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COMMERCIAL BROCCOLI CULTIVARS FOR TROPICAL LOWLAND ENVIRONMENTS

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ABSTRACT

Commercial cultivation of broccoli (*Brassica oleracea* cv. *italica* Plenck) is not widely practiced in the Eastern Caribbean in spite of a modest but steady demand which is satisfied by imports. Development of heat-tolerant commercial varieties in recent years has encouraged some *ad hoc* attempts at commercial production based on individual farmer experience and seed catalogue ratings especially in relation to varietal adaptability. Evaluation of nine currently available commercial varieties, and field observations on the performance of a few others, have indicated good levels of adaptability of most varieties for year round production, and the ability of most varieties to head satisfactorily in the cool season. Yields of over 10,000 kg ha⁻¹ were recorded for most varieties, but three entries--Early Value, Southern Comet and Green Top--were outstanding for yield and head size. Green Comet, the standard variety, also produced well and rated highest for head uniformity. Earlier maturing varieties seem to have an advantage under the erratic environmental conditions of the region.

INTRODUCTION

Broccoli (*Brassica oleracea* cv. *italica*) is a relatively new commercial crop in the Eastern Caribbean. It is grown primarily by specialist vegetable farmers in the cooler part of the year (November to April). There is an increasing local demand for broccoli which is met from imports and there is a possibility that the crop can command some status on the export winter vegetable market. Further, broccoli is considered to be of high nutritional quality and is increasingly recommended by dietitians and health authorities as a staple in daily diets.

Being a new crop in tropical vegetable production systems, documentary research information on broccoli, relating to varietal adaptability and production technology, is sparse. Local seed distributors and garden shops, however, have continuously carried small stocks of seed with which farmers and gardeners have conducted their own observational trials with varying degrees of success.

Recent interest in commercial broccoli production has been stimulated by the development and availability of commercial cultivars that are reportedly adapted to hot tropical lowland conditions. Kwang et al. (1975) recommended to the Government of Barbados a series of vegetable crop cultivars for commercial production based on three years of field trials. Two broccoli varieties--Farmers Early and Chang Kan Hybrid--were mentioned. Both showed a yield potential of over 10,000 kg ha⁻¹ and were recommended for cool season production. More recent work in Montserrat (CARDI, 1985) identified two Japanese commercial varieties (Green Comet and Hi Crown) with good adaptability for year round production. Further field tests

and observations between 1984 and 1986 confirmed that Green Comet was an acceptable variety for year round production. Investigations revealed that during this period Green Comet was also being adopted by a few specialist vegetable producers in Barbados and Antigua, while the variety Southern Comet was introduced into St. Kitts. In Trinidad and Tobago, seed distributors have been offering a number of commercial Taiwanese varieties, including Green King and Early value to vegetable farmers and home gardeners.

Field station research and on-farm trials during 1983-85, and observations with broccoli in Montserrat have indicated that a field production technology akin to that cabbage was generally acceptable for commercial production of the crop (Fletcher and Weeks, 1985). Farmers have, however, discovered that timely harvesting and marketing is essential because of the perishability of the crop.

With the acceptance of broccoli as a commercial and home garden crop in Montserrat (Fletcher and Weekes, 1985) it was considered necessary to assess as many available tropicalized commercial varieties as possible for high yield, evenness of maturity, head size, hot season adaptability and pest and disease tolerance and resistance, in order to offer the farmer a sufficiently broad-based technological package to permit sustained development of the crop. Varietal adaptability was considered a priority area for investigation because of the increasing number of commercial varieties appearing on the seed market. Positive identification of suitably adapted cultivars would provide the basis for further on-farm investigations and would also assist in establishing the crop as an important component in vegetable production systems.

MATERIALS AND METHODS

A series of variety trials were conducted at the Brades Agricultural Station in the north of the island of Montserrat (16° 48'N and 62° 12'W) during November 1985 to July 1986. Trials 1 and 2 were conducted in the main vegetable growing season corresponding with the cool part of the year (November to April) when environmental conditions are best suited to the crop. Trial 3 was carried out in the hot dry season (May to July, 1986). Table 1 summarizes climatic data for the location, based on a 10 year average, 1975-1985.

The soils at the trial location are classified in the order Inceptisol and the subgroup Typic Ustropepts. The soil series is Cudjoe Head clay loam with a pH of 5.9 to 6.2 and a low native P status and apparently a high fixing capacity for applied fertilizer P (Ahmad, 1983). Nutrient status of this subgroup is generally low and impeded drainage is experienced in high rainfall situations.

In all the trials land preparation involved conventional cultivation and shaping into 1 m wide ridges, approximately 15 cm high. Two rows per ridge were spaced 50 cm apart, at an within-row spacing of 30 cm, resulting in a plant population of approximately 60,000 plants per ha.

Nursery techniques were similar in all the trials and included sowing in prepared seed beds in the open and allowing 25 to 30 days for

Table 1. Climatic data summary - The Grove, Montserrat^{1/}

Month	Rainfall (mm)	Temperature, °C	
		Max.	Min.
January	99	27.6	21.8
February	62	27.8	22.0
March	61	28.6	23.2
April	83	28.9	24.8
May	98	30.6	26.1
June	99	30.7	26.2
July	96	30.9	25.4
August	186	30.7	26.8
September	113	31.0	26.3
October	114	30.2	25.7
November	149	30.1	24.2
December	117	29.8	24.1

^{1/} Source: Department of Agriculture, Montserrat.

development prior to transplanting. Routine cultural practices included weeding, and preventive pest and disease control.

Trial 1 followed a split-plot design with three replications in which 4 commercial varieties were evaluated in main plots, and the effect of pen manure in subplots. Main plot size was 5 m² and subplot size (2 per main plot) 2.5 m². Main plot treatments (varieties) and their sources are set out in Table 2. Subplots treatments comprised pen manure (1 litre added to each planting hole) or no pen manure. Seedlings were transplanted on 18th December, 1985.

Table 2. List of commercial broccoli cultivars in variety trials 1 to 3

Cultivar	Commercial Source	Country	Trial No.		
			1	2	3
Prize Head	Known You	Taiwan	X	X	-
Green Comet	Takii & Co.	Japan	X	X	X
Green King	Known You	Taiwan	X	-	-
Early Value	Known You	Taiwan	X	X	-
Cape Queen	Takii & Co.	Japan	-	X	-
Southern Comet	Takii & Co.	Japan	-	X	-
Hi Crown	Takii & Co.	Japan	-	X	X
Green Top	Takii & Co.	Japan	-	X	-
Toro	-	Thailand	-	-	X

In Trial 2 the number of varieties was increased to seven, including three tested in Trial 1. This trial followed a randomized complete block design with seven varieties replicated four times. The varieties tested are indicated in Table 2. Trial 2 was transplanted on 27 January, 1986. Plot size was 2 m x 1 m, with plants spaced at 50 cm x 30 cm on 1 m ridges,

equivalent to 60,000 plants per hectare. Two hand weedings were done and the entire trial received a 12-24-12 fertilizer one week after transplanting at the rate of 400 kg ha⁻¹, and three weeks subsequently (N at 67 kg ha⁻¹ + K at 52 kg ha⁻¹). Routine pest management practices were employed primarily to control the diamond back moth (*Plutella xylostella*) which is a major pest.

In trial 3, it was only possible to evaluate three varieties, one of which was a new entry (Toro) which had showed some promise in earlier observations. This was a randomized complete block design replicated four times with 6 m² plots. Spacing and plant population was similar to the other trials as was weed control and fertilizer regimes. This trial was conducted at the height of the hot dry season, and required supplementary irrigation which was provided by sprinkler and misting systems. Trial 3 was transplanted in May 1986. Cultural operations were similar to those used in the previous trials.

In all the trials heads were harvested as soon as they were considered mature, usually recognized by slight splitting of the earlier formed beads or florets. The length of the stalk harvested with the head varied with the inflorescence morphology but generally carried three or four upper leaves and ranged from 10 to 15 cm. Heads were weighed and individual head diameters were recorded. Harvesting intervals were also noted.

RESULTS AND DISCUSSION

Trial 1: Yields of fresh heads from trial 1 are presented in table 3. Several harvests were necessary to ensure good quality mature but unbolted heads. The number of harvests ranged from 4 for Prize Heat to 6 for Green Comet and Early Value.

Table 3. Yields obtained in the broccoli variety/manurial trial 1

Treatment	Yield of indicated variety (kg/ha)				Mean
	Prize Head	Green Comet	Green King	Early Value	
Pen manure	11,072	12,569	10,383	8,941	10,741
No pen manure	10,201	11,085	9,949	10,494	10,432
Mean	10,637	11,827	10,166	9,718	

LSD (0.05) Varieties = 2,342 kg/ha (n.s.) C.V. 16.3%

LSD (0.05) Pen manure = 1,370 kg/ha (n.s.) C.V. 23.8%

Neither varietal yield differences nor the effect of pen manure was significant at the 5% level.

Differences in head size among varieties were not significant. Green Comet bore the largest heads (194 g) followed by Prize Head. Early Value heads were the smallest (151 g). Use of pen manure did not significantly affect head size (Table 4).

Table 4. Average head size obtained in the broccoli variety / manurial trial 1

Treatment	Head Size				Mean
	Prize Head	Green Comet	Green King	Early Value	
Pen manure	197	193	145	149	171
No pen manure	168	195	186	153	175
Mean	183	194	166	151	-

LSD (0.05) - Varieties - 46 C.V. 14.5%
 LSD (0.05) - Pen manure - 154 C.V. 29.7%

A proper evaluation of heading frequency (% of plants producing potentially marketable heads) was not possible in this trial because of damage to some of the treatments in the earlier stages of the trial. Data in Table 5 must therefore be interpreted with reservation. Early value (87.5%) demonstrated a higher heading frequency than the others followed by Green Comet (80%). The no pen manure treatment seemed to have improved heading frequency in all cases by percentages ranging from 4 in Green Comet to 9 in Early Value.

Table 5. Heading frequency in the broccoli variety/manurial trial 1

Treatment	Heading Frequency, %			
	Prize Head	Green Comet	Green King	Early Value
Pen manure	66.0	78.0	75.0	83.0
No manure	74.0	82.0	78.0	92.0
Mean	70.0	80.0	76.5	87.5

Early Value matured first (44 days) after transplanting. At 50 days all other varieties had commenced maturing, however, peak maturity varied from 55 days for Early Value to 65 days for Prize Head. Final harvest of all varieties was done at 70 days (Table 6). These data should be interpreted with caution in the light of setbacks experienced by some plants early in the trial.

Trial 2: In trial 2, where there was a greater degree of control over environmental and other variables, there were also no significant yield differences among varieties with the exception of Prize Head which yielded lowest (Table 7). In this trial the varieties Southern Comet and Early Value yielded highest (12,250 kg/ha) while Green Top with its attractive fine beaded light green head was next best (11,313 kg/ha). The standard variety Green Comet and another recommended variety, Hi Crown, both yielded just over 10,000 kg/ha.

Average head weight, considered here as a function of head size, did not vary significantly (5%) between varieties Green Top and Early Value

Table 6. Peak maturity and maturity profile in the broccoli variety/
manurial trial 1

	Prize Head	Green Comet	Green King	Early Value
Initial harvest (days)	50	50	50	44
Peak harvest	65	59	66	55
Harvest period (days)	25	20	20	15

were the heaviest (226 g and 223 g, respectively). Smallest heads were produced by Cape Queen (177 g) and Prize Head (172 g). Green Comet produced the most uniform heads while widest variability occurred in Southern Comet and Early Value. Data in head sizes of Green Comet and Prize Head in Trial 2 compared favourably with data in Trial 1, however, Early Value heads were on the average 50% heavier in Trial 2.

All the varieties had a heading frequency in excess of 85% which suggests adequate environmental adaptability in all cases. Early Value (97.8%) was highest while Green Top, Green Comet and Cape Queen were at the lower end of the scale (87-88%). Plants with undersized heads were considered as non-productive, however, the majority of non-heading plants either sustained some form of mechanical damage to the growing point or had not flowered at the time the trial was concluded.

Table 7. Yield of heads and mean head weight in broccoli trial 2

Cultivar	Yield, kg/ha	Mean head wt (g)	Head diameter (cm)	Heading frequency (%)
Cape Queen	9,250 a ^{1/}	177 a	9.3	87.5 a
Green Comet	10,312 a	184 a	12.9	88.3 a
Prize Head	8,812 b	172 a	10.2	93.8 a
Southern Comet	12,250 a	216 a	12.9	93.8 a
Hi Crown	10,125 a	183 a	10.5	91.3 a
Early Value	12,250 a	223 a	13.4	97.8 a
Green Top	11,313 a	226 a	13.3	87.0 a
	LSD (0.05) 2876 kg/ha	LSD (0.05) CV - 16%		LSD (0.05) 15.7% CV - 11.6%

^{1/} Means followed by the same letter are not significantly different (P = 0.05) in accordance with Duncan's Multiple Range Test.

Table 8 shows the date on initial maturity as well as peak maturity. The earliest maturing variety was Early Value at 50 days after transplanting with a peak maturity occurring in 55 to 60 days. Green Comet and Green Top came in more uniformly with the former maturing 92% of its heads and the

latter 80% of its heads in days 55 to 60. Southern Comet and Hi Crown showed a much wider maturity profile while Hi Crown and Cape Queen were the last to mature. Prize Head had the widest maturity profile extending from 55 to 80 days.

Table 8. Time of heading and maturity profile in broccoli trial 2

Cultivars	% of heads maturing in indicated number of days						
	50	55	60	65	70	75	80
Cape Queen	-	-	32	34	10	3	21
Green Comet	-	63	29	2	-	-	5
Prize Head	-	4	31	25	17	8	8
Southern Comet	-	42	29	20	-	7	2
Hi Crown	-	12	33	30	7	16	2
Early Value	16	61	18	-	-	5	-
Green Top	-	50	30	10	-	-	10

Trial 3: Of the three varieties evaluated, Green Comet was the only one common in all the trials while Hi Crown was included in Trial 2. Toro had previously performed well in observation trials. At the time of conclusion of the trial at 70 days after transplanting, Hi Crown had only headed sporadically while Green Comet and Toro had produced mature marketable heads. Green Comet yielded significantly higher than both Hi Crown and Toro, however, Toro yields were 18% lower while Hi Crown was 63% lower (Table 9).

Table 9. Performance of three cultivars of broccoli in trial 3

Cultivar	Yield (kg/ha)	Head wt. (g)	Head diameter (cm)	Heading frequency (%)
Green Comet	6,917	132.8	8.5	87
Toro	3,658	116.0	7.6	81
Hi Crown	2,542	132.6	7.8	32

LSD (0.05) = 675 kg/ha

CV = 7.8%

Yields from this trial were 33% less for Green Comet and 75% less for Hi Crown than those achieved in Trial 2. This suggests that reduced yields can be anticipated even under irrigation for hot season production and also that Hi Crown is not suited for out of season production as confirmed by its significantly lower heading frequency.

A cursory observation was made on side shoot development on harvested plants at 60 days after transplanting. This observation would have been biased against later maturing varieties, however, some indicators on the secondary shoot potential were obtained. Early Value demonstrated a

propensity for earlier side shoot development and averaged 3.3 sideshoots per harvested plant at 60 days. Other varieties that showed potential were Green Top (1.0 shoot per plant) and Green Comet (0.6 shoot per plant). No yield data were taken on yields of side shoots, however, they ranged in weight from 8% to 32% of main head weights in the case of Early Value.

There were no marked variations in varietal resistance to pests or diseases. Diamond back moth (*Plutella xylostella*) seemed the most troublesome pest, but there were attacks of aphids and spider mite. During the latter half of the harvesting period heavy rains caused waterlogging in a section of the experimental area. Fortunately, most plots were already harvested. Some late maturing plants were affected by what was identified as black rot (*Xanthomonas* sp.) and in a few cases dark brown or black areas developed in the heads.

Head appearance and quality of all varieties were considered good based on subjective judgement. Green Top and Hi Crown both had light green tightly packed fine beaded heads that seemed to have good potential for packing and shipping. Other varieties had dark green or blue-green heads with coarser beads.

SUMMARY AND CONCLUSIONS

Data and observations derived from these trials suggest fairly good adaptability of all varieties to prevailing cool season conditions. The earlier maturing characteristic and higher yields of Early Value, Southern Comet, Green Comet and Green Top identify them as material for further scrutiny. Traditional farming practices in Montserrat and for that matter in all of the Eastern Caribbean, combined with the vagaries of the weather will favour earlier maturing varieties for the average farmer. Early Value fits this bill and has the advantage of multiple side shoot production. The narrow maturity profile of Early Value may be disadvantageous to the farmer who markets in small quantities. Green Comet or Southern Comet may be preferred in such a situation. Green Top is a new hybrid variety from Japan with very attractive light green small beaded compact heads that should pack and ship well. This variety seems to have some export potential.

In the current trials Green Comet and Toro have both demonstrated an ability to perform in the hot season albeit at a reduced level. Early Value, Southern Comet and Green Top have not been subjected to the hot season test and it will be necessary to determine their adaptability at that time of the year. However, it is clear that out of season or hot season production will be much lower (estimated at 25 to 30%) or projected in-season yield.

Based on the results obtained from this series of experiments it would appear logical to concentrate further work in the following areas:

1. On-farm evaluation of short listed varieties Green Comet, Southern Comet, Green Top, Toro, and Green King for year-round production.
2. Monitoring of field performance in farmers commercial plots with specific interest in pest and disease relationships.

3. Regional trials with the varieties tested here along with any other potentially good candidates available from other sources.

4. Studies of the economics of production and market potential at country and regional levels.

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