocky	130 x 90mm
971202	Hendersons	good shape, slightly tapered	90 x 80mm
971227	Hendersons	variable shape	120 x 75mm
Blockbuster	Charlcon Seeds	slightly pointy shape	100 x 75mm
Major	Charlcon Seeds	good shape	110 x 80mm
Legend	Lefroy Valley	poor shape, large blocky	95 x 90mm
Olympian	Yates	variable shape, vigorous plants	110 x 70mm
Treasurer	Yates	good shape	100 x 65mm
Nassau	Rikj Zwaan	short blocky	60 x 90mm
Mazurka	Rikj Zwaan	good shape	90 x 80mm
Sirtaki	Rikj Zwaan	poor shape, very short blocky	70 x 75mm

Appendix 4

Capsicum harvest Turners Beach 1998–2000

Green harvest: Weekly harvest (kg/m^2) by cultivar. Plant density 3.8/square metre.

1998–99	Fiesta	Mazurka	Nassau	Spirit	1999–2000	Fiesta	Mazurka	Nassau	Spirit	Emily	Sirtaki
1st Grade					**1st Grade**						
6-Oct	1.85	2.41	1.00	1.66	24-Aug	0.74	0.33	0.12	0.44	0.21	0.39
9-Oct	0.02	0.04	0.05	0.06	31-Aug	0.37	0.26	0.14	0.26	0.08	0.22
12-Oct	0.24	0.28	0.28	0.31	7-Sep	0.65	0.52	0.36	0.56	0.25	0.30
16-Oct	0.13	0.08	0.22	0.12	14-Sep	0.32	0.22	0.10	0.28	0.15	0.28
22-Oct	0.31	0.15	0.25	0.13	21-Sep	0.45	0.24	0.10	0.28	0.19	0.38
29-Oct	1.79	1.99	1.57	1.30	28-Sep	0.31	0.22	0.12	0.14	0.18	0.34
3-Nov	1.24	0.91	0.94	0.95	4-Oct	0.64	0.90	0.52	0.63	0.46	0.49
10-Nov	0.87	0.91	0.68	0.60	6-Oct	0.66	0.39	0.16	0.31	0.35	0.44
13-Nov	0.26	0.15	0.24	0.22	14-Oct	1.45	1.15	0.57	0.96	0.97	0.93
17-Nov	0.34	0.38	0.47	0.28	21-Oct	0.34	0.29	0.19	0.28	0.37	0.31
					28-Oct	0.54	0.60	0.32	0.32	0.16	0.48
Total	**7.05**	**7.30**	**5.72**	**5.63**	**Total**	**6.48**	**5.12**	**2.72**	**4.47**	**3.36**	**4.55**
% 1st Grade	77%	81%	75%	71%	% 1st Grade	78%	79%	57%	67%	54%	80%
Reject	**Fiesta**	**Mazurka**	**Nassau**	**Spirit**	**Reject**	**Fiesta**	**Mazurka**	**Nassau**	**Spirit**	**Emily**	**Sirtaki**
6-Oct	1.52	1.35	1.33	1.74	24-Aug	0.16	0.17	0.14	0.17	0.37	0.12
9-Oct	0.04	0.00	0.09	0.03	31-Aug	0.08	0.15	0.13	0.14	0.21	0.10
12-Oct	0.05	0.06	0.08	0.10	7-Sep	0.31	0.24	0.38	0.25	0.47	0.17
16-Oct	0.04	0.00	0.04	0.02	14-Sep	0.06	0.02	0.01	0.08	0.16	0.06
22-Oct	0.08	0.04	0.03	0.05	21-Sep	0.05	0.01	0.03	0.06	0.14	0.03
29-Oct	0.08	0.12	0.10	0.13	28-Sep	0.02	0.02	0.08	0.04	0.06	0.07
3-Nov	0.04	0.00	0.01	0.03	4-Oct	0.12	0.07	0.26	0.18	0.27	0.08
10-Nov	0.16	0.14	0.09	0.13	6-Oct	0.22	0.16	0.17	0.18	0.17	0.11
13-Nov	0.03	0.04	0.03	0.03	14-Oct	0.43	0.29	0.43	0.59	0.72	0.19
17-Nov	0.03	0.01	0.07	0.07	21-Oct	0.10	0.03	0.17	0.18	0.12	0.06
					28-Oct	0.23	0.18	0.27	0.31	0.20	0.17
Total	**2.07**	**1.75**	**1.87**	**2.33**	**Total**	**1.79**	**1.33**	**2.06**	**2.19**	**2.89**	**1.16**
Total Green	**9.12**	**9.05**	**7.59**	**7.96**	**Total Green**	**8.27**	**6.45**	**4.78**	**6.66**	**6.25**	**5.71**

Coloured harvest: Weekly harvest (kg/m^2) by cultivar. Plant density 3.8/square metre.

1998–99	**Fiesta**	**Mazurka**	**Nassau**	**Spirit**	**1999–2000**	**Fiesta**	**Mazurka**	**Nassau**	**Spirit**	**Emily**	**Sirtaki**
1st Grade					**1st Grade**						
11-Dec	0.10	0.04	0.04	0.02	25-Nov	0.54	0.05	0.05	0.02	0.03	0.07
15-Dec	0.14	0.03	0.03	0.00	2-Dec	0.62	0.26	0.75	0.32	0.42	0.66
21-Dec	0.73	0.09	0.26	0.09	9-Dec	1.76	0.71	1.17	0.79	0.48	1.05
23-Dec	2.04	0.58	0.54	0.50	16-Dec	1.21	1.40	1.84	1.60	0.97	1.35
29-Dec	1.48	1.78	1.25	1.62	23-Dec	0.77	1.46	1.47	1.27	0.97	0.88
4-Jan	0.63	1.75	1.10	1.36	30-Dec	0.43	1.06	0.79	0.81	0.60	0.47
7-Jan	0.38	0.75	0.41	0.55	6-Jan	0.57	0.84	0.87	0.31	0.66	0.57
15-Jan	0.51	1.08	0.66	0.94	13-Jan	0.43	1.00	0.73	0.34	0.38	0.86
22-Jan	0.66	0.39	0.42	0.31	20-Jan	0.11	0.36	0.27	0.14	0.09	0.15
29-Jan	0.92	0.52	0.92	0.59	27-Jan	0.06	0.30	0.05	0.01	0.01	0.10
5-Feb	0.88	0.93	0.74	0.67	3-Feb	0.06	0.02	0.02	0.00	0.01	0.02
12-Feb	0.90	0.44	0.33	0.52	10-Feb	0.06	0.05	0.04	0.06	0.00	0.03
19-Feb	0.70	0.39	0.42	0.38	17-Feb	0.02	0.02	0.00	0.04	0.00	0.01
26-Feb	0.69	0.42	0.65	0.48	24-Feb	0.04	0.06	0.04	0.02	0.00	0.06
5-Mar	1.30	1.32	0.92	0.98	2-Mar	0.06	0.13	0.12	0.06	0.04	0.24
12-Mar	0.42	0.57	0.48	0.55	9-Mar	0.06	0.28	0.13	0.24	0.08	0.34
19-Mar	0.15	0.38	0.16	0.26	16-Mar	0.03	0.15	0.17	0.13	0.02	0.07
26-Mar	0.33	0.31	0.25	0.22	23-Mar	0.01	0.19	0.05	0.15	0.00	0.08
2-Apr	0.26	0.24	0.23	0.30	30-Mar	0.11	0.53	0.17	0.27	0.05	0.47
9-Apr	0.62	0.23	0.13	0.19							
16-Apr	0.54	0.26	0.35	0.19							
23-Apr	0.48	0.65	0.61	0.59							
30-Apr	0.35	0.69	0.27	0.48							
4-May	1.79	2.58	1.45	1.48							
Total	**17.00**	**16.41**	**12.63**	**13.27**	**Total**	**6.96**	**8.87**	**8.72**	**6.58**	**4.81**	**7.48**
% 1st Grade	68%	74%	68%	67%	% 1st Grade	50%	62%	53%	54%	46%	64%

1998–99	Fiesta	Mazurka	Nassau	Spirit	1999–2000	Fiesta	Mazurka	Nassau	Spirit	Emily	Sirtaki
2nd Grade					**2nd Grade**						
11-Dec	0.05	0.00	0.01	0.02	25-Nov	0.02	0.01	0.04	0.00	0.01	0.01
15-Dec	0.05	0.03	0.03	0.02	2-Dec	0.06	0.01	0.06	0.03	0.05	0.01
21-Dec	0.09	0.03	0.03	0.01	9-Dec	0.27	0.01	0.07	0.07	0.10	0.04
23-Dec	0.33	0.04	0.04	0.07	16-Dec	0.21	0.02	0.19	0.13	0.06	0.09
29-Dec	0.38	0.18	0.26	0.27	23-Dec	0.14	0.01	0.13	0.16	0.11	0.04
4-Jan	0.14	0.32	0.19	0.45	30-Dec	0.06	0.00	0.04	0.08	0.01	0.02
7-Jan	0.14	0.21	0.18	0.24	6-Jan	0.19	0.02	0.22	0.07	0.21	0.07
15-Jan	0.20	0.37	0.23	0.44	13-Jan	1.03	0.19	1.26	0.62	0.92	0.22
22-Jan	0.05	0.08	0.26	0.12	20-Jan	0.61	0.49	0.44	0.51	0.69	0.95
29-Jan	0.16	0.13	0.28	0.11	27-Jan	0.16	0.39	0.52	0.30	0.21	0.10
5-Feb	0.08	0.10	0.12	0.10	3-Feb	0.18	0.36	0.21	0.19	0.16	0.05
12-Feb	0.10	0.08	0.12	0.12	10-Feb	0.14	0.06	0.05	0.05	0.04	0.05
19-Feb	0.13	0.04	0.04	0.04	17-Feb	0.11	0.21	0.10	0.09	0.09	0.11
26-Feb	0.10	0.08	0.15	0.08	24-Feb	0.40	0.60	0.42	0.11	0.10	0.18
5-Mar	0.83	0.44	0.55	0.24	2-Mar	0.72	0.39	0.37	0.15	0.16	0.32
12-Mar	0.26	0.11	0.11	0.20	9-Mar	0.42	0.31	0.39	0.49	0.18	0.28
19-Mar	0.25	0.16	0.16	0.13	16-Mar	0.26	0.26	0.21	0.34	0.08	0.13
26-Mar	0.23	0.11	0.16	0.13	23-Mar	0.19	0.27	0.29	0.13	0.11	0.11
2-Apr	0.21	0.08	0.13	0.18	30-Mar	0.62	0.55	0.59	0.64	0.28	0.52
9-Apr	0.54	0.17	0.15	0.19							
16-Apr	0.78	0.07	0.23	0.16							
23-Apr	0.31	0.23	0.42	0.37							
30-Apr	0.18	0.13	0.18	0.40							
4-May	1.04	0.74	0.58	0.93							
Total	**6.63**	**3.93**	**4.62**	**5.02**	**Total**	**5.79**	**4.17**	**5.59**	**4.18**	**3.58**	**3.32**
% 2nd Grade	26%	18%	25%	25%	% 2nd Grade	41%	29%	34%	34%	34%	29%

1998–99 Reject	Fiesta	Mazurka	Nassau	Spirit	1999–2000 Reject	Fiesta	Mazurka	Nassau	Spirit	Emily	Sirtaki
11-Dec	0.00	0.00	0.00	0.00	25-Nov	0.01	0.00	0.00	0.00	0.00	0.00
15-Dec	0.00	0.00	0.01	0.00	2-Dec	0.01	0.01	0.02	0.00	0.00	0.00
21-Dec	0.00	0.00	0.00	0.02	9-Dec	0.02	0.01	0.00	0.02	0.00	0.00
23-Dec	0.01	0.02	0.02	0.01	16-Dec	0.02	0.01	0.00	0.02	0.01	0.05
29-Dec	0.01	0.00	0.01	0.02	23-Dec	0.00	0.01	0.00	0.01	0.02	0.03
4-Jan	0.02	0.07	0.04	0.13	30-Dec	0.02	0.05	0.02	0.07	0.09	0.04
7-Jan	0.00	0.02	0.01	0.04	6-Jan	0.03	0.08	0.05	0.12	0.21	0.02
15-Jan	0.02	0.02	0.01	0.04	13-Jan	0.07	0.01	0.07	0.06	0.08	0.05
22-Jan	0.01	0.04	0.02	0.01	20-Jan	0.18	0.15	0.22	0.29	0.40	0.09
29-Jan	0.01	0.03	0.03	0.04	27-Jan	0.03	0.17	0.29	0.16	0.25	0.04
5-Feb	0.00	0.12	0.03	0.05	3-Feb	0.07	0.17	0.32	0.11	0.31	0.10
12-Feb	0.02	0.04	0.01	0.03	10-Feb	0.09	0.02	0.05	0.01	0.07	0.03
19-Feb	0.00	0.07	0.03	0.01	17-Feb	0.03	0.09	0.07	0.03	0.08	0.02
26-Feb	0.04	0.16	0.06	0.12	24-Feb	0.05	0.06	0.11	0.02	0.05	0.01
5-Mar	0.10	0.23	0.05	0.14	2-Mar	0.11	0.03	0.12	0.02	0.05	0.03
12-Mar	0.01	0.03	0.00	0.03	9-Mar	0.08	0.03	0.09	0.08	0.07	0.05
19-Mar	0.02	0.05	0.01	0.01	16-Mar	0.06	0.03	0.09	0.08	0.05	0.01
26-Mar	0.03	0.01	0.04	0.00	23-Mar	0.11	0.07	0.10	0.05	0.14	0.03
2-Apr	0.01	0.01	0.03	0.00	30-Mar	0.25	0.23	0.40	0.21	0.23	0.24
9-Apr	0.07	0.16	0.05	0.08							
16-Apr	0.44	0.23	0.17	0.14							
23-Apr	0.09	0.08	0.24	0.06							
30-Apr	0.09	0.05	0.10	0.19							
4-May	0.51	0.36	0.23	0.42							
Total	**1.55**	**1.81**	**1.21**	**1.60**	**Total**	**1.26**	**1.23**	**2.02**	**1.35**	**2.10**	**0.82**
% Reject	6%	8%	7%	8%	% Reject	9%	9%	12%	11%	20%	7%
Total Coloured	**25.18**	**22.14**	**18.46**	**19.88**	**Total Coloured**	**14.01**	**14.26**	**16.33**	**12.11**	**10.49**	**11.61**