THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, Mayagüez Campus, for the publication of articles and research notes by staff members or others, dealing with scientific agriculture in Puerto Rico and elsewhere in the Caribbean Basin and Latin America.

VOL. 75 JULY 1991 No. 3

Plant population and pruning of pepper cultivars[1,2]

David W. Unander,[3] Lucas N. Avilés-Rodríguez,[4] Felícita Varela-Ramírez[4] and Alvaro Acosta,[5]

ABSTRACT

Seven cultivars of pepper (*Capsicum annuum* L.), representing both frying and bell types, and open-pollinated and hybrid varieties, were planted at population levels of 35,878, 53,818, and 71,757 plants/ha. The lowest density is the conventional rate in Puerto Rico. They were planted at the Fortuna Substation, Juana Díaz, Puerto Rico. Irrigation was supplied throughout the dry season. After the fourth harvest, two replicates were pruned to 12 cm for a second crop. Planting density affected yield but not fruit size. There was a density x cultivar interaction at P=0.09 for yield. Doubling the population increased yield 12 to 40%. Response to pruning was cultivar-specific. Total yield was 25 to 100% greater than yield before pruning. Both practices could serve as low capital innovations for the tropics.

RESUMEN

Densidad de siembra y poda de variedades de pimiento

Se sembraron siete variedades de pimiento, *Capsicum annuum* L., usando tres densidades de siembra: 35,878, 53,818 y 71,757 plantas/hectárea. La densidad más baja es la tradicional en Puerto Rico. Se sembraron híbridos y variedades de polinización abierta que incluyeron morrones y de cocinar en la subestación de Fortuna en la costa sur de Puerto Rico. Se podaron a 12 cm. para una segunda cosecha. La densidad de siembra tuvo efectos significativos sobre el rendimiento, pero no sobre el tamaño de la fruta. En cuanto a rendimiento, hubo una interacción entre densidad y variedad a nivel de P=0.09. El rendimiento aumentó de 12 a 40% al duplicar la densidad de siembra. La reacción a la poda fue diferente entre los genotipos. El rendimiento total aumentó de 25 a 100% con la poda. Estos dos métodos podrían ser innovadores y de bajo costo en el trópico.

[1]Manuscript submitted to Editorial Board 3 January 1991.

[2]The authors thank Ms. Amelia Cortés de Monllor and Mr. Apolinar Sánchez-Miranda, Department of Crop Protection, for assistance in identification of diseases.

[3]Former Assistant Professor, Department of Horticulture.

[4]Assistant Researchers, Department of Horticulture.

[5]Research Technican, Fortuna Substation.

INTRODUCTION

Peppers, (*Capsicum annuum* L.), are grown in Caribbean basin countries under systems ranging from large plantings with intensive management and technological input to small plantings with minimal input. Many recent innovations in pepper are capital intensive, however, and thus have been more feasible for large operations.

One simple innovation to increase pepper yield is to increase plant population. Higher yields were obtained in Florida and Georgia with higher densities of the bell pepper cultivar "Early Colwonder", "Keystone Resistant Giant", "Keystone Resistant Giant No. 2". and the breeding line "811" (1, 2, 3, 6). In these experiments there were significant linear increases in yield from increased density up to about 98,765 plants/hectare (40,000 plants/acre) Fruits per plant decreased but mean fruit size did not decrease significantly (2, 6). Yield increases as a function of higher densities were found consistently across seasons (1, 3), fertilizer rates (1, 2, 3), locations (6), and different irrigation regimes. There were no significant interactions with fertilizer or irrigation treatments (1, 3, 4). Stoffella et al. (6) have estimated that doubling the conventional planting rate in Florida from 34,848 to 69,696 plants/ha (14,113 to 28,226 plants/acre) would increase pepper yields by 16 to 24%.

There have been no reports on testing the response of the sweet elongate frying peppers of the type popular in Puerto Rico at different plant densities. The existing recommendation in Puerto Rico is about 35,878 plants/ha (5).

Pruning and cultivation of crop regrowth could also be a low capital procedure to increase pepper yield in the tropics. This procedure has been successful with eggplant, (*Solanum melongena* L.) in Brazil (4). Plants were cut back to about 30 cm above the soil after yields began decreasing, and manure, irrigation, insecticide and fungicide were applied. Yield of the second crop was about 30% more than that of the first crop (4).

Preliminary experiments were done in Puerto Rico with the following objectives: 1) to test the yield response of different elongated and bell peppers to higher planting population under Puerto Rico's south coast environmental conditions; 2) to determine whether interactions occur between cultivars and planting density; 3) to measure the extent to which yield might be increased by pruning and cultivating regrowth of the plants after pruning.

MATERIALS AND METHODS

Table 1 includes the pepper cultivars studied, their seed source, fruit type, and varietal type. The seven cultivars were planted in the greenhouse 26 September 1985 and transplanted at the Fortuna substa-

TABLE 1.—*Pepper cultivars, their seed source, fruit type and type of seed*

Cultivar	Source	Fruit type	Varietal type
Early Niagra Giant	Stokes Seeds, Ltd.	Bell	Open-pollinated
Staddon's Select	Stokes Seeds, Ltd.	Bell	Open-pollinated
Skipper	Asgrow Seed Co.	Bell	Hybrid
Gypsy	Petoseed Co., Inc.	Elongate[1]	Hybrid
GAtor Belle	Petoseed Co., Inc.	Bell	Hybrid
Cubanelle	Petoseed Co., Inc.	Elongate	Open-pollinated
Blanco del País	ASA[2]	Elongate	Open-pollinated

[1]"Elongate" refers to sweet elongated peppers which have a yellow-green color when immature and are frequently used in Hispanic foods.

[2]Adminisatración de Servicios Agrícolas, Programa de Semillas, Departamento de Agricultura.

tion (semiarid) and Isabela substation (humid) 14 and 21 November, respectively. The plots at Isabela were discarded after a severe infestation of *Fusarium sp.* Only one replicate was unaffected and kept for observational purposes.

There were three population levels consisting of 35,878, 53,818, and 71,757 plants/ha (14,520, 21,780, and 29,040 plants/acre, respectively). The experimental design was a randomized complete block with four replicates of 21 treatments (seven cultivars × three population densities). To minimize effects from soil heterogeneity, each replicate consisted of the 21 treatments randomly assigned to one of three adjacent beds of seven treatments each. Each plot consisted of two rows 3 m long, with 10, 15, or 20 plants/row. Rows were spaced 0.9 m apart with replicates, and ends of rows were 1.5 m apart. Rows were made of beds approximately 0.3 m high and 0.3 m wide, in which the transplants were set by hand. Mulch was not used. Immediately after transplanting, a 10-10-10 fertilizer was applied at the rate of 750 kg/ha alongside the rows. Fertilizer at the same rate was applied again after the second harvest. A preventive spraying program was followed to reduce damage by insects and diseases. Irrigation was applied as necessary. The soil at Fortuna is a Mollisol of the San Antón series.

All non-diseased fruits with a diameter of about 5 cm or larger (USDA #2 or better) were considered marketable. Fruits were harvested 13 and 22 January and 8 and 25 February 1986. Plants at the ends of rows were not harvested for yield data; yield data were based on the middle 2.7 m of the two rows. Population stand counts (taken at each harvest) were analyzed as to whether yield increased as plant population increased, and thus whether adjusting yield data for stand loss would bias the analysis. Analyses of variance were performed for unadjusted total yield after stand loss was analyzed.

After the fourth harvest (25 February), two replicates were pruned back about 12 cm from the soil surface. Fertilizer was applied alongside the rows of these replicates at the rate of 750 kg/ha.

After the second harvest, there were many plants with viral symptoms. By immunodiffusion tests, the virus was diagnosed as potato virus Y (PVY)[6]. In many of these plants, however, the disease later appeared to take a latent form, particularly with plants of "Blanco del país."

RESULTS AND DISCUSSION

Increasing plant density increased the yield of all cultivars (tables 2, 3). The analysis of variance of stand loss (not shown) indicated that increased population significantly increased the stand loss. Thus, correction for stand loss would upwardly bias yield data from the higher population plots, and the appropriate analysis was for unadjusted data. In the analysis of yield, the cultivar × population level interaction had an effect at $P = 0.09$. Examination of the means (table 2) shows that although this effect can be seen in some rank-order changes among the highest yielding cultivar for any given density, all cultivars had greater yield as the planting rate was increased beyond the conventional rate. Yield gains ranged from 12% to 40% as population was doubled over the conventional rate. The range of response related to individual cultivars, with little apparent difference among the types of peppers in this experiment (table 2). Effects of fruit size were small, non-significant and thus consistent with previous experiments (2, 6).

On the basis of these and previous results (1, 2, 3, 6), yield increases obtainable by higher plant populations seem relatively predictable re-

TABLE 2.—*Means yield (kg/ha) of marketable pepper fruits at three population levels*

Cultivar	Population level		
	Low	Medium	High
		kg/ha	
Early Niagra Giant	26,137	25,931	29,635
Staddon's Select	18,522	25,931	30,870
Skipper	28,195	28,812	37,250
Gypsy	25,313	25,519	38,690
Gator Belle	25,313	34,163	30,047
Cubanelle	23,050	24,284	29,841
Blanco del País	19,551	24,696	27,989

[6]A. Monllor, personal communication.

TABLE 3.—*Analysis of variance for fruit yield (kg/plot) of seven pepper cultivars at three population levels before and after pruning and regrowth at Fortuna, Juana Díaz, P.R.*

Sources	Degrees of freedom	Mean squares
Regrowth (R)	1	885.9 **[1]
Cultivar (C)	6	52.9 **
Population (P)	2	57.6 **
R X C	6	62.5 **
R X P	2	24.9 **
C X P	12	6.1
R X C X P	12	6.0
Replicates	1	139.4 **
Error	41	3.8

[1]**Denotes significance at P = 0.01.

gardless of different levels of production input, provided that a source of irrigation is available.

Regrowth following pruning differed among cultivars (tables 3, 4). Yields of plants after pruning were generally lower, with the striking exception of "Blanco del País" (table 4). The yield of hybrids "Skipper", "Gypsy" and "Gator Belle" decreased less than that of the open-pollinated cultivars (with the exception of "Blanco del País"). Total yield was 25% to 100% greater yield than before pruning, relative to cultivar (table 4).

TABLE 4.—*Mean pepper yields in kg per cultivar or population level before and after pruning and regrown*[1]

Cultivar		Before	After	Total
		kg	*kg*	*kg*
Early Niagra Giant		13.6	3.6	17.2
Staddon's Select		12.4	3.6	16.0
Skipper		16.0	8.7	24.7
Gypsy		14.9	8.4	23.3
Gator Belle		12.4	4.2	16.6
Blanco del País		11.1	14.6	25.7
F-LSD	0.05	2.6	2.6	1.6
	0.01	3.0	3.0	2.2
Population Level				
5,880 plants/ha		11.8	6.1	17.9
8,820		13.4	8.3	21.7
11,760		16.1	7.4	23.5
F-LSD	0.05	1.5	1.5	1.0
	0.01	2.0	2.0	1.4

[1]To obtain estimated kg/ha of yield, multiply by 2058.

Increased planting densities maintained their advantage after pruning and regrowth. Analysis of stand counts showed that there had been a greater stand loss at the highest plant population. This loss was reflected in lower mean yields after pruning at the highest density than at the medium density. The highest population still produced a significantly greater total yield, however. There were no apparent differences among pepper types.

The pruning and regrowth of peppers in the tropics is a procedure worthy of further testing. The large differences in yield response among cultivars suggested that further experiments should include several genotypes for adequate evaluation of this technique.

Tentative conclusions on the basis of these results: 1) Increasing plant population over the current recommended density should increase pepper yields in Puerto Rico, and probably in other Caribbean areas, if irrigation is available. 2) All pepper types commonly grown in Puerto Rico yield better at a higher planting density. 3) The lack of a cultivar × population interaction sufficient to cause substantial rank order changes suggests that there may be no need to select cultivars for specific planting densities. 4) Pruning of peppers in the tropics for regrowth and a second harvest merits further testing.

LITERATURE CITED

1. Batal, K. M. and D. A. Smittle, 1981. Response of bell pepper to irrigation, nitrogen and plant population. *J. Am. Soc. Hort. Sci* 106: 259-62
2. Everett, P. H. and R. Subramanya, 1983. Pepper production as influenced by plant spacing and nitrogen and potassium rates. Proc. Fla. State Hort. Soc. 96: 79-82.
3. Locascio, S. J. and W. M. Stall, 1982. Plant arrangement for increased bell pepper yield. *Proc. Fla. State Hort. Soc.* 95: 333-35.
4. Price, M., 1986. ECHO Development Notes No. 14:4. Educational Concerns for Hunger Organizations, 17430 Durrance Rd., North Ft. Myers, FL. 33903.
5. Rico-Ballester, M. and G. Jackson, 1979. Conjunto technológico para la producción de hortalizas. Publ. 102, Esta. Exp. Agric., Univ. P. R., Río Piedras, P. R.
6. Stofella, P. J., B. J. Williams, M. Sherry and I. Stough, 1984. Influence of plant population on fruit yield and size of bell peppers. *Proc. Fla. State Hortic. Soc.* 97: 143-45.