Table 1. Summary of costs for direct seeding and transplanting tomatoes for processing, Midwest, 1970, based on 120 acre production unit.

	Direct seeding					Transplanting				
	Hr per acre	Cost per acre (dollars)				Hr per acre	Cost per acre (dollars)			
Operation		Labor	Equipment[t]	Materials	Total		Labor	Equipment[t]	Materials	Total
Seeding or transplanting										
Tractor	.6	1.35	1.29		2.64	1.0	2.25	2.09		4.34
Seeder or transplantor	.6	1.20	2.76		3.96	1.0	12.60	2.11		14.71
Seed or plants				7.00	7.00				42.00	42.00
Anticrustant				5.40	5.40					
Fertilizer				.48	.48				3.64	3.64
Herbicide				5.48	5.48				5.95[u]	5.95
Planting subtotal					24.96					70.64
Cultivation[v]										
Tractor	1.2	2.70	2.51		5.21	.9	2.03	1.84		3.87
Rolling cultivator	1.2		.74		.74	.9		.74		.74
Hoeing (labor)[w]	5.0	27.00	.02		27.02	5.0	18.00	.02		18.02
Disease and insect control										
Custom spraying[x]					36.00					30.00
Disease[y]				27.00	27.00				21.00	21.00
Insect[z]				15.00	15.00				9.00	9.00
Total	8.6	32.25	7.32	60.36	135.93	8.8	34.88	6.80	81.59	153.27

[t]Includes investment, fuel, and maintenance costs.
[u]Application plowed down in the spring.
[v]Based on 3 cultivations under transplanting and 4 under direct seeding.
[w]Based on 2 hoeings under transplanting and 3 under direct seeding.
[x]Excludes materials.
[y]Based on 7 applications under transplanting and 9 under direct seeding.
[z]Based on 3 applications under transplanting and 5 under direct seeding.

Costs allocated to tractor and seeder use in the planting operations averaged $6.60 per acre for direct seeding and $19.05 for transplanting. Seed costs averaged $7.00 per acre under direct seeding compared to average costs of $42.00 per acre for tomato seedlings under transplanting. Further savings resulted from reduced costs for herbicide chemicals and fertilizers in the planting operation under direct seeding.

Although cost reductions resulting from direct seeding were sizeable in the planting operation, some of these comparative benefits were reduced when total operational costs up to harvest were analyzed. Increased costs for cultivation, hoeing labor, and disease and insect control under direct seeding offset some of the savings that accrued from the planting operation. Additional economic returns, estimated at $110 to $185 per acre as a result of increased useable raw product tonnage, provide further net profit incentives to growers under direct seeding.[3]

Literature Cited

1. Wilcox, G. E. and Nelson, P. E. 1968. Yields and color grade relationships of tomatoes for mechanical harvesting. Res. Progress Rpt. 337, Purdue University.
2. ———. 1970. Influence of row spacing and plant density on single harvest tomatoes *J. Amer. Soc. Hort. Science.* 95:435-437.
3. ——— and Johnson, P. E. 1971. An integrated tomato seeding system. *HortScience* 6:214-216.
4. Zahara, M. 1970. Influence of plant density on yield of processing tomatoes for mechanical harvest. *J. Amer. Soc. Hort Science* 95:510-512.

Pepper Performance After Transplant Clipping[1]

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Abstract. **'Keystone Resistant Giant' and 'Hungarian Yellow Wax Hot' peppers (*Capsicum frutescens* L.), which were clipped 6 and 12 days before transplant harvest in southern U. S. fields, yielded as well as non-clipped plants. In general, pepper plants clipped 12 days prior to transplant harvest produced the best results and frequently gave significantly higher yields than the non-clipped plants. The clipping technique can be used to regulate transplant size, and transplant harvest schedules without adversely affecting fruit yield, provided the transplants are free of infectious diseases.**

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Approx 200 million pepper transplants are field-grown in south Georgia each spring for shipment to northern pepper production areas of the midwestern and eastern United States and southern Canada.[3] These transplants are grown in accordance with Georgia certification regulations and are non-clipped (1).

[3]Estimated by Jack Ratcliffe, Chief Plant Inspector, Georgia Department of Agriculture, Coastal Plain Station, Tifton.

Northern buyers usually demand, and southern producers ship relatively large, sturdy pepper transplants. However, many transplants are so large that they are broken in the packaging operation. Also, fewer large transplants can be packed per crate, thereby increasing packing and shipping cost.

Recent research on tomato transplant clipping showed that clipping improved size uniformity and permitted field-holding of marketable-size transplants up to 2 weeks, when unfavorable weather prevailed in northern production areas (2, 3). Clipped tomato transplants performed as well as non-clipped ones if they were free of infectious diseases, and when sufficient time was allowed between clipping and transplant harvest for healing of cut areas and for initiation of new growth. McCarter and **Jaworski (4,** 5) recently confirmed in greenhouse and field tests that pathogens, *Pseudomonas* solanacearum E. F. Sm. and tobacco mosaic virus are easily spread from diseased to healthy tomato plants by clipping. However, these diseases have not been major problems in commercial tomato transplant fields when clipping was used as a management practice.

Growers and canning companies recently expressed interest in the performance of clipped pepper transplants; consequently, this research was conducted to determine how clipping at various periods prior to transplant harvest influenced fruit yield.

Field tests on performance of clipped pepper transplants were conducted during the 1968, 1969, and 1970 growing seasons at Beltsville, Maryland. Another test was conducted in 1969 at Tifton, Georgia.

Peppers were field-seeded in south Georgia with 30, 60, and 30 lb./acre, respectively, of elemental N, P, and K under the seed row. Superphosphate and muriate of potash were the sources of P and K. The N-source mixture consisted of 15, 5, and 10 lb. N/acre from ammonium nitrate, urea, and ureaform, respectively. An additional 20 lb. N/acre as ammonium nitrate was sidedressed 3 to 4 weeks prior to transplant harvest. Cultivars used were 'Keystone Resistant Giant' in 1968, 1969, and 1970 and 'Hungarian Yellow Wax Hot' in 1969 and 1970. Seeding rate was approx 60 seeds/ft of row or 1,700,000 seeds/acre.

The treatments consisted of non-clipped controls and plants clipped 4 and 9 days prior to transplant harvest in 1968, and clipped 6 and 12 days prior to transplant harvest in 1969 and 1970. A modified rotary lawn mower was used for clipping (Fig. 1). Transplants at 10-12 inches high were clipped to 8 inches. This clipping removed the terminal bud and upper leaves and the first flower cluster, and left the plant with 3 to 5 auxillary buds for new growth. Transplants for all treatments within an experiment were of the same age; however, transplant type at harvest varied considerably between clipping treatments. Non-clipped transplants were 11 to 13 inches high, were in blossom, and had very small auxillary buds (Fig. 2). Transplants clipped 6 days prior to harvest were 8 to 9 inches high with auxillary bud growth averaging about 0.5 inch. Those clipped 12 days prior to harvest were 8 to 9 inches high with auxillary bud growth averaging 1.5 inches (Fig. 2).

Transplants for evaluation at Beltsville were wrapped in bundles of 55 with roots surrounded by moist peat moss, packed in keystone-shaped crates according to commercial practices (6), and shipped via air express.

The experimental design utilized was a randomized complete block design

Fig. 1. Clipping 10-12 inch tall pepper transplants back to 8 inches with a modified rotary lawn mower. The left 2 rows have been clipped.

Fig. 2. Representative 'Hungarian Yellow Wax Hot' pepper plants at transplant harvest. Left to right: non-clipped, clipped 6 days, and clipped 12 days prior to transplant harvest.

with 4 replications at Beltsville and 6 replications at Tifton. All plants were transplanted and grown according to recommended practices for the area. At Beltsville, fruit was harvested for yield 3 times in 1968 and 4 times in 1969 and 1970. At Tifton, 'Hungarian Yellow Wax Hot' was harvested 5, and 'Keystone Resistant Giant' 3 times. Only green fruit of 'Keystone Resistant Giant' and yellow fruit of 'Hungarian Yellow Wax Hot' were included in the usable yield. The data were analyzed by analysis of variance, and means were compared by Duncan's Multiple Range Test.

Beltsville test, 1968. Usable fruit yield averaged only 2.24 tons/acre and was not significantly affected by clipping treatments. The poor yields were due primarily to weather unfavorable for fruit set. The clipped plants exhibited very little wilting after transplanting and the early growth on these plants appeared to be greener. Plants of all treatments appeared to be relatively disease free.

Tifton test, 1969. The 'Hungarian Yellow Wax Hot' plants clipped 12 days prior to transplant harvest produced about 3 more tons of usable fruit/acre than the non-clipped plants (Table 1). Usable yield from plants clipped 6 days prior to transplant harvest was similar to the non-clipped plants. The fruit yields for the first and second harvests were larger from the clipped transplants than from the non-clipped ones. The 'Keystone Resistant Giant' plants clipped either 6 or 12 days before transplant harvest produced more fruit in 3 harvests than the non-clipped ones. Most of this increase in yield was in the first 2 harvests.

Table 1. Effect of pepper transplant clipping on usable fruit yield in tons/acre at Tifton, Georgia, 1969 and Beltsville, Maryland, 1969 and 1970.

	Days clipped prior to transplant harvest[z]		
Cultivar	Non-clipped	6	12
Tifton, Georgia - 1969:			
Hungarian Yellow Wax Hot	7.23a	7.54a	10.21b
Keystone Resistant Giant	2.46a	4.27c	3.29b
Beltsville, Maryland - 1969:			
Hungarian Yellow Wax Hot	4.60a	4.31a	5.17a
Keystone Resistant Giant	2.65a	2.70a	2.99a
Beltsville, Maryland - 1970:			
Hungarian Yellow Wax Hot	8.29a	8.59a	10.45b
Keystone Resistant Giant	9.31a	8.55a	10.48b

[z]Treatment means for the same cultivar in the same experiment followed by different letters are significantly different at the 5% level.

Beltsville test, 1969. Usable yield averaged 4.69 and 2.78 tons/acre for 'Hungarian Yellow Wax Hot' and 'Keystone Resistant Giant', respectively, and was not affected by the clipping treatments (Table 1).

Beltsville test, 1970. Usable yield for both cultivars was significantly larger from plants which were clipped 12 days before transplant harvest (Table 1). This increased yield was noticeable in all 4 harvests. Yields from non-clipped plants and from plants clipped 6 days before transplant harvest were very similar.

These results indicate that clipped pepper transplants will perform as well as non-clipped ones. In 2 of the 4 tests, the pepper plants clipped 12 days prior to transplant harvest out-yielded the non-clipped ones. In most instances, the performance of those plants clipped 12 days was superior to those clipped 6 days prior to transplant harvest. Yield for the early harvest was not reduced by transplant clipping.

A clipped pepper transplant would be much smaller than a non-clipped plant of the same age. This should result in reduced packaging and transportation costs because more transplants can be packed per crate.

Regulations for the production of Georgia certified pepper plants specify that plants must be free of infectious diseases (1). The clipping technique can cause major disease problems by dissemination of certain plant pathogens as recently shown by McCarter and Jaworski (4, 5) with tomatoes. Since many tomato diseases are also found on peppers, there is a potential danger of spreading pepper pathogens from diseased to healthy pepper transplants by the clipping practice. Therefore, the clipping practice should only be used in pepper transplant fields that are free from potentially serious pathogens.

Literature Cited

1. Anonymous. 1970. Regulations for the production of Georgia certified pepper plants. Ga. Dept. Agr., Div. Entomol. and Plant Indus., Atlanta, Georgia. 5 p.
2. Jaworski, C. A., and R. E. Webb. 1967. Preliminary tests on the performance of clipped tomato transplants. *Proc. Amer. Soc. Hort. Sci.* 91:550-555.
3. ________ ,________ , G. E. Wilcox, and S. A. Garrison. 1969. Performance of tomato cultivars after various types of transplant clipping. *J. Amer. Soc. Hort. Sci.* 94:614-616.
4. McCarter, S. M., and C. A. Jaworski. 1968. Greenhouse studies on the spread of *Pseudomonas solanacearum* in tomato plants by clipping. *Plant Dis. Rptr.* 52:330-334.
5. ________ ,________ . 1969. Field studies on spread of *Pseudomonas solanacearum* and tobacco mosaic virus in tomato plants by clipping. *Plant Dis. Rptr.* 53:942-946.
6. Miller, E. V., W. D. Moore, H. A. Schomer, and E. K. Vaughan. 1949. Handling and shipping southern-grown tomato plants. *U. S. Dept. Agr. Cir.* 805:26 p.

Effects of Plant Population, Nitrogen, and Harvest Date on Yield and Maturity of Single-Harvested Broccoli[1]

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Abstract. **The effects of various equidistant plant spacings, rate of N and harvest date on the yield and maturity of single-harvested broccoli (*Brassica oleracea* L. var. *italica* Plenck) were investigated during 3 successive cropping seasons. Plant population had only a slight effect on marketable yield. Spear wt decreased and crop maturity was delayed as plant population increased. Yields were increased and maturity was slightly delayed by N top-dressing. The optimum period for single-harvest extended over 3 to 4 days and began when about 11% of the spears were over-mature.**

Machine-harvesting of broccoli, a prime goal of the industry, may be achieved by development of a cultural system adapted to a single-harvest. Greater plant populations have increased single-harvest yields of many vegetable crops. Several studies have been conducted on the effects of plant populations on the yield of broccoli (1, 7, 9, 11), however, plant population was increased by reducing the within-row spacing at constant between-row distances and the crops were sequentially harvested as the spears matured. Single-harvest yields were about the same for different plant populations in a trial conducted by Campbell et al. (4) with cv. Coastal, where the plants were spaced at 25.4, 15.2, and 7.6 cm in rows 106.7 cm apart. However, Palevitch (8) obtained increased yields with 'Spartan Early' by increasing the plant population, especially with spacings approaching equidistant arrangements. Also, Kraus (6) found that plant population markedly affected single-harvest broccoli yields and suggested optimum plant spacing for mechanical harvesting probably will be between 38.1 x 7.6 cm (345,350 plants/ha) and 38.1 x 30.5 cm (86,060 plants/ha) with average yield expectations of 7.8 to 9.0 tons/ha.

The objective of this study was to investigate yield-plant population relationships for once-over mechanical harvest of broccoli. Factorial experiments, comprised of 10 spacing treatments, 3 rates of N, 3 harvest dates, and 2 replications were conducted during each of 3 growing seasons. 'Primo' was used in 1968 but, because of unavailability, 'Gem Hybrid' was used in 1969 and 1970.

Seed was sown in outdoor beds in early to mid-June each year. Plants were pulled at approx 5 weeks and transplanted in a systematic fan design extended to fill a rectangle as described by Bleasdale (2) with fan orientation varied at random. The soil was a fine sandy loam and fertilizer was added prior to transplanting in keeping with the N, P and K requirements of broccoli as defined for conventional spacing and sequential harvesting in the area (5). N treatments were applied as a broadcast top dressing of ammonium nitrate 15 to 20 days after transplanting at the rates of 0, 90 and 180 kg N/ha in addition to a preplant application of 90 kg/ha for all treatments. A preventative insect control program was followed and the plots were not irrigated.

The crop was single-harvested when 3 to 5% of the plants flowered. Later harvests followed at 4-day intervals in 1968 and 1969 and at 3-day intervals in 1970. All plants except those in guard rows and at row ends were harvested. The spears (central inflorescences) were graded and those considered to be marketable were cut to 15 cm lengths and weighed. Spears with open flowers were classed as over-mature and the percentages so classed were converted into angles for statistical analysis.

Marketable yields. Plant spacing had very little effect on single-harvest marketable yields within the range of spacings tested (Table 1).

N rate had the most marked effect on marketable yields (Table 1). Plots that were top-dressed with 90 kg N/ha, in addition to the basic fertilizer application, produced 2.01 tons/ha more than those receiving the basic fertilizer only. Top-dressing with 180 kg N/ha resulted in greater yields than the 90 kg N/ha rate, but the difference was not significant.

Marketable yields increased at later

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