VG119
Buttercup squash (kabocha) as a potential export crop from Tasmania to Japan

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VG119

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4.	COMMENCEMENT DATE:	May 1991
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5.	TOTAL PROJECT COST IN 1991-92:	$30,881

6. SUMMARY:

Buttercup squash is a potential new export crop for Tasmania because of its declared freedom from fruit fly, suitable climate, experienced growers and export awareness, and a recognised reputation for clean, healthy food. This study investigated various agronomic practices which can influence crop production in Tasmanian conditions.

Delica and Kurijiman were found to be the best yielding and best quality cultivars across five production sites throughout the state. Forthside Vegetable Research Station in the main vegetable production areas of the NW Coast gave the highest total yields, but there was some losses due to fungal disease. Good marketable yields of 16-22 t/ha were recorded in the Cressy, Scottsdale and Cambridge sites. There was a skewed relationship between marketable yield and plant density and a plant density of about 1.8 plant/m^2 was considered to be suitable for Tasmania. Sweet corn shelter belts can provide a yield increase but will need further on farm assessment. A cultural bulletin on the production of Buttercup squash under Tasmanian conditions has been prepared and will be provided free to growers and to exporters. Significant quantities of Buttercup squash was exported from Tasmania to Japan during 1991/92 and exports are likely to expand during 1992/93.

BUTTERCUP SQUASH AS A POTENTIAL EXPORT CROP FROM TASMANIA TO JAPAN

(A) INTRODUCTION

Japan has recognised that Tasmania is the only State in Australia free from both Mediterranean fruit fly (*Ceratitis capitata*) and Queensland fruit fly (*Dacus tryoni*). Negotiations have resulted in agreement for produce to be shipped economically to Japan in fantainers. These developments open up the possibility for Tasmania to access the Japanese market with new crops such as Buttercup squash.

In Japan a shortfall in the supply of Buttercup squash occurs from March to May and imports are taken primarily from New Zealand and Mexico. Imports by Japan have shown considerable growth but are dependent upon Japanese production and the quality of the imported product. In 1989-90 over 60,000 tonnes were imported by Japan with an estimated value in excess of $A15 Million.

This work was conducted following encouragement from Tasmanian exporters and Japanese importers who are keen to develop the industry. There appears to be a place for Tasmania to enter this market because the Japanese seek security of supply and the association of Tasmania with high quality clean foods. Tasmania could anticipate to capture 10 - 20% of the market with a value of $1.5 - 3 Million and has a well organised exporting infrastructure from which to work.

Preliminary research in Tasmania by the DPIF have defined several cultivars which would grow well under local conditions. However, there are deficiencies in several agronomic requirements of this crop under local conditions which will need to be defined. These include a need to evaluate promising cultivars in several locations (North West, North, East and South of the State) with genotype location analysis, the effects of plant density on the quality and yield of export grade fruit and the value of windbreaks in improving yield and quality.

Reports from New Zealand (Foster 1985, Montgomery 1986) has shown that Buttercup squash require a relatively high rate of basal fertiliser (1000 kg/ha 9:14:17) and a top dressing of 60 kgN/ha at the early growth stage. A well irrigated crop (30mm/7-10 days) was shown to double the yield of dryland crops. Wind was shown to reduce plant growth and fruit

yield and increase vine markings on the fruit. Douglas et al. (1990) showed that plant density significantly affected total fruit yield and size grade distribution. In contrast, squash exhibited high elasticity in relation to plant arrangement with row spacing and within plant width having much less influence on production parameters than plant density.

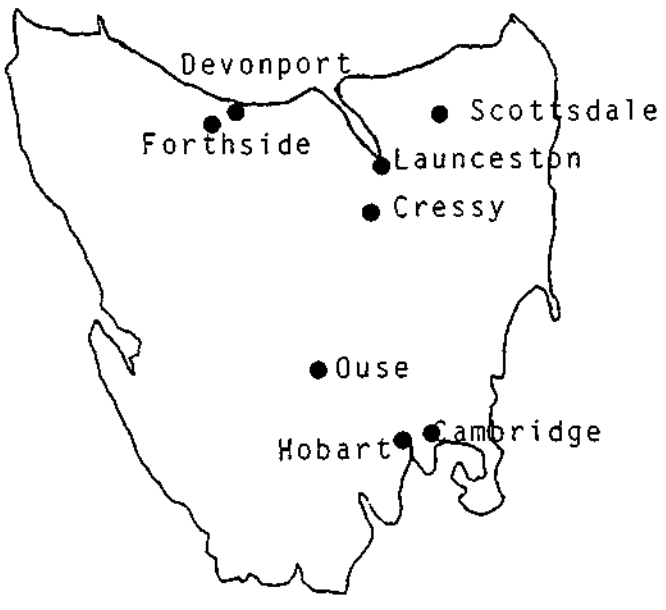
(B) OBJECTIVE

To define under Tasmanian conditions the influence of location, plant density, and windbreaks on the yield and quality of Buttercup squash. A bulletin incorporating these research findings will be prepared outlining the basic cultural requirements for this crop. Marketable grade fruit from each of the following studies were provided to an existing exporter for test marketing in Japan.

(C) MATERIALS AND METHODS

(a) Region *cultivar study

Three well performed cultivars from previous cultivar studies (Delica, Kurijiman and Sue) were sown at five sites; Forthside, Cambridge; Scottsdale; Cressy and Ouse. At each site the experimental design was a randomised complete block of three cultivars and four replicates. The plot size was 3 rows 1.8m wide and 4.5m long (24.3 m^2).



Location of experimental sites for Buttercup squash cultivar evaluation.

High analysis fertiliser 14:16:11 was pre-drilled or broadcasted at each site prior to planting at a rate of 750 kg/ha. The seed was hand planted at 300 mm spacings within each row to give a plant density of 1.85/m^2. Two seeds were placed at each station and then thinned as needed to one per station after emergence. Irrigation was applied as needed throughout the season and ceased about one week prior to harvest. During the season, approximately 30mm was applied each week. Weeds were controlled by using a stale seed bed procedure followed by mechanical cultivation as required. Diseases such as powdery mildew were not present or were at such low levels that fungicide sprays were considered not necessary.

All fruits were once-over hand harvested at maturity - subjectively assessed as having 30-50% corkiness of the stem. Fruits equal or greater than 1.0 kg weight with nil or minimal blemish or defects were considered to be marketable. Blemished or defective fruit were grouped into the following categories:

rots -	obvious rotting due to disease
blanched -	blanching due to contact with the soil, area blanched greater than 100 cm^2
vine marking -	markings deeper than 2 cm and/or longer than 10 cm
sun burnt -	obvious discolouring on the surface of the fruit due to exposure to the sun
callus -	raised callus area greater than 4 cm^2
shape -	misshapened fruit

(b) Plant density study

One experiment was carried out at Cambridge to study the influence of six plant densities (0.5 - 6.0 plants/m^2) on the yield parameters. The cultivar used was Delica and the experimental design was a randomised complete block of six treatments and four replicates. The row spacing was 1.8 m and plots varied from 3 row 4.5 m long (24.3 m^2) to 10 rows 4.5 m long (81.0 m^2). The row spacings and number of plants per plot were:

Plant density (No./m^2)	Within row Spacing (mm)	No. plants per plot
0.5	1112	40
1.0	556	40
2.0	278	49
3.0	185	75
4.0	139	97
6.0	93	145

Cultural details, harvesting and grading procedures were the same as for the region * cultivar study. The total and marketable yield data was fitted to the yield- density function of Holliday (1960):

$$w^{-1} = a + Bp + yp^2$$

where w = the mean weight per plant (g), p = the plant density (number/m_2) and a, B and y are parameters of the model. this yield density model was chosen in preference to other models because the estimates of the parameters had been shown to be less biased (Gillis and Ratkowsky, 1978).

The form of this relationship is determined by the parameter y; where y = 0, the relationship between yield per unit are (wp) and plant density is asymptotic, and where y>0 the relationship is parabolic. The function was fitted in the natural logarithm form.

For the asymptotic relationship, the parameters a and B can be given simple biological interpretations (Willey and Heath, 1969; Frappell, 1979). As density tends toward zero, the value of the weight per plant tends to a^{-1} and this value is considered to be a measure of the genetic potential of a crop in a particular environment, ie a^{-1} is a measure of the size of the plant when there is no competition. As density tends toward infinity, the yield per unit area approached the asymptotic value of B^{-1} and this value is considered to be a measure of the potential of the environment.

(c) **Wind break study**

A preliminary study was carried out at Forthside into the influence of sweet corn shelter belts on the yield and external defects of Buttercup squash. Four rows of sweet corn Jubilee at 800 mm spacings were sown around the entire perimeter of two areas 20 m x 40 m. The sweet corn was planted 3 weeks prior to planting of the Buttercup squash. Squash Delica (Yates) was sown in rows 1.8 m wide throughout this area. At maturity, the yield and external quality parameters was assessed at regular distances from the sweet corn shelter belt. The cultural details, harvesting and grading procedures were the same as for the region * cultivar study.

D. RESULTS

(a) Site * cultivar study

1. *Growing season*

The growing season from planting to harvest varied from 117-126 days for the five sites:

Site	Planting date	Harvest date
Forthside Vegetable Research Station (FVRS)	13/11/91	10/3/92
University Farm, Cambridge (Uni Farm)	4/11/91	16/3/92
Cressy	6/11/91	12/3/92
Scottsdale (S'dale)	21/11/91	26/3/92
Ouse	27/11/91	2/4/92

2. *Temperature during the growing season*

All sites had a generally average season with Scottsdale and Cressy having a relatively cooler than average January and February (Table 1). The maximum average monthly temperature varied from 16.5°C at Forthside during November to 23.4°C at Ouse during February. Forthside and Cambridge had lower maximum temperatures but higher minimum temperatures during the season.

3. *Yield and yield analysis*

Sites had the greatest effects on the yield and yield components. Forthside gave the highest total yield of 39.6 t/ha while Ouse had the lowest total yield 21.4 t/ha (Table

2). Delica and Kurijiman gave higher yields than Sue at all sites. Total fruit number was highest at Forthside (3.1 fruits/m^2) and lowest at Ouse (1.9 fruits/m^2). Both Forthside and Cressy gave the highest marketable yield of 22-23 t/ha while Ouse had the lowest marketable yield of 14t/ha. Cressy had the largest marketable fruit weight (1.6 kg/fruit) while Cambridge and Ouse had average marketable fruit weights of 1.4 kg/fruit. The percentage recovery varied from 56% at Forthside to 71% at Cressy with the other three sites having a recovery of about 65%. Callus was a major contributor to wastage, especially at Forthside and to a lesser extent at Scottsdale. Forthside also had more wastage from vine marking and rots due to fungal infection while Ouse had more undersize fruit than other sites.

(b) Plant density study

1. *Yield density relationship*

In this study, there was an asymptotic relationship between total fruit yield and plant density (Fig 1). From the parameters of this relationship the potential total yield of Delica at this site is 40.7 t/ha.

There was a parabolic relationship between marketable fruit yield and plant density (Fig 1.). From the parameters of this relationship, the maximum yield of marketable fruit was 16.6 t/ha and this was achieved at a density of 1.1 plants/m^2. Due to the skewed nature of this relationship, a yield equal to 90% of this maximum can be achieved over a plants density range from 0.8 - 3.0 plants/m^2. Lower densities will substantially reduce yield while higher density will gradually reduce yield.

2. *Yield components*

The mean weight of marketable fruit varied from 1.27 kg at 6 plants/m^2 to 1.63 kg at 0.5 plants/m^2. Plant density had no significant effects on defects such as callus, vine marking, rots or misshapened fruits, but had a very significant effect in increasing the proportion of undersize fruits at densities above 2.0 plants/m^2.

(c) **Shelterbelt Study**

In the preliminary study at Forthside crop growth and squash yield on the northern/leeward side of the sweet corn shelterbelt appeared to be affected by the windbreak (Table 4). The sweet corn shelterbelt grew very well and reached a height of about 2.5m. The best total and marketable squash yields were achieved in the zone 3.6 - 14.4m on the leeward side of the wind. Substantially lower total and marketable squash yields were recorded in plots exceeding 14.4m from the shelterbelt.

The reductions in total fruit yield in plots exceeding 14.4m from the shelterbelt is associated with a reduction in the number of fruits/m^2 an a reduction in fruit size. The percentage recovery of marketable fruits varied from 58.6 - 66.1%. Wastage closer to the shelterbelt appears to be due more to callus development where the fruit is in contact with the soil while under size fruits and rots due to disease appears to be the major types of defects on plots exceeding 14.4m from the shelterbelt.

(d) **Market acceptance**

A total of 3t of marketable fruit from these studies were provided to a local exporter and were exported to Japan with his commercial crop. All the fruit provided were equally as acceptable to the Japanese importer as the commercial crop.

(e) **Cultural Bulletin**

A draft cultural bulletin on the production of Buttercup squash under Tasmanian conditions has been prepared and the cover and content pages attached. This bulletin will be provided free to all interested growers, exporters and seed companies.

(f) Employment of Staff

Two technical officers were employed full time for six months to assist with the conduct of these studies.

(E) DISCUSSION

The results of this study showed that Buttercup squash can be successfully grown in Tasmania with yield and quality as good as major producers such as New Zealand. Fruits of three cultivars grown in five different regions of the state were equally acceptable to the Japanese markets.

The highest total yield was recorded at Forthside, which is located in the fertile vegetable growing region of the north west coast. However, this crop was also the most effected by rotting of the fruit from fungal diseases, probably as a result of moist coastal conditions and the intensiveness of vegetable cropping in the area. Very acceptable marketable yields of 16-22t/ha were recorded in less intensely cropped areas of Cressy, Scottsdale and Cambridge. Averaged over all the five sites, Delica and Kurijiman were the two best cultivars in yield and quality.

At the Cambridge, 90% of the maximum marketable yield can be achieved from a density range of 0.8 - 3.0 plant/m^2. However, this is a skewed relationship with densities below 0.8 plants/m^2 having a rapid reduction in marketable yield while densities above 3.0 plants/m^2 will reduce marketable yield relatively gradually. In view of the high cost of seed and this skewed marketable yield - density relationship, the plant density of 1.85 plants/m^2 used in most of these studies would appear to be a reasonable compromise for Tasmanian conditions. This value is in agreement with the recommended density of 1.8-2.2 plants/m^2 for New Zealand growers (Foster 1985, Douglas et al, 1990).

The preliminary study on the use of sweet corn shelter belts suggest some yield benefits from shelter. However, sweet corn shelter belts are expensive in terms of the cost of sweet corn seed, the land lost from squash production and

the extra management costs of planting and weeding the sweet corn. Hence, growers would be advised to make their own judgement as to the need for shelter belts depending on the exposure of their paddock and their cost structure. Small scale on farm observations of the value of sweet corn shelter belts may be conducted by growers who believe their crops could benefit from shelter.

During the 1991/92 season, an estimated 1,000t of Buttercup squash was exported by Tasmanian based exporters to Japan. A similar volume is expected to be exported by these exporters during the 1992/93 season. In addition, mainland based exporters have shown interest in sourcing additional Buttercup squash from Tasmania and these interests could contribute to another 500-1,000t being exported from Tasmania during the 1992/93 season. The cultural bulletin prepared as a result of this study will be of use to new and existing growers and exporters.

(F) ACKNOWLEDGEMENTS

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Table 1. The monthly maximum and minimum temperatures at five sites

	Forthside	Cambridge	Cressy	S'dale	Ouse
Nov 1991					
Max °C	16.5	18.7	18.6	19.2	18.5
Min °C	7.5	8.7	6.2	7.0	6.7
Long term average					
Max °C	17.2	18.8	18.6	18.6	19.6
Min °C	8.7	9.0	7.1	7.6	6.8
Dec 1991					
Max °C	19.1	19.9	20.9	21.0	21.3
Min °C	10.1	10.8	9.6	9.5	9.3
Long term average					
Max °C	18.9	20.3	21.0	20.4	21.8
Min °C	9.7	10.6	8.5	8.9	9.2
Jan 1992					
Max °C	20.2	20.2	20.7	20.8	20.7
Min °C	10.3	10.8	9.8	9.3	8.7
Long term average					
Max °C	20.0	22.3	23.1	22.6	23.6
Min °C	10.7	11.8	10.0	10.2	10.0
Feb 1992					
Max °C	20.5	21.0	23.0	21.8	23.4
Min °C	11.1	11.2	10.2	10.6	8.3
Long term average					
Max °C	20.4	22.2	23.1	23.2	23.7
Min °C	11.1	11.8	10.2	10.7	10.1
March 1992					
Max °C	21.3	22.2	23.3	22.7	22.9
Min °C	11.3	11.4	9.7	10.4	8.3
Long term average					
Max °C	18.4	20.6	20.9	21.2	21.7
Min °C	10.0	10.6	9.0	9.7	7.9

Table 2. The effect of production site on the yield and yield components of three Buttercup squash cultivars.
* Marketable yield = fruit ≥ 1.0 kg and has nil or minimal blemish.

Site	Cultivar	Total yield (t/ha)	Marketable Yield (t/ha)	Mean Marketable Fruit weight (kg)	Total fruit number per m^2	Defects (t/ha)		
						Callus	Smalls	Vine
Forthside	Delica	41.4	23.1	1.5	3.2	9.3	2.8	3.8
	Kurijiman	40.5	23.6	1.5	3.2	6.7	2.9	4.8
	Sue	36.9	23.3	1.6	2.8	5.8	1.6	4.8
	Mean	39.6	23.3	1.5	3.1	7.2	2.5	4.5
Cambridge	Delica	27.5	17.2	1.4	2.4	2.5	4.8	2.8
	Kurijiman	23.8	15.7	1.3	2.2	2.6	3.3	2.2
	Sue	23.0	15.9	1.5	1.8	1.1	2.7	2.9
	Mean	24.7	16.3	1.4	2.1	2.1	3.6	2.6
Cressy	Delica	35.0	26.9	1.6	2.3	3.1	1.7	0.4
	Kurijiman	33.1	23.6	11.6	2.4	2.3	2.4	1.5
	Sue	25.8	16.2	1.6	1.9	2.8	2.8	0.8
	Mean	31.3	22.2	1.6	2.2	2.7	2.3	0.9
Scottsdale	Delica	28.2	18.3	1.5	2.0	4.8	1.8	3.2
	Kurijiman	25.2	16.21	1.5	2.0	4.5	3.1	1.3
	Sue	25.2	16.8	1.5	2.0	3.9	3.1	1.4
	Mean	26.2	17.11	1.5	2.0	4.4	2.7	2.0
Ouse	Delica	23.5	15.4	1.4	2.0	2.0	3.6	2.6
	Kurijiman	22.3	14.3	1.3	2.2	0.7	6.5	0.8
	Sue	18.4	11.4	1.4	1.6	2.0	4.1	0.9
	Mean	21.4	13.7	1.4	1.9	1.6	4.7	1.4
LSD (5%)								
Sites		6.52	4.82			1.74	1.33	1.68
Cultivar		3.90	2.95			NS	NS	NS

Table 3. The effect of plant density on the yield and yield components of buttercup squash 'Delica' grown at Cambridge.

Yield Parameters	Plant Density N^o/m^2						
	0.5	1.0	2.0	3.0	4.0	6.0	LSD (5%)
Total yield (t/ha)	18.3	25.8	28.8	35.3	34.2	38.4	8.01
Defect yield (t/ha)							
Callus	2.9	4.1	5.3	3.8	3.8	3.5	NS
Vine marks	2.9	3.0	2.8	3.9	2.1	3.3	NS
Smalls (less than 1 kg)	0.5	2.5	4.1	9.6	13.2	20.3	8.56
Other defects	0.2	0.4	0.5	0.3	0.2	0.4	NS
Marketable yield (t/ha)	11.8	15.8	16.2	17.8	14.9	11.1	4.83
% marketable	63.5	60.0	55.6	50.1	46.9	28.6	
Mean marketable fruit weight (kg)	1.63	1.56	1.44	1.33	1.15	1.27	0.110

Table 4 The effects of distance from a sweetcorn shelterbelt (leeward side) on the yield and quality of buttercup squash 'Delica'. Note: Data from the mean of two replicates, each replicate consists of 3 rows 30m long.

Yield parameter	Distance from the windbreak northern - leeward side (m)			
	3.6	9.0	14.4	20.6
Total Yield (t/ha)	35.9	37.9	38.0	25.6
Total fruit (N^0/m^2)	2.48	2.51	2.48	2.06
Mean weight of all fruits (kg)	1.45	1.51	1.53	1.24
Marketable yield (t/ha)	22.2	23.8	25.1	15.0
Percent marketable (%)	61.8	62.8	66.1	58.6
Wastage (% of total yield)				
Callus	14.7	20.9	17.7	7.8
Vine marking	11.2	8.1	7.8	8.8
Undersize fruits	9.0	4.9	5.5	12.3
Rots	-	-	3.7	11.8

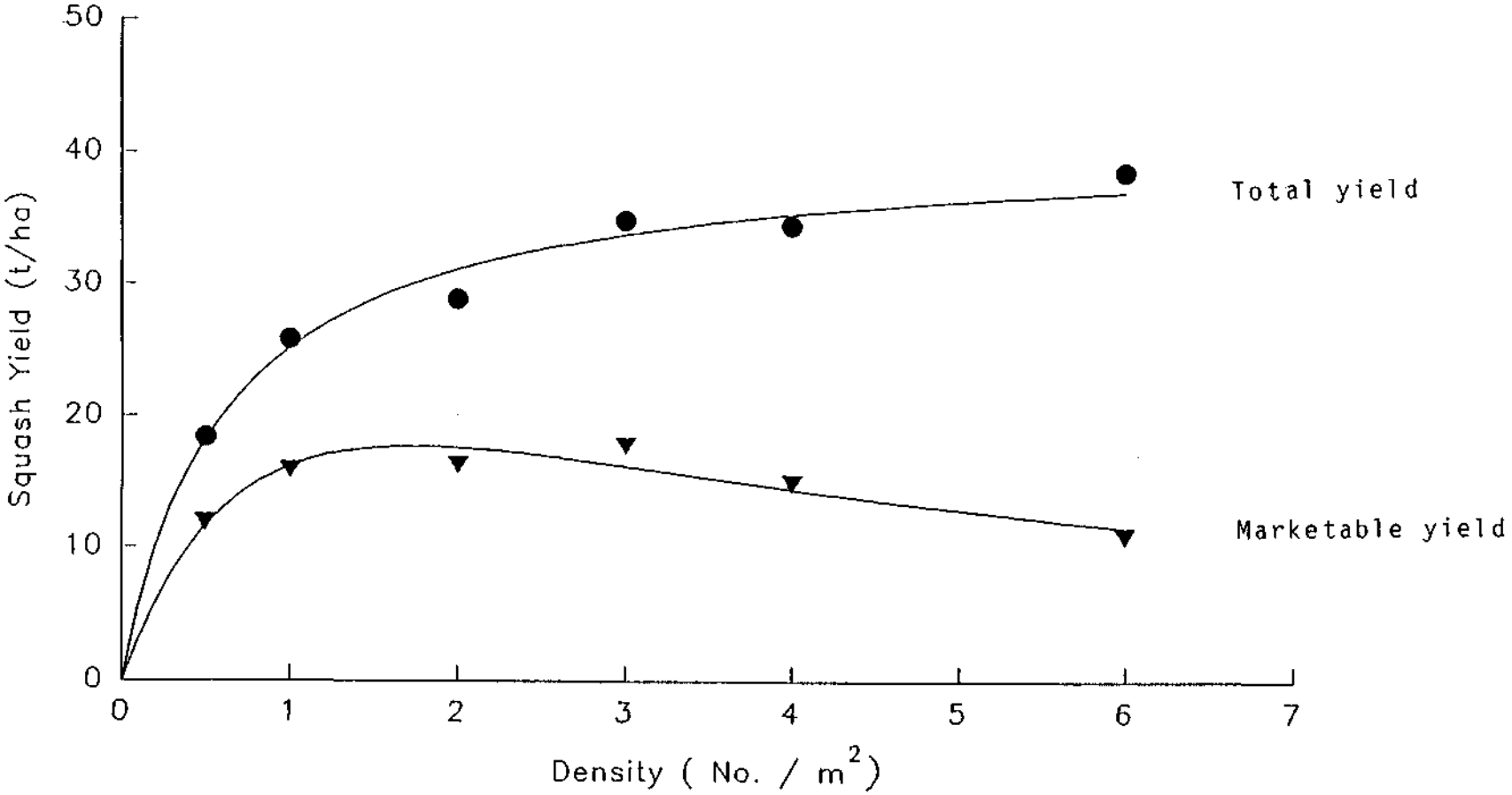

Figure 1. The effects of plant density on the total fruit yield and marketable fruit yield (fruits greater than 1.0kg) of buttercup squash grown on the University Farm, Cambridge