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YIELD PERFORMANCE OF TOMATO CULTIVARS GROWN UNDER ORGANIC MANAGEMENT SYSTEM

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ABSTRACT: On-farm trials were conducted during the spring season of 1999 and 2000 to evaluate the yield performance of tomato (*Lycopersicon esculentum* Mill.) cultivars grown under an organic management system. In 1999, twelve cultivars: 'Bonita', 'Celebrity', 'Colonial', 'Empire', 'Floramerica', 'Joker', 'Liberty', 'Merced', 'Mountain Pride', 'Olympic', 'Pilgrim' and 'Sunmaster' were grown under an organic management system consisting of mulching with grass straw, fertilizing with cow manure and using organic pesticides for insect control. Similar cultivars were evaluated in spring 2000, but due to lack of seed, 'Bonita' and 'Liberty' were replaced with cultivars 'Keepsake' and 'Mountain Fresh'. In 1999, significant differences ($P<0.05$) in tomato fruit yield were observed among cultivars. Marketable yield ranged from 28.5 t ha^{-1} for cultivar 'Pilgrim' to 43.8 t ha^{-1} for 'Sunmaster'. The top three cultivars with yields of over 40 t ha^{-1} were 'Sunmaster', 'Bonita', and 'Empire'. 'Sunmaster' also produced the highest total number of tomato fruits (233,000 ha^{-1}). Significant yield differences were also observed in 2000. Marketable fruit yield in 2000 ranged from 20.0 t ha^{-1} for cultivar 'Olympic' to 38.6 t ha^{-1} for 'Merced'. The top four cultivars were 'Merced', 'Mountain Pride', 'Sunmaster' and 'Keepsake'. Tomato fruit worm was the major insect pest affecting most cultivars. The organic pesticides used were not very effective in controlling fruit worms. This study indicates that cultivars 'Bonita', 'Empire', 'Keepsake', 'Merced', 'Mountain Pride' and 'Sunmaster' are suitable for tomato production under an organic management system.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a very popular crop among small-scale growers in the U.S. Virgin Islands (USVI). Although tomato ranks first in importance, about 90 percent is imported from the U.S. mainland. Local production is not sufficient to meet increasing demands. The 1992 Census of Agriculture (U.S. Dept. of Commerce, 1995) reported a total production of 45,003 kg (99,006 lbs) harvested from 37 farms with a combined area of 14.98 ha (37 acres). In 1998, production dropped to 11,283 kg (24,823 lbs) harvested from 54 farms with a combined area of 10 acres (U.S. Dept. of Commerce, 2000). This represents a 75 percent decrease in production over previous years. The USVI imports most of the tomatoes from the U.S. mainland and neighboring Caribbean islands (Pearrow, 1992).

Tomato is a high management crop because it is very susceptible to damage by insect pests and diseases. Growing tomato in the USVI with minimum pest control usually results in reduced yields. Although the climate of the Virgin Islands is favorable for year-round tomato production, growers are confronted by a number of production constraints associated with crop management practices. The major constraints are high cost of production (labor and production inputs such as fertilizers and pesticides), limited water resources for irrigation and an inefficient marketing system. The cost of inputs constitutes a major expenditure in vegetable production. Reducing the use of these inputs would cut production cost and increase economic returns to vegetable growers. In addition, the environmental impact of toxic pesticides can be minimized if growers would use other options, such as organic methods, to produce vegetables. Sustainable crop management systems encourage efficient use of local resources, thereby reducing dependency on external and imported inputs.

Sustainable vegetable production can be achieved in the USVI by adopting a combination of sound crop management strategies including the use of cultivars adapted to low production and

management inputs. These cultivars have high tolerance to pests and diseases as well as efficient in utilizing soil nutrients. To develop a sustainable and profitable vegetable production enterprise, growers must be able to meet market demands in terms of vegetable cultivar preferences, volume, quality and seasonal requirements. There is little information on sustainable crop management practices and cultivars for USVI vegetable growers. Palada et al., (2000) reported that eggplant can be grown successfully without the use of chemical fertilizers and pesticides. Information on new and improved vegetable cultivars adapted to low-input sustainable crop management practices is lacking. There is a need for continuous screening of new vegetable varieties developed and released by seed companies and research institutions to provide growers with information on promising varieties. Most of these new varieties are grown under high management inputs and may not perform well under low-input systems of limited-resource growers.

Tomato cultivar evaluation has been a continuous and on-going activity under the vegetable variety evaluation project at the Agricultural Experiment Station, University of the Virgin Islands. Results of tomato variety evaluation trials have been summarized in several reports (Collingwood et al., 1992; Navarro, 1982; Ramcharan, 1981; Petersen, 1987; Palada et al., 1993; 2001). These trials were all conducted using high-input crop management practices. The objectives of the studies presented in this paper were to: 1) evaluate the performance and adaptability of tomato cultivars under low-input/sustainable production systems; and 2) select superior cultivars in terms of yield stability, pest and disease tolerance and quality for commercial production and home gardening.

MATERIALS AND METHODS

The trials were located on farmer=s field in Estate Glynn, St. Croix, USVI (lat. 17°42'N, long. 64°48'W). The soil is a Glynn gravelly loam (clayey, skeletal, mixed, superactive, isohyperthermic, typic argiustoll) as described by Lugo-Lopez, et al. (1998). Average rainfall is 1015 mm per year. The field trials were planted on 9 February 1999 (first season) and 26 January 2000 (second season).
Twelve cultivars were evaluated for each season. All cultivars were hybrid with determinate plant type and are recommended for spring season production except cultivar Sunmaster, a heat-tolerant tomato recommended for summer planting. Seeds of all cultivars were obtained from Otis S. Twilley Seed Co., Inc., South Carolina.

The cultivars were planted in plots consisting of three rows 7.3 m long and spaced 1.2 m apart. Each plot measured 3.6 m x 7.3 m or 26 m^2. Plants were spaced 0.61 m within rows. All plots were drip irrigated to maintain soil moisture tension at -20 kPa. The experiment was established using a randomized complete block design with three replications. The organic management system consisted of application of dehydrated cow manure (2-1-2), applying organic and botanical sprays such as Dipel, M-Pede, Rotenone, and Bioneem. Cow manure was applied at the rate of 26 kg/plot (10 $t.ha^{-1}$). All plots had dry guinea grass (*Panicum maximum*) straw mulch applied in a 15 cm thick layer.

Data on plant height, number of fruits, fruit size, and fruit yield (total and marketable) were taken at each harvest. In 1999, samples were harvested seven times on April 20, 23, 26, and 28 and on May 3, 7, and 10. Only six harvests were taken in 2000 (April 5, 11, 19, 26, and May 3 and 8). All data were taken from a harvest sample of 10 plants in the middle row. Fruit quality attributes such as percent soluble solids (brix) and pH were determined at harvest, from random samples. Visual field observations were performed on the incidence of pests and diseases during the early plant establishment, active vegetative growth and bloom stage. Plant height and stem diameter were measured only during the first harvest. Data were analyzed for statistical significance using the SAS program.

RESULTS AND DISCUSSION

Plant Height and Stem Diameter

Average plant height and stem diameter are presented in Table 1 for the 1999 and 2000 trials. In 1999, significant differences ($P<0.05$) among cultivars were observed in both plant height and stem diameter (Table 1). Tallest plants were observed in cultivars 'Joker' (83.6 cm), 'Floramerica' (82.4 cm), 'Empire' (81.8 cm) and 'Mountain Pride' (80.5 cm). Shortest plants were found in cultivars 'Sunmaster' (63.3 cm) and 'Merced' (64.9 cm). There was no evidence of lodging in taller cultivars since all cultivars were supported with steel rods (stakes) and tied with plastic string. Cultivars 'Colonial', 'Celebrity' and 'Mountain Pride' developed larger stem diameter compared to other cultivars (Table 1). These cultivars had an average stem diameter of 10 mm or higher. Stem diameter is an important character that determines the tendency of plants to lodge. Also, a larger stem diameter is ideal for supporting larger and heavier fruits than a smaller stem diameter.

Significant differences in plant height and stem diameter were also observed in 2000 (Table 1). Cultivar 'Mountain Fresh' produced the tallest plants (90 cm). Most cultivars attained average plant height greater than 80 cm. Cultivars 'Sunmaster' and 'Keepsake' produced the shortest plants. Average stem diameter for all cultivars was relatively higher than in the 1999 trial. Cultivars 'Empire' and 'Mountain Pride' developed the largest stem diameter (15.4 mm and 14.9 mm, respectively). Cultivars 'Joker' and 'Sunmaster' produced the smallest stem diameter with average of 11.0 and 12.0 mm, respectively.

Number of Fruits and Yield

The number of fruits (total and marketable) and fruit yield (total and marketable) are shown in Tables 2 and 3 for the 1999 and 2000 trials, respectively. All cultivars matured in 70 days (first harvest) after transplanting. Significant differences in fruit number and yield were found in both years. In 1999, total number of fruits ranged from 183,000 ha^{-1} for cultivar 'Olympic' to 332,000 ha^{-1} for 'Sunmaster' (Table 2). 'Sunmaster' produced the largest total number of fruits which was significantly ($P<0.05$) higher that all cultivars except 'Bonita'. Cultivars 'Olympic' and 'Merced' produced the lowest total number of fruits averaging less than 200,000 ha^{-1}. Although 'Merced' produced the lowest total number of fruits, this cultivar produced the highest percentage (79%) of marketable fruits (Table 2). Only 70 percent of fruits from cultivar 'Sunmaster' was marketable. Other cultivars, which produced marketable fruits of 70 percent or greater were 'Celebrity', 'Floramerica', 'Liberty', 'Mountain Pride' and 'Olympic'.

'Sunmaster' produced the highest total fruit yield (56.9 t ha^{-1}) however, this yield was not significantly different from any other cultivar except 'Olympic' (Table 2). 'Sunmaster' also produced the highest marketable fruit yield (43.8 t ha^{-1}) followed by cultivars 'Bonita' (42.9 t ha^{-1}), and 'Empire' (42.7 t ha^{-1}). Most of the cultivars, which produced high percentage of marketable fruits, did not differ significantly in marketable fruit yield. The three top yielding cultivars in terms of marketable fruit yield (>40 t ha^{-1}) were 'Sunmaster', 'Bonita' and 'Empire'. Most cultivars produced marketable fruit yield greater than 30 t ha^{-1}.

Results from the second season (2000) trial also showed significant differences ($P<0.05$) among cultivars in terms of number of fruits and yield (Table 3). Total number of fruits ranged from 140,000 ha^{-1} for cultivar 'Joker' to 245,000 t ha^{-1} for 'Sunmaster'. In general, the number of fruits (total and marketable) from the 2000 trial was relatively lower compared to the first season (1999). Only six harvests were made due to the incidence of foliar diseases (bacterial spot and mosaic) later in the season. The top four cultivars with high marketable fruit yield (>30 t ha^{-1}) were 'Merced' (38.6 t ha^{-1}), 'Mountain Pride' (35.2 t ha^{-1}), 'Sunmaster' (31.0 t ha^{-1}) and 'Keepsake' (30.8 t ha^{-1}). All other cultivars produced marketable fruits in the range of 20 to 27 t ha^{-1} (Table 3).

Fruit Weight, Soluble Solids and pH

Significant differences ($P<0.05$) in fruit size and soluble solids were found among cultivars in 1999 (Table 4). Average fruit weight ranged from 160 g for cultivar 'Liberty' to 318 g for 'Empire'. Fruit weight of cultivar 'Empire' was superior to all other cultivars. Cultivars 'Liberty', 'Mountain Pride', 'Pilgrim' and 'Sunmaster' produced fruits with an average weight of less than 200 g. Soluble solids of all cultivars were ranged from 4.03 to 4.58%. Fruits of cultivar 'Empire' contained the highest (4.58%) soluble solids, whereas fruits of 'Sunmaster' contained the lowest (Table 4). Although 'Sunmaster' produced the highest number of fruits as well as fruit yield, fruit quality (weight and soluble solids) was inferior to the other cultivars. No significant differences in juice pH were observed among cultivars. Juice pH ranged from 3.73 ('Bonita') to 3.96 ('Sunmaster').

Results of the evaluation trial in 2000 indicated significant differences ($P<0.05$) in fruit weight and pH but not in soluble solids as shown in Table 4. All cultivars except 'Mountain Pride' produced fruits with an average weight greater than 200 g. Cultivars 'Floramerica', 'Merced' and 'Olympic' had an average fruit weight greater than 250 g and were significantly superior to 'Mountain Pride' (Table 4). Soluble solids and pH were relatively higher in 2000 than those obtained in 1999. Soluble solids ranged from 4.70% for cultivar 'Floramerica' to 5.44% for 'Empire', while juice pH ranged from 4.17 ('Mountain Fresh') to 4.37 ('Olympic'). Results from two seasons evaluation trial indicate that cultivar 'Empire' has ideal fruit quality attributes for fresh market organic tomatoes as shown by its larger fruit size and higher soluble solids. It is also one of the cultivars with high marketable fruit yield. Thus, organic vegetable growers in the Virgin Islands should consider growing this cultivar for fresh market tomatoes.

Cultivar Response to Insect and Disease Pests

The incidence of insect and disease pests was monitored by visual observation throughout the growing season. In 1999, the incidence of pests and disease was low. Damage due to insect pests was not serious since the pest population was low. However, tomato fruit worms, caterpillars and spider mites affected all cultivars. The most common leaf disease was the tomato mosaic virus which appeared later in the season. All cultivars seemed to be affected but the degree of infection varied among cultivars. In 2000, high insect and disease incidence was observed and this accounted for the relatively lower yield compared with yield in 1999. Several insect pests were observed during the growing season and among them were ants, caterpillars, mealy bugs, whiteflies, stinkbugs and fruit worms. Incidence of bacterial leaf spot and tomato mosaic virus was also common among cultivars. Despite the high incidence of insect pests and diseases, some cultivars produced high fruit yield. Regular applications of organic pesticides were quite effective in reducing pest damage. These observations suggest that organic pesticides can be as effective as conventional pesticides in minimizing insect pest populations in tomato production. Tomato growers have the option of using organic sprays and still maintain economical yields.

SUMMARY AND CONCLUSIONS

This study has shown that tomato can be grown successfully under an organic management system without the use of chemical fertilizers and pesticides. Marketable yield levels were comparable to or better than those obtained in previous tomato germplasm evaluation trials conducted using a conventional crop management system. The cultivars differed in their yield performance when grown under sustainable crop management practices. Outstanding cultivars for organic tomato production in terms of marketable yield and fruit quality are 'Bonita', 'Empire', 'Keepsake', 'Merced', 'Mountain Pride' and 'Sunmaster'. These cultivars performed well and appeared to be adapted to the growing environment of the Virgin Islands under low-input sustainable crop management practices. Vegetable growers should consider selecting these cultivars for spring production season using minimum inputs.

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Table 1. Plant height and stem diameter of tomato cultivars grown under organic management system. Agricultural Experiment Station, University of the Virgin Islands, St. Croix.

	Plant height (cm)		Stem diameter (mm)	
Cultivar	1999	2000	1999	2000
Bonita	76.6 abc	-	8.34 b	-
Celebrity	77.5 ab	80.2 abcde	10.25 ab	13.3 ab
Colonial	73.7 abc	85.2 abc	11.22 a	13.5 ab
Empire	81.8 a	85.6 abc	9.91 ab	15.4 a
Floramerica	82.4 a	84.7 abc	8.11 b	12.8 ab
Joker	83.6 a	89.4 ab	9.54 ab	11.0 b
Keepsake	-	72.4 c	-	12.3 ab
Liberty	72.2 abc	-	9.60 ab	-
Merced	64.9 bc	79.7 bcde	9.37 ab	12.7 ab
Mountain Fresh	-	90.9 a	-	13.2 ab
Mountain Pride	80.5 a	82.7 abcd	10.02 ab	14.9 a
Olympic	74.4 abc	84.1 abcd	8.00 ab	14.2 ab
Pilgrim	75.1 abc	77.6 cde	8.33 b	13.5 ab
Sunmaster	63.3 c	74.7 de	9.70 ab	12.9 b

Mean separation in columns by Duncan's Multiple Range Test, P=0.05.

Table 2. Yield of tomato cultivars grown under organic management system, Spring, 1999, Agricultural Experiment Station, University of the Virgin Islands, St.Croix, USVI.

	Number of fruits/ha		Fruit yield		Marketable
Cultivar	Total (x1000)	Marketable (x1000)	Total (t/ha)	Marketable (t/ha)	fruits (%)
Bonita	298 ab	199 abc	56.0 a	42.9 ab	67
Celebrity	246 bcde	175 bcd	49.6 ab	39.2 abc	71
Colonial	243 bcde	165 bcd	47.6 ab	33.6 abcd	68
Empire	207 de	140 d	49.9 ab	42.7 ab	68
FlorAmerica	211 de	151 cd	44.5 ab	33.3 bcd	72
Joker	224 cde	153 cd	56.0 a	33.7 abcd	68
Liberty	265 bcd	199 abc	42.1 ab	31.9 cd	75
Merced	192 e	152 cd	43.5 ab	37.1 abcd	79
Mountain Pride	281 abc	211 ab	50.8 ab	39.8 abc	75
Olympic	183 e	130 d	39.9 b	31.3 cd	71
Pilgrim	247 bcde	160 cd	43.1 ab	28.5 d	65
Sunmaster	332 a	233 a	56.9 a	43.8 a	70

Mean separation in columns by Duncan's Multiple Range Test, P=0.05.

Table 3. Yield of tomato cultivars grown under organic management system, Spring, 2000. Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI.

Cultivar	Number of fruits/ha		Fruit yield		Marketable fruits
	Total (x1000)	Marketable (x1000)	Total (t/ha)	Marketable (t/ha)	(%)
Celebrity	198 abc	136 abc	39.0 bc	27.4 bcd	69
Colonial	191 abc	104 bcd	38.7 bc	22.8 cd	54
Empire	211 abc	129 abcd	41.8 abc	28.6 bcd	61
Floramerica	171 bc	89 cd	39.6 bc	22.4 cd	52
Joker	140 c	95 cd	32.5 c	22.3 cd	68
Keepsake	203 abc	144 abc	40.6 bc	30.8 abc	71
Merced	195 abc	152 ab	47.6 ab	38.6 a	78
Mountain Fresh	164 bc	105 bcd	33.2 c	23.9 cd	64
Mountain Pride	230 ab	180 a	43.7 abc	35.2 ab	78
Olympic	151 c	79 d	35.6 bc	20.0 d	52
Pilgrim	198 abc	116 bcd	38.8 bc	24.3 cd	59
Sunmaster	245 a	155 ab	53.5 a	31.0 abc	63

Mean separation in columns by Duncan's Multiple Range Test (P=0.05).

Table 4. Fruit weight, soluble solids and pH of tomato cultivars grown under organic management system. Agricultural Experiment Station, University of the Virgin Islands, St. Croix, USVI.

Cultivar	Fruit weight (g)		Soluble solids (%)	pH
	1999	2000	1999	2000
Bonita	216 bcde	-	4.36 ab	-
Celebrity	229 bcd	205 ab	4.22 bc	4.22 ab
Colonial	201 bcde	242 ab	4.19 bc	4.34 a
Empire	318 a	222 ab	4.58 a	4.29 ab
Floramerica	222 bcd	253 a	4.17 bc	4.34 a
Joker	221 bcd	235 ab	4.42 ab	4.34 a
Keepsake	-	216 ab	-	4.34 a
Liberty	160 e	-	4.42 ab	-
Merced	242 bc	255 a	4.22 bc	4.27 ab
Mountain Fresh	-	227 ab	-	4.17 b
Mountain Pride	189 bcde	195 b	4.44 ab	4.32 ab
Olympic	246 b	253 a	4.42 ab	4.37 a
Pilgrim	177 de	214 ab	4.37 ab	4.34 a
Sunmaster	187 cde	201 ab	4.03 c	4.26 ab

Mean separation in columns by Duncan's Multiple Range Test (P=0.05).