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Sustainable Production of Quality Capsicums in Carnarvon

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Western Australia

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Purpose of the Report

The purpose of this project is to facilitate the development of sustainable production of quality capsicums from Carnarvon. This was assessed through the identification of suitable varieties that will meet the quality specifications and raising the selected varieties under structures to offer protection against sun and wind to improve quality.

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Media Summary

In Western Australia, Carnarvon is the main source of supply of capsicums during the southern winter months of June to August. The quality and quantity of capsicums reaching Perth market, however, are variable and the prices are very volatile. The prices are generally higher in November-December when Carnarvon capsicums are prone to sunburn and wind damage.

A desktop study and a grower survey on the marketing potential of capsicums were carried out. This found the need for suitable varieties that meet the quality specifications (see page 8 for details) and a production system that will offer protection against environmental vagaries. Varieties that produce uniform, blocky fruit are preferred by the market. Three variety x time of planting trials were conducted in Carnarvon to identify capsicum varieties suitable for early (April/May), mid (June/July) and late (August/September) plantings. Early planting in April gave the highest yield followed by mid and late season plantings. The average yields were 41, 22 and 14 t/ha, respectively, of early, mid and late season crops.

A simple structure that offered wind protection and reduced sunlight by 30% extended the cropping season late into the summer. Without this protection sunburn was high (70%) and marketability was low at 22%. Premium grade fruit, however, was low at 10-15% due to blossom end rot, powdery mildew and soil-borne diseases under the protected system.

To compete in export markets, the proportion of premium grade fruit has to be increased. This will allow Carnarvon growers to supply capsicums to niche markets in SE Asia, Taiwan and Mauritius. Further study on different protective structures and their economics is needed.

Technical Summary

Carnarvon growers produce around 2500 tonnes of capsicums from May to September to supply mainly the Perth markets. The quantity and quality of capsicums produced are variable due to changing seasonal conditions. Prices for capsicums are volatile but are generally higher in November-December when Carnarvon capsicums tend to suffer from sunburn and wind damage. A desktop study and a grower survey found the need for consistent supply of quality capsicums that demand better prices in both domestic and export markets. Varieties with uniform, bell or blocky type fruit were preferred by the markets.

Three capsicum variety x planting time trials were conducted to identify varieties suitable for early, mid and late plantings, respectively, in April 2001, June and August 2000. Varieties differed in their response to the different planting dates. Early planting in April gave the highest yield followed by mid and late season plantings. The average yields were 41, 22 and 14 t/ha, respectively, of early, mid and late season crops. Varieties that met the quality specifications and specific to seasons have been identified.

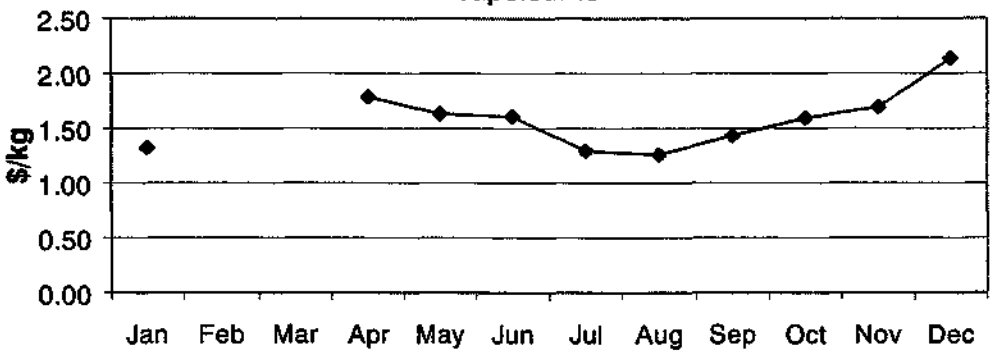
By growing selected varieties under a simple structure that offered protection against sun and wind, the cropping season was extended late into the summer. Without this protection, sunburn was as high as 70% and marketability was low at 22%. Some varieties identified as suitable for the protected cultivation are: DRP 3948, Flemenco and Sirtaki. The size and marketable percent of the fruit was improved under the protective structure but the percentage of premium grade was low at 10 to 15% due to blossom end rot and soil-borne diseases. Management has to be optimal to realise the potential of the selected varieties.

The proportion of premium grade fruit needs to be improved to be cost-effective and to supply niche markets in SE Asia, Mauritius and Taiwan. Further studies on the economics of suitable protective structures along with management requirements for nutrition and pests and diseases under the protective cultivation are warranted.

Introduction

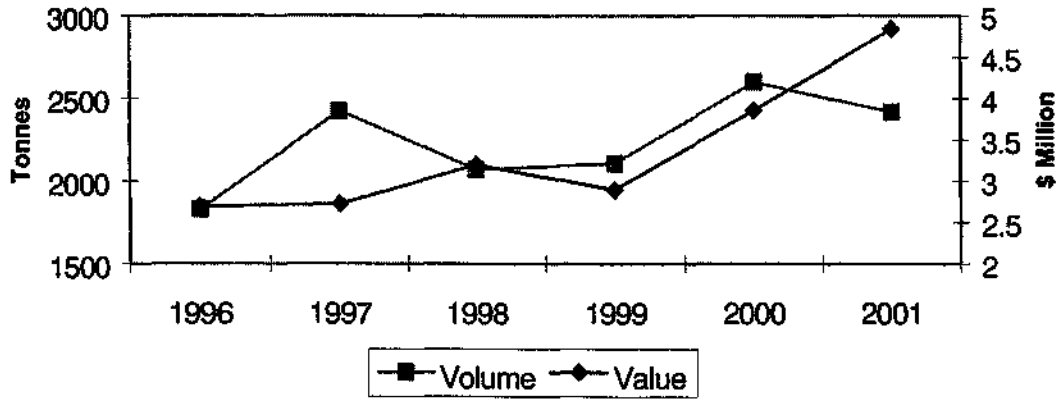
Vegetables account for 60% of gross value of horticultural production in Carnarvon. Tomatoes and capsicums are the two major crops and these were valued at $ 18 million in 2001. Of this, capsicums accounted for $ 4.8 million. Capsicums grown in Carnarvon are the main source of supply to Perth market during the southern winter months of June to August The quality and quantity of capsicums reaching the market are variable due to fluctuations in seasonal conditions. The prices they fetch are volatile ranging from $0.30 to $4.50 / kg (Burt and Gartell, 1998). The five year average price for capsicums from Carnarvon (Figure 1) indicates a supply from April to January and an increase in price in November to December at the beginning of summer (Embry and Gartrell, 2001). This is a price window Carnarvon growers would like to exploit but field-grown capsicums need protection against sun and wind in summer and early spring.

Fig. 1. Five year (1997-2001) average price for Carnarvon capsicums



The production of capsicums in Carnarvon has increased from around 1,700 t in 1996 to 2400 t in 2001 (Figure 2). The need for improving production practices to capture export markets was assessed by Hawkins (1995) who recommended SE Asia as a potential market at that time. The industry is also facing increasing competition from large production centres in northern Australia and overseas. The importance of quality and proactive marketing from Carnarvon horticultural producers was recognised by Delroy and Blakers in 1989 who recommended group marketing of quality produce for a sustainable industry.

Fig 2.Carnarvon Capsicum Production & Value



These recommendations have led to the emergence of two leading marketing groups in Carnarvon, namely, Love Apple and Gascoyne Gold. Both produce vegetables under best practice management and central packing. This allows for quality control, direct marketing, product differentiation and ultimately better returns to the growers. These groups have also provided a measure of cohesiveness to the industry. The Department of Agriculture works closely with these groups to transfer technology, supply market information and facilitate training in business skills and quality assurance.

Previous trials at Gascoyne Research Support Unit (GRSU) have shown suitable varieties, improved production practices and pest control as important in developing a viable capsicum industry (Anon, 1998; Bissell, 1994 and Darcey, 1996). The existing system for growing capsicum in the field, however, generally produces a low proportion of around 5-10% as premium grade fruit. Besides, there are wide fluctuations in seasonal conditions from early (April/May), mid (June/July) and late (August/September) plantings of capsicums. The early and late season crops are prone to damage from strong wind and sun further reducing quality and returns (Dean Wiggins and Ron Watson-personal communication).

Production and supply of consistent quality vegetables from Carnarvon is essential for the industry to survive and prosper. Dutch capsicums raised in glass houses have gained the reputation as the international bench mark for quality in export markets (van Waard, 1998). To compete internationally, it is essential to improve the quality of field-grown capsicums. The Love Apple and Gascoyne Gold vegetable marketing groups are aware of this and are willing to improve their product quality by using a simple structure that will offer protection against sun and wind.

Objectives

This project aimed to:

- Survey quality specifications for capsicums in domestic and export markets;
- Monitor local best management practices on production and quality;
- Test a range of new varieties and planting dates in order to select varieties that match market specifications
- Study the effect of wind and sun protection on quality; and
- Assess the profitability of field-growing systems with protection to produce high quality capsicums.

Materials and Methods

Desktop Study, Best Practice and Quality Specifications

A desktop study on the market potential for capsicums was conducted in 1999 at the start of the program. Market specifications for quality capsicums were assessed through discussions with the Love Apple and Gascoyne Gold group growers and market agents. The survey questionnaire is given in Appendix 1. The key fruit quality characteristics demanded by customers and market agents were:

- Medium fruit, 12-16 cm long and 8-10 cm in diameter;
- Uniform, blocky type of fruit, easy to pack and attractive in the box;
- Glossy fruit with uniform green or ripe fruit colour of red or yellow;
- Premium grade of between 10 and 40 % of total harvest to get good returns;
- Firm fruit with 6-8 mm thick walls free of blemishes;
- Addition of calcium to prevent blossom end rot and improve wall thickness and quality; and
- Fruit that is blocky, uniform and blemish-free graded into premium fruit and the rest of the marketable fruits as standard grade.

Variety x planting time trials

Capsicum varieties that met the quality specification were included in a series of trials. Three variety trials under three planting dates (early, mid and late season crops) were conducted to select suitable varieties at Gascoyne Research Support Unit (113 30' E, 24 53' W), Carnarvon, Western Australia (WA). The planting dates were:

Early season trial planted on 10 April 2001,
Mid season trial planted on 15 June 2000 and
Late season trials planted on 19 August 1999 and 8 November 2000.

The source of seed supply and fruit characteristics of the 27 capsicum varieties used in the trials during 1999-2000 are given in Table 1. In the early season trial of 2001 another set of 24 new varieties were assessed along with 11 varieties from the previous trials. Thus a total of 41 varieties were evaluated in Carnarvon during the trial period from 1999 to 2002. Aries and Mamba were used as control varieties as these two were the most popular varieties grown in Carnarvon.

The experimental design used for the variety trials was randomised complete blocks with three replications for each variety or treatment. The data were subject to analysis of variance using Genstat 5 statistical package and treatment means were separated by Fisher's F test.

Survey on local best practice (Appendix 1) resulted in the following schedule of management practices:

Capsicum varieties were grown on raised beds. Each plot was 10 m long and 0.75 m wide double row/ treatment with two buffer rows on each side of the trial site. Plant spacing within rows was 0.3 to 0.4 m on double plant rows spaced at 0.5 m; row centres were 2.2 m apart. Seedlings were transplanted alternately in rows in a zigzag pattern with a population density of 22,700 to 30,300 plants/ha. Twenty plants in the centre of each plot were used as data plants and thus each plot also had buffer plants on either end of the beds.

Pre planting fertilisers:

Supa spud® @ 500 kg/ha, Organic 2000® (composted chicken manure) @ 500 kg/ha and gypsum @ 2 to 5 t/ha broadcast over the entire trial area and lightly incorporated before forming beds.

Post planting fertiliser:

Beginning approximately 2-3 weeks after planting, calcium nitrate @ 60 kg/ha was applied fortnightly three times followed by urea @ 35 kg/ha fortnightly for the next three applications.

The raised beds were covered with 900-mm black polythene mulch. A day or two before planting, holes were punched in plots and irrigated to field capacity to allow for transplanting of seedlings into moist beds.

Soil moisture was maintained at 35 kPa at 30-cm depth. The low-flow 'T' tape with a delivery of 2.5 L/m/h was used for irrigation. The T tape was buried to 50 mm within each raised bed. Other cultural practices were according to local standard practice (Burt, 1999).

The fruits were harvested at the mature green stage and samples were kept to assess ripe fruit colour, shape and firmness. At harvest, fruit weight and fruit number were recorded and size and marketable % of fruit were calculated; fruits were graded as premium and standard based on the quality specifications.

Protective Structure Trial

To offer protection against wind and sun for the late season crop, an area under the netted structure (bird netting) used for table grapes in Carnarvon was modified. This included construction of a simple structure to spread shade cloth over the capsicum trial area so that it reduced sunlight by 30% and provision of artificial windbreak around the site (Figure 3).

Fig. 3. The protective system within the bird-netting structure with additional shade and wind break for growing late-season capsicums in Carnarvon, WA.

Under this simple protective structure, the ground was prepared and six selected capsicum varieties were planted on 29 August 2001 and managed as a late season crop in the summer of 2001-2002 following the practices described above. These varieties were harvested and packed for test marketing. The volumes were not adequate for testing in overseas markets. But all due care was taken to grade the fruits so that they met the requirements for export marketing.

TABLE 1 Source and fruit characteristics of capsicum varieties used in the planting time trials (1999-2000)

	Variety	Source of Seed	Fruit Characteristics
1.	Aries	South Pacific	Green to red, elongated
2.	Aristocrata	Rijk Zwaan	Green to red, medium, blocky
3.	Blitz	Yates	Green to red, medium, blocky
4.	Blockade (CP 474)	S & G / Novartis	Green to red long, blocky
5.	CP 441 (Inca)	S & G / Novartis	Green to yellow, long, blocky
6.	CP 647 (Blocky)	S & G / Novartis	Green to red, medium, blocky
7.	CPS 7403	Lefroy Valley	Green to red, medium, blocky
8.	CPS 8014	Lefroy Valley	Green to red, medium
9.	DRP 3948	Rijk Zwaan	Green to red, large blocky
10.	Elapaso	Lefroy Valley	Green to red, short, blocky
11.	Emily	Rijk Zwaan	Green to orange, medium, blocky
12.	Flamenco	Rijk Zwaan	Green to red, medium, blocky
13.	Legend	Lefroy Valley	Green to red, medium, blocky
14.	Mamba	Yates	Green to red, medium, elongated
15.	Mazurka	Rijk Zwann	Green to red, medium, blocky
16.	Midas (CP 98)	S & G / Novartis	Green to yellow, short, blocky
17.	Nassau	Rijk Zwaan	Green to orange, medium, blocky
18.	Purple Flame	Rijk Zwaan	Purple to red, medium, blocky
19.	Raptor	S & G / Novartis	Green to red, long, elongated
20.	Rex (CP 462)	S & G / Novartis	Green to red, medium, blocky
21.	Saxo	Lefroy Valley	Green to red, long, blocky
22.	Sienor	Lefroy Valley	Green to yellow, long, blocky
23.	Sirtaki	Rijk Zwaan	Green to yellow, medium, blocky
24.	Y 4496 (logic)	Yates	Green to yellow, medium, blocky
25.	Y 4505	Yates	Green to red, medium
26.	Yatasto	Rijk Zwaan	Green to red, medium, blocky
27.	Zirconio	Rijk Zwaan	Green to red, medium, blocky

Results

Desktop Study on Market Potential

A desktop study involving visits to market agents in Perth and analysis of export statistics was conducted in 1998-99 at the onset of this project. The discussion with the agents revealed that worldwide markets are supplied by Dutch greenhouse producers, who provide an all year supply of very high quality, evenly sized, blocky or square bell type of fruit in three colours: green, red and yellow. This fruit sets the standard for exports and high prices (>$4/kg) are paid for this product.

Export trends for WA capsicums from 1992-98 are presented in Appendix 2. This showed that the volumes exported were small (150 to 26,800 kg) and were on an *ad hoc* basis. A shift in export away from traditional markets in Hong Kong, Singapore and Malaysia to new destinations in Taiwan, Thailand and Mauritius was also noticeable.

The prices obtained were generally low except for quality products, which can attract prices of $2 to $4.50 per kg of fruit. This indicates the need to improve the quality of capsicums produced by investigating varieties that fit the quality specifications and production systems that provide protection against environmental fluctuations.

Variety X Planting Time Trials

The first of the three varieties x planting time trials was planted on 19 August 1999 at Gascoyne Research Station. This late season planting had 19 varieties under evaluation. Results, given in Table 2, showed the effect of high temperatures of around 35° C for a few days in mid October 1999. Severe sunburn led to 30-70% loss of fruit. Apart from sunburn, capsicum varieties also suffered from blossom end rot resulting in a very low percentage of marketable fruit (average of 22%) and projected yield was also low ranging from 5 to 10 t/ha. Some promising varieties for late planting were: Elpaso, Emily, Flemenco, Legend, Mazurka and Purple Flame. The trial proved the need for sun protection for late-planted capsicums in Carnarvon.

Two replicated variety x planting time trials were completed in 2000 to identify varieties with consistent high quality and yield; one in mid season (June to October, 2000) and another in late season (November 2000 to February, 2001). The twenty six varieties in the mid season planting time trial differed significantly ($p<0.05$) in fruit weight and size, percentage marketable fruit and yield (Table 3). Fruit weight ranged from 8 to 13 kg/plot; fruit size ranged from short to medium at 80-150 g and percent marketable fruit was low with a range of 18 to 52%. Projected yield was around 20 t/ha with a range of 18-29 t/ha. The top-yielding varieties in this mid season planting were Aristocrata, Blitz, Mazurka, Sienor and Zirconio with yields of over 24 t/ha.

Late season planting (November 2000) recorded low yields (Table 4). The 26 varieties in the trial differed significantly ($p<0.05$) in yield and yield components. Fruit weight varied from 5 to 11 kg/plot, fruit size ranged from 80-200 g and percentage marketable fruit from a low 2% in CPS 7403 to 85 % in Sirtaki. As in the preliminary late season trial of 1999, the main reason for low marketability was blossom end rot and consequent secondary infections. Yield, however, was reasonable with a range of 9-18 t/ha. The high yielding varieties were DRP 3948, Emily, Flamenco, Mazurka, Nassau and Sirtaki. Apart from Mazuraka these are all different from the promising varieties identified in the mid season planting above.

Table 2: ***Capsicum Variety x Planting Time (August 1999) Trial.*** *Fruit weight, fruit size, yield and percentage marketable fruit of capsicum varieties, GRSU, Carnarvon, WA.*

Variety	Fruit wt (kg/plot)	Fruit size (g)	% Marketable fruit	% Sunburnt fruit
Aries	5.8	145	22	41
Blockade	6.5	143	12	32
CP 446	5.4	159	16	71
CP 647	8.4	143	11	23
CPS 7403	9.3	151	13	46
CPS 8014	4.8	135	14	69
Elpaso	10.9	147	14	39
Emily	9.4	124	47	23
Flamenco	10.3	118	18	52
Legend	11.1	153	18	29
Mazurka	10.2	113	16	41
Midas	9.2	144	26	42
Nassau	4.4	123	35	42
Purple Flame	13.8	138	25	31
Raptor	9.6	154	46	30
Rex	5.7	140	19	42
Saxo	9.5	141	36	39
Senior	8.1	185	23	31
Sirtaki	8.1	139	16	37
Lsd ($p<0.05$)	ns	31.3	ns	23.8

ns-not significant

Table 3: ***Capsicum Variety x Planting Time (June 2000) Trial.*** *Fruit weight, fruit size, yield and percentage marketable fruit of capsicum varieties, GRSU, Carnarvon, WA.*

Variety	Fruit wt (kg/plot)	Fruit Size (g)	Yield (t/ha)	% Marketable fruit
Blitz	11.0	146	24.4	52.3
Y4496	7.9	133	22.1	39.2
Flamenco	9.1	122	20.2	23.5
Nassau	9.3	87	20.7	31.4
Sirtaki	9.6	114	22.2	33.1
Emily	8.1	81	18.0	30.1
Yatasto	8.7	122	19.4	24.2
Zirconio	12.8	145	28.5	35.4
Purple flame	9.7	108	21.9	29.9
Aristocrata	11.7	145	26.4	29.9
DRP3948	8.3	124	18.5	25.7
Mamba	11.2	134	24.9	34.2
Mazurka	10.9	112	24.2	44.4
Y4505	10.4	158	23.1	44.7
CP647	7.8	127	17.9	33.3
CP0098	9.3	122	20.6	36.7
CP397	8.9	128	19.7	52.5
CP474	10.3	116	23.1	37.1
CP446	9.8	113	21.7	18.1
CP462	9.9	128	21.9	39.9
Sienor	11.3	138	25.1	47.8
CPS8014	8.3	122	18.4	32.5
CPS7403	8.7	137	19.2	26.4
Legend	107	130	23.7	43.8
Elpaso	9.1	130	21.5	40.9
Saxo	8.6	132	19.1	34.5
Lsd ($p<0.05$)	2.39	18.1	4.52	21.76

Table 4: ***Capsicum Variety x Planting Time (November 2000) Trial.*** *Fruit weight, fruit size, yield and percentage marketable fruit of capsicum varieties, GRSU, Carnarvon, WA.*

Variety	Fruit wt (kg/plot)	Fruit Size (g)	Yield (t/ha)	% Marketable fruit
Aristocrata	8.8	180	14.7	34.3
Blitz	7.7	105	12.8	4.4
CP 098	7.0	154	11.6	31.5
CP 397	6.3	113	10.5	36.3
CP 446	6.6	177	11.1	16.4
CP 462	5.4	94	9.1	43.9
CP 474	9.5	109	15.8	26.3
CP647	7.9	124	13.1	21.9
CP 8014	6.7	85	11.1	8.6
CPS 7403	5.1	81	8.5	2.3
DRP 3948	10.7	195	17.8	54.8
Elpaso	8.4	135	13.9	43.2
Emily	9.8	151	16.3	81.5
Flamenco	10.9	147	18.2	38.1
Legend	7.4	124	12.3	16.4
Mamba	6.8	148	11.4	5.2
Mazurka	10.4	149	17.3	65.3
Nassau	104	131	17.4	83.4
Purple Flame	9.3	131	15.4	31.3
Saxo	7.2	111	11.9	31.0
Senior cap	7.5	154	12.5	33.2
Sirtaki	9.6	201	16.0	84.6
Y 4496	8.1	180	13.5	48.5
Y 4505	8.8	151	14.7	25.5
Yatasto	8.4	161	14.0	39.0
Zirconia	6.5	160	10.9	35.3
Lsd ($p<0.05$)	2.44	55.94	4.07	20.11

The third replicated trial was planted on 15 April 2001 as an early season crop (April-September 2001). The results of the third trial with 35 varieties are presented in tables 5 and 6. This early season trial proved to be the best with the highest average yield of 41 t/ha, though the yield varied from 18 to 54 t/ha. Marketable fruit was around 55 % (range of 25 to 69%). But the premium grade fruit was low (3% on average) with a range of 0 to 16%. The differences between varieties were significant ($p< 0.05$) for yield and related characteristics. Fruit weight varied from 8 to 24 kg/plot and fruit size from medium to large, with a range of 171 to 342 g and an average size of 250 g. Some high yielding cultivars were: Blitz, Bessa, Flemenco, Matrix and Midas with yields of 48 to 54 t/ha, the highest yields recorded in this trial series.

This screening, in addition to the previous selections, identified a few potential new varieties for growing under Carnarvon conditions (Table 6). These were: Belair, Helix, Midas and Matrix. These will widen the choice of available varieties both for yield, colour and quality. Previous selections with potential were: DRP 3948, Emily, Flamenco, and Mazurka.

Table 5: ***Capsicum Variety x planting time (April-Sep. 2001) trial.*** *Fruit weight, fruit size, yields, percntage marketable and % premium fruit of capsicum varieties, GRSU Carnarvon, WA.*

Variety	Fruit wt (kg/plot)	Fruit size (g)	Yield (t/ha)	% Marketable fruit	% Premium grade
35-911	21.6	253	47.9	58.3	0.0
Belair	20.4	307	45.4	68.8	8.3
Blitz	21.6	251	48.1	57.1	3.8
CLX1555-Eolo	20.2	292	45.0	49.1	0.0
CP0098-Midas	22.4	254	49.7	60.1	2.4
CP462-Rex	21.2	255	47.2	57.5	0.0
CP474-Blockade	19.9	261	44.1	38.9	0.0
CP595-Matrix	24.1	289	53.6	55.0	5.9
CP632-Sentinel	21.6	260	48.0	49.2	0.0
CP647-Blocky	12.4	192	27.5	24.6	0.0
CP651-Bessa	21.9	342	48.7	67.1	2.8
CP704-Predator	20.1	293	44.7	62.7	0.0
DRP 3948	17.5	265	38.9	52.5	3.4
Emily	17.8	191	39.4	47.7	0.0
Flamenco	23.8	250	52.9	61.8	2.8
Helix	20.4	288	45.3	64.2	15.8
Ingot	18.1	237	40.2	67.2	1.2
Mazurka	20.6	224	45.7	68.6	0.7
Nassau	13.8	184	30.6	66.4	0.0
Sardana	16.0	237	35.6	72.4	2.4
Sirtaki	15.5	224	34.4	44.6	0.0
Toledo	18.9	307	42.0	66.1	0.0
Tycoon	18.8	267	41.8	48.6	0.0
Warlock	19.4	304	43.1	67.4	16.2
Y4496-Logie	11.8	235	26.1	61.3	1.7
Y4502	13.8	188	30.6	39.2	1.4
Y4510	19.4	265	43.1	57.1	2.4
Y4512	12.1	179	27.0	27.7	11.1
Y4513	8.4	171	18.7	32.1	0.0
YCS-4510	16.7	272	37.2	52.8	0.0
YCS-4512	12.0	169	26.7	42.0	7.6
YCS-4513	18.5	280	44.1	61.4	7.2
YCS-5049	22.1	318	49.1	49.6	0.0
Zambra	18.5	248	41.2	64.1	5.1
Zingaro	20.5	310	45.6	56.9	0.0
Trial Average	18.3	253	40.8	54.9	2.9
Lsd(<0.05)	7.4	94.4	16.4	20.3	9.0

Table 6: ***Yield, fruit size, percentage marketable fruit and percentage premium grade fruit of selected (top-performing) capsicum varieties (April-September, 2001).***

Variety	Yield (t/ha)	Fruit size (g)	% Marketable fruit	% Premium grade	Ripe Fruit colour
Belair	45	307	69	8	Red
DRP 3948	39	265	53	3	Red
Emily	39	191	48	0	Orange
Flamenco RZ	53	250	62	3	Red
Helix	45	288	64	16	Red
CP0098-Midas	50	254	60	2	Yellow
CP595-Matrix	54	289	55	6	Red
Mazurka RZ	46	224	69	1	Red

A summary of the yield of seven promising varieties over the three planting dates (Table 7) showed that early planting in April gave the highest yield followed by mid and late season plantings. The average yields were 41, 22 and 14 t/ha, respectively, of early, mid and late season crops.

Table 7: ***Capsicum Variety x Planting Time Trial.*** *Yield (t/ha) of selected capsicum varieties in early (Apr.-Sep. 2001), mid (Jun.-Oct. 2000) and late (Nov. 2000- Feb. 2001) season plantings at GRSU, Carnarvon, WA.*

Variety	Yield (Early) t/ha	Yield (Mid) t/ha	Yield (Late) t/ha
Blitz	48.1	24.4	12.8
DRP 3948	38.9	18.5	17.8
Emily	39.4	18.0	16.3
Flamenco	52.9	20.2	18.2
Mazurka	45.7	24.2	17.3
Nassau	30.6	20.7	17.4
Sirtaki	34.4	22.2	16.0
Trial average	40.8	21.8	13.5

Protective Structure Trial

Six varieties with consistent yield and quality were selected and planted in August 2001 both within and outside the protective structure for test marketing in November-December when prices are generally high (Figure 1).

The six selected varieties did not differ significantly in yield, fruit weight, size and marketable percentage of fruit under the protected cultivation system (Table 8). In the comparative trial outside the structure (unprotected), yield and fruit weight were not different but the varieties differed significantly ($p<0.05$) in fruit size with a range of 145-195 g and marketable percentage of fruit (43-62%). The yield in the protected system was lower (average of 12.6 t/ha) than that found in the unprotected, field-grown trial (average of 24.6 t/ha). This was largely due to powdery mildew and soil borne bacterial spot (Xanthomonas sp.) disease. Fruit size (183 g on average) and

marketable percentage of fruit (67%), however, were higher in the protected system than in the unprotected system. Fruit was graded into premium and standard grades. The percentage of premium grade was at 10-15% in both the systems. This is considered low but an improvement compared to the 3% average premium fruit (Table 5) obtained in the field-grown early season crop of 2001.

Table 8: Fruit weight, size, percentage marketable fruit and yield of selected capsicum varieties under protective structure and in the field (August-December 2001)

	Protected				Unprotected			
Variety	**Fruit Wt (kg/plot)**	**Fruit Size (g)**	**% Marketable Fruit**	**Yield (t/ha)**	**Fruit Wt (kg/plot)**	**Fruit Size (g)**	**% Marketable Fruit**	**Yield (t/ha)**
DRP 3948	40.9	197	76	14.0	81.9	195	52	26.7
Emily	40.3	189	66	13.5	59.3	141	45	18.9
Flemenco	35.0	165	63	11.4	73.6	157	49	23.5
Mazurka	36.9	166	54	12.2	68.5	145	50	21.2
Sirtaki	38.7	184	71	13.1	84.7	188	62	27.4
Tycoon	34.9	195	74	11.6	87.4	182	43	29.7
Mean	37.8	183	67	12.6	75.9	168	50	24.6
Lsd ($p<0.05$)	ns	ns	ns	ns	ns	21.8	7.0	ns

ns- not significant

Discussion

Desk Top Study and Quality Specifications

The analysis of WA exports trends and discussions with growers and market agents clearly showed the need for:

- Varieties suited to early, mid and late season planting and that will meet the quality specifications;
- A protective system of cultivation that will extend the season and improve quality and the proportion of premium grade fruit; and
- Niche marketing of quality WA capsicums in Australia and SE Asia, Mauritius and Taiwan.

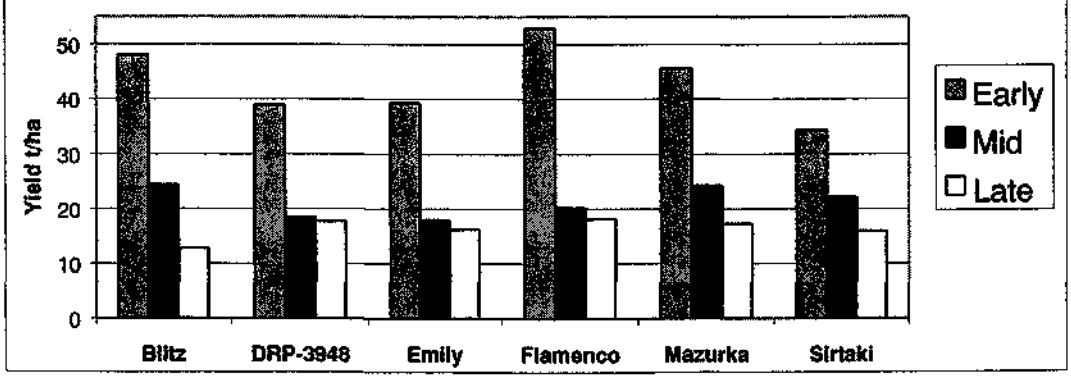
Quality specifications identified by growers and agents and consumers showed that small to medium fruits, with blocky shape are preferred. The preferred ripe fruit colour is either red or yellow. Fruit should also be firm, uniform fruits with a glossy sheen.

These are the varieties grown by Dutch greenhouse producers who dominate the export market (Kesavan et. al. 1998; van Waard, 1998). Such varieties were sourced from various seed companies (Table 1) and used for the variety x planting time trials during 2000 and 2001. These blocky types are also popular for greenhouse production in Australia (Roberts, 1999).

Variety x Planting Time Trials

A comparison of the selected varieties over the three planting dates indicates that early planting (April-May) is crucial for high yield in Carnarvon (Table 7 and Fig. 4). Mid season planting during winter (June-July) was affected by low night temperatures which reduces fruit set and yields. Late planting in November suffered from heat stress and severe sunburn without protection. Growing the late season crop in a protective structure reduced sunburn but a slow uptake of calcium led to severe blossom end rot. Management has to be optimal to realise the potential of these capsicum varieties.

Fig. 4. Yield of capsicum varieties in three planting dates



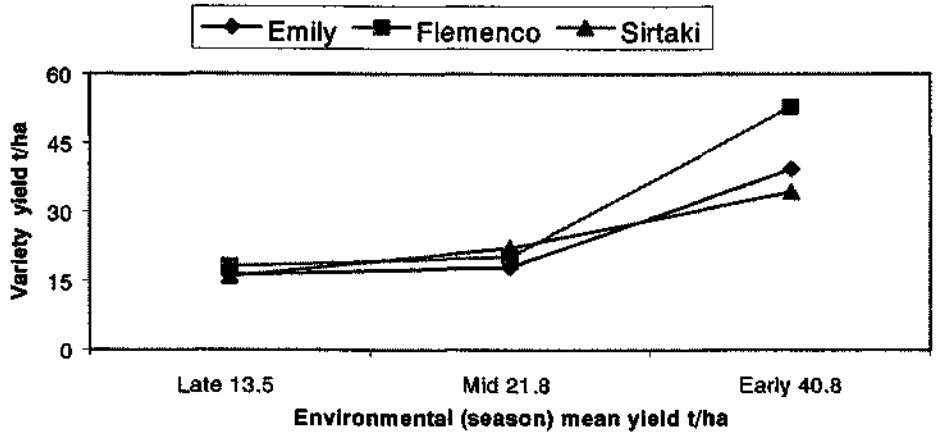
The preliminary late season trial of 1999 (Table 2) clearly showed the consequences of high temperature. Losses due to sunburn were as high as 70%. Secondary infections further reduced the marketable percentage of fruits to as low as 11% and the crop was a total loss. The trial confirmed the need for a production system that will offer protection against sunburn and wind damage for capsicums planted late in August/September in Carnarvon. This will extend the season and improve quality and capture better prices both in domestic and export markets.

The list of high-yielding varieties in the early, mid and late planting time trials is given in Table 9. This indicated that there are varieties specifically suited to early (Matrix, Midas), mid (Aristocrata, Sienor, Zirconio) and late (DRP 3948, Emily, Flemenco, Sirtaki) season cropping. One or two varieties such as Blitz and Mazurka can be used over an extended planting time (early to mid or mid to late season plantings). But such generally-adapted varieties are few and far between. In Figure 5, yields of three selected varieties were plotted against the average yield of all varieties (environmental mean, Table 7) in each of the three planting time trials. This shows the differing response of three blocky type of capsicum varieties to different seasons (early, mid and late) or environments in Carnarvon This type of genotype x environment interaction is common in varietal evaluation (Simmonds, 1979). In addition, the seed companies release only F1 hybrids from parents with high specific combining abilities and introduce new hybrid varieties continually in order to be competitive. So the best option for growers is to choose specific variety(s) for a specific season based on variety evaluation trials.

Table 9 High yielding Capsicum varieties identified in the variety x planting time trials

Planting Time	Varieties
Early (April/May)	Blitz, Bessa, Flemenco, Matrix and Midas
Mid (July)	Aristocrata, Blitz, Mazurka, Sienor and Zirconio
Late (August/September)	DRP 3948, Emily, Flemenco, Mazurka, Nassau, Sirtaki

Fig. 5 Genotype x Environment effect in capsicums



Protective System of Cultivation

In order to produce blemish-free, high quality produce that comes close to the Dutch standards, it is increasingly becoming necessary to grow capsicums under greenhouses in Australia (Roberts, 1999). The simple, protective system used in this trial reduced sunburn considerably but had other managerial problems such as blossom end rot and diseases.

Such a system may not be economical considering the prices offered for Carnarvon capsicums ($0.30-$1.50/kg) in Perth markets. Grower survey indicated premium grade fruit should be above 20% in order to be profitable. The premium grade obtained under the simple protective structure tried was low at 10-15%.

The trial of selected varieties within the simple protective structure (Figure 3 and Table 8), gave lower yields than the field grown capsicum with no protection. This was mainly due to managerial problems in controlling blossom end rot, powdery mildew and soil-borne bacterial spot. These problems can be minimised by better management practices.

Blossom end rot is a physiological disorder linked to low calcium levels in fruit tissues accentuated by faster growth of plants within an enclosed structure. Alexander and Clough (1998) found sun-bonded polypropylene row covers and calcium nitrate application at 68 kg/ha reduced sun scald and blossom end rot substantially. Soil fumigation with methyl bromide or other alternatives such as dazomet (Basamid®) and biofumigants (Kesavan et.al. 2002) can control soil borne pathogens and nematodes. Hart (1998) has demonstrated integrated pest management for capsicum production systems. Incorporation of these practices should minimise these problems and increase yield and quality of capsicums in the protected system.

The fruit size and marketable percentage were higher in the protected system than in the field-grown system; fruits were medium, attractive, uniform and blocky (Table 8). This indicates that quality and hence returns can be improved under the protective system.

Preliminary gross returns using certain assumptions are given below. Important assumptions are an average yield in late season planting of 25 t/ha and a price premium of at least $0.20 for quality fruit above the average price of $2/kg in 2001 (Parr, 2002) for field-grown capsicums. The actual marketable percent of fruits obtained in the trials were used for calculations.

Table 10. Comparative returns from capsicums grown within and outside a protected system

System	Yield (kg/ha)	% Marketable fruit	Price ($/kg)	Gross returns ($/ha)
Simple protective structure – high yield (a)	25,000	67	2.20	36,850
Simple protective structure – low yield (b)	12,600	67	2.20	18,572
Field grown – no protection (c)	25,000	50	2.00	25,000
Difference (a-c)				+11,850
Difference (b-c)				- 6,,428

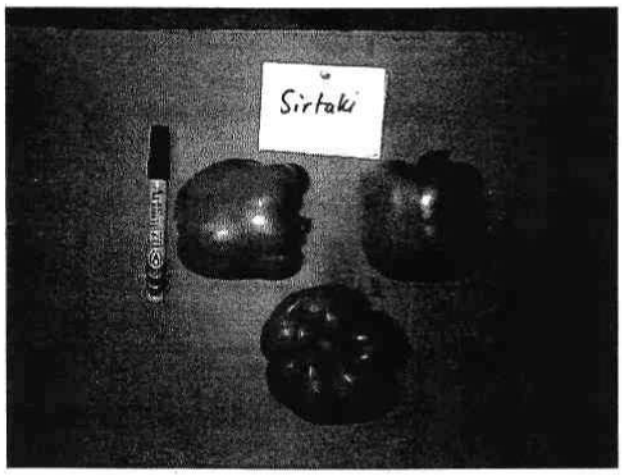
The gross returns ($/ha) from the above comparison (Table 10) showed that in order to be profitable the yield in the protected system has to be as good or better than in the field-grown system with no protection. In addition, the proportion of premium grade has to be high around 20-30%. Simple protective structures as the kind tried in this trial are becoming popular in Carnarvon. The area under such a system has grown from 0 to 10 ha in the last two years. Discussions with these leading growers indicate a premium grade of 20 to 30% with a price increase of $0.50 to $1/kg over other grades. This will amply compensate for the extra cost of approximately $10,000/ha expended for the shade cloth, windbreak and supporting structures in the protected system.

Embry and Gartrell (2001) reported a gross margin of $8632/ha at an average price of $1.38/kg and a yield of 33.3 t/ha for a capsicum enterprise in Carnarvon. It is possible and profitable to improve the quality of field-grown capsicums in a protected system and supply both domestic and niche markets in South East Asia and Taiwan. This will lead to a sustainable and profitable production of quality capsicums in Carnarvon.

Future needs and plans

- Continued trials on new varieties as seed companies release/introduce new varieties;
- Regular updates on prices, niche marketing opportunities and market access;
- Work with the existing producer marketing groups who will need training & net working to integrate the supply chain; and
- Economics of the enterprise especially the protective system needs to be quantified.

Fig.6 Fruit shape, size and colour of three blocky type capsicum varieties: DRP 3948, Emily and Sirtaki



Recommendations

In addition to supplying the domestic market, Carnarvon growers have a window of opportunity to extend the season and supply niche markets overseas. Some recommendations from this study are:

- Small to medium, bell type capsicum described as blocky are preferred by consumers and market agents;
- Specific varieties to suit specific planting dates (early, mid, late) have been identified;
- Protection against sun and wind is necessary to plant capsicums late in August/September to capture the high price market window and improve quality;
- Varieties suited to the simple protective structure were: DRP 3948, Emily and Sirtaki (Figure 6);
- It is necessary to manage nutrition to control blossom end rot and diseases to obtain high yield of quality fruit within the protected system of cultivation;
- Preliminary calculations indicate that improved fruit quality (ie. 20-30% premium grade) and a marketable yield of 25-30 t/ha will compensate the extra cost involved in constructing the structure.
- Group marketing as practised by the Love Apple and Gascoyne Gold groups with the aim of producing consistent quality fruit will lead to a sustainable capsicum industry in Carnarvon.

Technology Transfer

The project evolved from the perceived needs of the industry. It was carried out with regular discussion with and input from the Love Apple and Gascoyne Gold Group of vegetable growers. Their participation was crucial in developing quality specification and best management practices.

In addition, three extension field walks/days were held in December 1999, August 2000 and July 2001 during the trial period. A number of vegetable growers attended and participated in these extension events. Also preliminary results were summarised in the periodic extension publication 'RiverAg' during the trial period of 1999-2001.

All these activities made it easy and practical to transfer the results of research. A proof of success of this study is the increase in the area of capsicums under protected cultivation. This area increased from 0 to around 10 ha in 2001-2002 season.

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Appendix 1
Grower survey on capsicum quality specifications and best management practices in Carnarvon

Aim:

To produce field-grown, quality capsicums in Carnarvon both for domestic and export markets

Methods:

- Quality specifications and Local Best Management Practices- Discussion with Love Apple & Gascoyne Gold groups
- Variety trials at GRSU—3 Planting dates (Early-March, Mid season- May and Late season- August)
- What is the local best variety?
- Best variety grown under protective structure wind and sun protection
- Test marketing & economic analysis
- Grower study tour to eastern states/overseas?

Capsicum Quality Specifications

Please circle the right answer or describe briefly:

1. Fruit colour, size, grading etc

Ripe fruit colour: Red Yellow Orange other

Fruit size: Small Medium Large

Fruit shape: Bell Blocky Long, elongated

Skin thickness; thin thick Intermediate

Other features: uniformity, glossiness, blemishes

2.What are considered premium grade?

3.What proportion of total would be classed as premium fruit in Carnarvon

a)<5% b) 5-10% c) 10-20% d) 20-30% e)>30%

B. Local Best Management Practices for Capsicum Production

Please describe the practices:

1. Land Preparation

2. Planting & spacing

3. Fertilisers: type, quantity, application methods

Gypsum application

Preplant Nutrition

Side dressing

4. Fertigation

5. Irrigation

6. Weed control

7. Crop protection
Pests

Nematodes

Caterpillars

Aphids

Mites

Others

Integrated pest management practices

8. Diseases

Bacterial

Fungal spots

Viruses: Two spotted wilt, mosaic etc.

9. Harvesting, post harvest handling & marketing

When? Green or red

Grading

Packing

Post harvest storage & handling

10. Interstate & Export markets

Quarantine- Med fly in Carnarvon

What do agents/ consumers want?

How to meet the demands by agents/consumers?

Appendix 2
WA Export Trends for Capsicums From 1992-98

Brunei	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	589	144	1617	570	0
Exported Value	$ A	2089	592	2596	2015	0
Hong Kong	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	0	1025	2900	0	0
Exported Value	$ A	0	2590	5700	0	0
Indonesia	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	1245	1489	600	120	0
Exported Value	$ A	5209	7130	1874	500	0
Malaysia	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	2573	17073	3230	334	0
Exported Value	$ A	5683	21952	2975	1698	0
Singapore	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	2959	26800	0	0	0
Exported Value	$ A	5931	33141	0	0	0
Taiwan	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	kg	0	0	0	0	620
Exported Value	$ A	0	0	0	0	1946
Thailand	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	Kg	0	0	0	0	620
Exported Value	$ A	0	0	0	0	2781
Mauritius	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	Kg	0	0	0	0	1512
Exported Value	$ A	0	0	0	0	3542
UAE	Units	1993/94	1994/95	1995/96	1996/97	1997/98
Exported Volume	Kg	0	630	0	0	0
Exported Value	$ A	0	838	0	0	0