Breeding of *Cucurbita* spp. in New Zealand

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Abstract

Production of *Cucurbita* spp. in New Zealand is based entirely upon a range of types from the species *C. maxima*, *C. pepo*, and *C. moschata*. Prior to the 1980's, the grey storage pumpkin cultivar Whangaparoa Crown and related strains were the most widely grown types. Since 1980 buttercup squash has become an important export vegetable crop of New Zealand.

Early breeding of *Cucurbita* spp. in New Zealand mainly involved the reselection of 'Crown' types and later the hybridisation of these types by farmers, seedsmen and DSIR Crop Research. Later breeding efforts included the development of grey bush types. Since 1980 the major emphasis for Crop Research has been breeding buttercup hybrids with extended storage life.

The storage life of buttercup hybrids has been extended through hybridization with the Whangaparoa Crown pumpkin. This work has resulted in an improved storage 'buttercup' type hybrid with similar appearance, eating quality and yields equivalent to standard buttercup cultivars.

Additional key words: Cucurbita maxima, *buttercup squash, pumpkin*

Introduction

Buttercup squash is now the most widely grown cucurbit in New Zealand and has become an important export crop (Table 1). The volume of fruit exported to Japan rose from 400t in 1979 to 45,400t in 1991 ($NZ38 million FOB), (Porter and Allison, 1991). Seventy percent of the crop is grown in the Pukekohe district with the balance produced throughout the rest of New Zealand.

Table 1. New Zealand Squash Production and Export, (Hort. News Year Books).

Year	Quantity (tonnes)	Export (tonnes)	FOB ($ 000)
1981	-	6 500	3 500
1982	37 000	13 000	6 500
1983	38 000	14 448	8 331
1984	40 000	31 182	18 636
1985	60 000	34 829	14 543
1986	66 000	37 765	36 069
1987	60 000	41 747	29 585
1988	63 000	51 014	33 884
1989	-	41 972	27 622
1990	-	60 351	37 428
1991	-	45 396	37 912

New Zealand supplies only 12% of the Japanese market over a three to four month period. Mexico supplies a similar volume with the balance either being grown domestically or imported from other countries. With importers being completely uncontrolled and with squash being imported from other countries such as Mexico, the Japanese market is very volatile.

In New Zealand the production of *Cucurbita* spp. is based on a number of different types (Table 2). Prior to the early 1980's the cultivar Whangaparoa Crown and related strains were the main types grown. In 1990 they accounted for 10 percent of the New Zealand area under production (F.Onland, pers. comm.). Whangaparoa Crown is a New Zealand selection from the cultivar Crown introduced from Australia (Darragh, 1932; Tapley *et al.*, 1937).

The main buttercup cultivars grown in New Zealand are the Japanese hybrids Delica, Kurijiman and Nishiki. Delica is now the most widely grown cultivar (Anon., 1987). These cultivars are a large improvement on the original buttercup first released in 1931 by the North Dakota Agricultural Experimental Station (Tapley *et al.*, 1937).

Other cucurbit cultivars including those from the species *C. pepo* and *C. moschata* have only limited commercial production. The *C. maxima* cultivars Red Warren, Golden Hubbard, Queensland Blue, Triamble

Table 2. Main cultivars of *Cucurbita* spp. grown in New Zealand

Species	Type	Main Cultivars
C. pepo	summer squash	Black Zucchini Blackjack hybrid Goldrush Scallopini
	local	Kumikumi
C. moschata	butternut	Waltham
C. maxima x *C. moschata*	tetsakabuto	Supermarket
C. maxima	hubbard	Golden Hubbard
	warty	Red Warren
	crown	Whangaparaoa Crown Early Dri-Crown hybrid Crown Prince hybrid
	buttercup	Delica Nishiki Kurijiman Ebisu Sweet Mama Buttercup Bush Pacifica
	others	Queensland Blue Triamble Tristar

and Tristar, are now only used in the packet seed trade in New Zealand (F. Onland, pers. comm.).

In November 1988 buttercup squash came under the Horticultural Export Authority (HEA) when it was declared a prescribed product under the HEA Act. The Buttercup Squash Council, made up of growers and exporters, was formed in April 1988. It is responsible for volume management, quality control, research and development and the licensing of exporters.

With the expansion of buttercup squash production in New Zealand there has been an increase in research. This research has followed the industry's needs with early work studying the agronomy of squash. The Ministry of Agriculture and Fisheries (MAF) has done much of this agronomic work with trials sown at the MAF Horticultural Research Station at Pukekohe in 1989 to study plant emergence, crop phenology, flower development, fruit expansion and the effect of time of planting. The research effort has included buttercup growth and development with different sowing times and crop locations (Buwalda and Freeman, 1986a), plant density (Douglas *et al.*, 1990), nutrition (Buwalda, 1986; Buwalda and Freeman, 1986b), weed control (Scheffer, 1986), and the evaluation of Japanese cultivars (Barrett, 1988). Most of the above research is summarised in the publication by King and Wishart (1990) in conjunction with the New Zealand Buttercup Squash Council which has guidelines for growers with recommendations for export production.

More recent research has concentrated on quality assurance including disease control and grading. MAF work has involved the use of penetrometers to assess maturity by measuring the force required to pierce the skin of the fruit. Fruit stalk browning (development of a brown corky appearance) is a useful indicator of maturity and can provide an adequate guide at the time of cutting. Other indicators such as flesh colour and seed hardness are essential secondary checks for maturity. Maturity of squash fruit can have a major influence on fruit quality parameters such as colour, flavour and texture (Harvey, 1990) but more research is required to define the effects precisely.

Maturity also has an effect on post harvest storage of squash. Hawthorne (1989) found that increasing the length of time (after maturity) fruit remained attached to the vines before harvesting appeared to increase its susceptibility to storage rots. Further research by Hawthorne (1990) showed that older buttercup fruit at harvest are more likely to rot than those that are younger.

Storage losses in export shipments of buttercup squash are of major concern. Hawthorne (1985) reports fruit losses of 2 to 98 percent, with an average loss of 16 percent in the 1984 season. This loss was estimated to cost $8 million.

Storage at high relative humidity (>95%) encourages high levels of rotting (Beaver and Yearsley, 1985). Hawthorne (1989) identified the factors, fungal spore load variation, incidence of wounds, and age of fruit at harvest as affecting the likelihood of fruit of the cultivars Crown, Triamble, Supermarket and Butternut to rot. It was recommended that fruit be handled carefully after harvest to help reduce rot. Also, later sown crops begin rotting earlier than early sown crops. The fungi causing storage rots of *Cucurbita maxima* and *C. moschata* have been surveyed by Hawthorne (1988). The involvement of phloem exudation and the subsequent scar tissue formation from wounded squash fruit has also been studied (MacGibbon and Mann, 1986; Hawthorne and Sutherland, 1991; Mann and MacGibbon, 1991).

Breeding History

Most *Cucurbita maxima* cultivars presently grown in New Zealand, except the grey fruited types, have originated as overseas introductions. The grey fruited cultivar Whangaparoa Crown, originally developed on the Whangaparoa Peninsula, is a farmer's selection from the cultivar Australian Crown. Further cultivars have since been produced by New Zealand seedsmen. These include Early Dri-crown hybrid, Crown Prince hybrid, Triamble and Tristar. Early Dri-crown and Crown Prince are hybrids developed from cultivar Whangaparoa Crown. Triamble is a darker fleshed, longer keeping selection from the Australian Triamble cultivar crossed with Queensland Blue. Tristar is a better keeping selection from the New Zealand Triamble cultivar (G.M. Fisher, pers. comm.).

Early breeding of *Cucurbita* spp. carried out at the Otara Research Station of DSIR Crop Research by M. Walker and J.M. Wheeler during the 1960's involved:

(i) Whangaparoa Crown improvement.
Pureline breeding and selection was carried out within the cultivar Whangaparoa Crown. This resulted in the release of an improved open-pollinated cultivar in 1970 with heavier yield, more uniform shape and improved flavour.

(ii) Butternut breeding.
Breeding and selection of butternuts (*C. moschata*) attempted to improve shape, size, colour and flesh characteristics.

(iii) Breeding of bush-habit crown types.
This was the objective of the DSIR Crop Research programme which commenced at Lincoln in 1973 (Moon, 1977) and transferred to Pukekohe in 1978. The aim of the programme was to develop a compact habit, grey fruited pumpkin having concentrated fruit set with storage and quality factors that typify the cultivar Whangaparoa Crown. The approach involved the selection of the lines from the cross between Whangaparoa Crown and Gold Nugget. Gold Nugget is a small, red fruited bush pumpkin released by the North Dakota Agricultural Experimental Station in 1966 (Minges, 1968).

Material developed from this programme was not released as the fruit was poor in quality and small in size. Grant (1985) has shown with these bush selections fruit size and fruit number can be controlled by plant density and seeding rate.

Current Breeding Strategy

The DSIR Crop Research cucurbit breeding programme, now based at Pukekohe, has two objectives: to develop buttercup type cultivars with improved storage and breeding grey fruited bush pumpkins.

Buttercup breeding

The programme commenced at Pukekohe in the 1980 season, the objective of the being to breed a hybrid cultivar with the following characteristics:

1. long storage life for the fruit,
2. fruit characteristics
   - uniformity in fruit shape, size and colour,
   - medium sized fruit 1.5 to 2kg,
   - fruit colour dark green with light green flecks and stripes,
   - thick orange-yellow flesh
   - small seed cavity size,
   - acceptable sweetness and flavour.
3. high yield,
4. disease resistance,
5. mid season maturity.

The DSIR Crop Research cucurbit breeding programme started with selections from segregating back-cross populations from crosses between buttercup types and storage *C. maxima* cultivars, mainly Queensland Blue and Crown types. Fruit selected from controlled hand pollinations with buttercup fruit characteristics were evaluated for extended storage life. This was after the fruit was subjected to conditions inducive to fruit decay, namely late harvesting, storage under high humidity and reduced air circulation (Beaver and Yearsley, 1985; Hawthorne, 1989; Hawthorne, 1990).

Inbred lines have been produced from a total of 50 F_2 populations and segregating backcross populations. Over the past 10 seasons, a total of 1450 single plant selections have been made after seed production. Only the best of these have been retained in the following years seed production for further inbreeding and later for crossing to produce experimental hybrids.

Inbred lines selected after evaluation for combining ability, seed production potential and maturity have since been used to produce buttercup hybrids. Advanced trials for 4 seasons (1987/88 to 1990/91), have averaged 19 experimental hybrids and controls each season. Over this period, observation trials with new experimental hybrids have averaged 30 entries per year and a total of 190 have been produced and evaluated during the 6 seasons from 1985/86 to 1990/91.

From extensive trials carried out over the past four seasons, 7 experimental hybrids, CRSQ1 - CRSQ7, have been evaluated in both off-station and grower trials. From these, the buttercup hybrid CRSQ7 has been selected for release and named Kaboten. A summary of field results in comparison to the standard Delica is presented in Table 3.

Harvey (1990) has carried out sensory evaluation of advanced buttercup squash hybrids for appearance (flesh colour), flavour (sweetness and fullness of flavour) and texture (coarseness or smoothness, fibrousness and moistness or dryness) using a trained taste panel. Furthermore, a preference survey was completed by a panel of Japanese students (Harvey, 1990) to gain some knowledge on the consumer preference of our importers.

In a comparison of Kaboten and Delica with squash fruits grown at both Pukekohe and Lincoln (Harvey, 1990), Kaboten was darker in flesh colour and dryer than Delica. With the Pukekohe grown fruit, Kaboten was sweeter, higher flavoured, smoother and had less fibre than Delica.

Bush pumpkin breeding

To improve fruit size and quality in bush pumpkins further crossing and selection has been carried out at Pukekohe. Lines selected from this programme have now been used as parents in developing hybrid varieties. These hybrid varieties have been selected for bush type, medium to large sized grey fruit, uniformity in fruit colour, shape and size and long storage life. These new experimental hybrids are now being evaluated prior to possible release.

Other squash breeding

Breeding of other *Cucurbita* spp. in New Zealand includes the work of G.M. Fisher (pers. comm.) in breeding squash and storage type pumpkins. From his programme the buttercup cultivar Pacifica which is similar in appearance to Delica but with a larger fruit size, has recently been released.

Conclusion

During the 1980's buttercup squash has become an important vegetable crop of New Zealand. DSIR Crop Research's breeding programme to extend the storage life of buttercup fruit is expected to result in a lengthened marketing season and the possibility of new export markets. Breeding of grey-fruited bush pumpkin types aims to develop a high quality crown type with easier plant management and smaller fruit size.

There is a good potential for New Zealand squash in Japan provided exporters are able to consistently supply quality fruit.

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Table 3. Yields and quality characteristics for Kaboten and Delica.

Cultivar	Total Yield (t/ha)	Export Yield (t/ha)	Fruit Weight (kg)	Fruit Number (per plant)	Storage Rots (%)		
					April	May	June
Kaboten	20.3	18.1	1.55	1.00	1	17	34
Delica	18.7	16.5	1.49	0.89	9	30	64

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