and TPW was not related to total yield for each quality factor. Therefore, the data suggest that some insect species are repelled while others are attracted to reflective surfaces.

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Increased Yield in Slicing Cucumbers with Vertical Training of Plants and Reduced Plant Spacing

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Abstract. **In field experiments conducted during 2 years, substantial yield increases were obtained with vertically trained (staked) cucumber plants (*Cucumis sativus* L.) over vining plants (unstaked). The marketable yield was doubled in some instances, and fruit rot was reduced significantly. More female flowers set and developed into marketable fruits on vertically trained plants than on vining plants. The fresh weight, length, and width of the leaves on the main stem of the staked plants prior to the first harvest were also greater than on unstaked plants. The staked plant fresh weight prior to the first harvest and after the last harvest was significantly greater than that of unstaked plants, but both had the same number of female flowers. Reducing within-row plant spacing from 30 to 15 cm significantly increased yield. Weekly foliar fertilization with 1.5N–0.4P–0.6K (kg·ha^{-1}) for 8 weeks did not increase yield.**

Improving the photosynthetic efficiency of many crop plants has been pursued. Some of the methods used have included genetic selection (2, 5) and environmental manipulation (4). Breeding for plants having leaves with erect angles of elevation to absorb sunlight more effectively and CO_2 enrichment of plant environment are good examples (4, 10).

The heavy foliage cover formed by the vining habit of the fresh-market cucumber restricts light penetration to lower leaves. However, the cucumber canopy can be efficient in absorption of sunlight if the plants are positioned properly. The dense vining canopy also restricts air movement and promotes humid conditions favorable for the growth of fruit rot organisms. Even when plant populations are low, the dense canopy and vining habit prevents effective fungicide application and results in more belly rots. This disease is caused mostly by *Rhizoctonia solani* and is known to be a severe deterrent to cucumber production in southern states (7, 8).

Most of the new cucumber cultivars used for commercial production are gynoecious hybrids. Many of the female flowers produced by these cultivars abort, and others set fruit but do not develop into marketable size. One way to improve marketable yield of these cultivars would be to increase net photosynthesis within the cucumber plant to increase assimilates for developing fruits; another would be to reduce the incidence of fruit rot.

It has been reported that trellising cucumber can improve yield and quality (1, 3). Konsler and Strider (3) found that trellising aided foliar and fruit disease control in two cucumber cultivars. They also suggested improved photosynthetic efficiency as one of the reasons for increased yield, but no evidence was provided. We, therefore, initiated this study to 1) evaluate the yield response of a wide range of cucumber germplasm to vertical training, 2) investigate the indirect evidence of the relationship between improved photosynthesis and productivity in vertically trained cucumber plants, 3) evaluate the effects of in-row spacing of plants on yield and quality, and 4) determine if supplemental foliar fertilization with N–P–K would increase yield.

Twelve and 13 cucumber cultivars (Table 1) were planted in June 1982 and 1983, respectively. Two cultural methods were used—staked vs. unstaked treatments. Experimental design was 12 × 2 and 13 × 2 (cultivar × cultural method) factorial arranged in a randomized complete block with three and four replications, respectively. In the staked treatments, the main stem of the plant was tied to a 1.8-m × 1.6-cm reinforcing bar with cloth ties. No pruning was done. In the unstaked treatments, plants were left to vine on the ground. Plot size was 4.5 × 3 m, and plants were spaced 30 cm apart within the row. Wide spacing (3 m) between rows was used to prevent shading of the unstaked treatments. Fertilizer was applied preplant broadcast and disked in at rates of 73N–32P–60K (kg·ha^{-1}). At that time, *S*-(*O, O*-diisopropyl phosphorodithioate ester of *N*-(2-mercaptoethyl) benzenesulfonamide (bensulide) was incorporated at a rate of 5.6 kg·ha^{-1}. Postplant fertilizer consisted of N at 38 kg·ha^{-1} applied as a sidedress when plants began to run. In the 1983 test, 10 female flowers selected at random from each treatment were tagged at the time of anthesis, and fruit set was recorded at harvest.

In Fall 1983, 'Dasher II' cucumber was planted in a 2 × 2 × 2 factorial experiment arranged in a randomized complete block with

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Table 1. Twelve and 13 staked (S) and unstaked (US) cucumber cultivars grown in 1982 and 1983 and their partitioned F-test significance for fancy yield.

	1982		1983	
Contrast	Cultivar	Significance	Cultivar	Significance
S vs. US	Verino	**	Dasher	**
S vs. US	HY5505	NS	DEXP1	**
S vs. US	XPH1187	NS	XPH1436	NS
S vs. US	Poinsett 76	NS	Poinsett 76	**
S vs. US	G8M	NS	G8M	
S vs. US	GRP6	**	Revenue	**
S vs. US	Spring 440S	**	Sprint 440S	**
S vs. US	Jet set	NS	FMX444	**
S vs. US	NKK2100	**	Raider	**
S vs. US	Centurion	**	Guardian	**
S vs. US	Castlehy 2506	**	NVH2100	NS
S vs. US	---	---	MOX5513	**

NS,*,**Nonsignificant and significant at the 5% and 1% levels by F test, respectively.

Table 2. Influence of cultural method on average yield of 12 cucumber cultivars grown in Summer 1982.

	Yield (kg/plant)			
Cultural method	Fancy	No. 1	Marketable	Culls
Staked	0.45	3.09	3.54	1.54
Unstaked	0.09	1.36	1.46	1.23
Significance				
Cultural method (CM)	**	**	**	NS
Cultivars (C)	*	NS	NS	NS
C × CM	**	NS	NS	NS

NS,*,**Nonsignificant and significant at the 5% and 1% levels by F test, respectively.

Table 3. Influence of cultural method on average yield, number of fruit rot, and percentage of fruit set in 13 cucumber cultivars grown in Summer 1983.

	Yield (kg/plant)					Fruit
Cultural method	Fancy	No. 1	Marketable	Culls	No. rot/ plant	set (%)
Staked	0.95	3.13	4.09	1.11	0.36	44.2
Unstaked	0.23	2.27	2.50	1.01	0.95	29.8
Significance						
Cultural method (CM)	**	**	**	NS	**	**
Cultivars (C)	**	*	**	**	NS	**
C × CM	*	NS	NS	NS	NS	NS

NS,*,**Nonsignificant and significant at the 5% and 1% levels by F test, respectively.

Table 4. Effect of cultural method, plant spacing, and N–P–K foliar fertilization on 'Dasher II' yield, Fall 1983.

	Yield (kg/plot^z)				
Treatment	Fancy	No. 1	Marketable	Culls	No. rot/ plot
Cultural method (CM)					
Staked	5.67	14.33	20.00	7.98	1.3
Unstaked	1.50	10.03	11.52	6.67	4.0
Plant spacing (PS)					
15 cm	4.26	12.97	17.24	7.53	2.8
30 cm	2.95	11.39	14.29	7.12	2.7
Foliar fertilization (F)					
Fertilized	3.40	12.20	15.56	7.39	3.2
Unfertilized	3.77	12.16	15.97	7.26	2.2
Significance^y					
CM	**	**	**	**	**
PS	**	NS	**	NS	NS
CM × PS	**	NS	NS	NS	NS
CM × PS × F	NS	NS	NS	NS	*

^{z}Plot size = 3 × 3 m.
^{y}Other main effects and interactions not significant.
NS,*,**Nonsignificant and significant at the 5% and 1% levels by F test, respectively.

four replications. Treatments were cultural method (staked vs. unstaked), in-row plant spacing (30 vs. 15 cm), and weekly foliar fertilization with 27N–6.5P–10K (Peters professional soluble plant food) at a rate of 1.5N–0.4P–0.6K ($kg \cdot ha^{-1}$) for 8 weeks vs. no foliar fertilization. Five plants from each treatment with 30-cm spacing were removed prior to the first harvest, and the average fresh weight per plant was recorded. Also, the fresh weight, length, and width of the leaves and the number of female flowers on the main stem were recorded. Ten plants from the treatments with closer spacing were removed and discarded to adjust for equality of plot size. The average fresh weight per plant of the remaining 10 plants was recorded after the last harvest. Other cultural practices were the same as in the previous tests.

Fruits were harvested three times a week and graded into U.S. Fancy, No. 1, cull, and rot. Marketable yield was produced by combining grades of Fancy and No. 1.

Vertical training of cucumber plants significantly increased the marketable yield (Tables 2 and 3). In fact, yield was doubled in the 1982 season and increased substantially in 1983. No significant difference was noted between staked and unstaked treatments in culls. Vertical training of plants also enhanced the quality of the fruit, as indicated by the increased yield of fancy fruits. Fruit rot was reduced significantly, and fruit set was increased significantly in the staked plots (Table 3). The effect of the cultivars on yield in 1982 (Table 2) was mostly insignificant. However, the effect of the cultivars grown in 1983 was significant for most of the yield grades (Table 3).

In Fall 1983, staking the 'Dasher II' cultivar resulted in substantial yield increase and reduction in the incidence of fruit rot. Reducing spacing between plants in row increased the marketable and fancy yield and did not affect the number of culls and incidence of fruit rot. O'Sullivan (6) reported that increased cucumber populations in unstaked culture significantly increased yield. Foliar fertilization with N–P–K did not change the yield significantly (Table 4).

Fresh weights of vertically trained 'Dasher II' plants taken before the first and after the last harvest were greater than the fresh weights of the untrained plants. Fresh weight, length, and width of the leaves on the main stem of the vertically trained plants before the first harvest were also greater than those of the untrained plants. However, the number of female flowers produced by vertically trained and untrained plants was the same (Table 5).

No significant cultivar × cultural method interaction was obtained, except in case of Fancy yield (Tables 1, 2, and 3). However, when Fancy and No. 1 grades were combined to produce total marketable yield, no significant interaction was obtained, indicating that the effect of cultural method was mostly independent from cultivars for marketable yield production and that any cultivar is expected to do well under a vertical training method. 'Dasher II' produced more Fancy

Table 5. The influence of cultural method on plant and leaf fresh weight (g), leaf size (cm), and number of female flowers per plant of 'Dasher II' cucumber.

Measurements	Cultural method: Staked	Unstaked	LSD, 5%
Plant weight before first harvest	278	184	90
Plant weight after last harvest	530	448	79
Weight of leaves	91	71	18
Leaf length	12	10	1
Leaf width	14	13	1
No. female flowers	13	12	2

fruits per unit area when the plants were trained vertically and spaced 15 cm apart (Table 4) than when unstaked.

Results of this study indicate that substantial yield increases were obtained by vertical training of the cucumber plants. The increased yield could be attributed to the reduction of fruit rot and, more importantly, to the increase in fruit set and development of the vertically trained plants.

Theoretically, in a gynoecious cucumber each female flower should develop into a fruit of marketable size. Results of this study indicate that more female flowers set and developed into marketable fruits on vertically trained plants than on unstaked plants. Also, the fresh weight of vertically trained plants was always greater and the size of the leaves was larger than those of the unstaked plants. These results indicate that the upward training of plants increased net photosynthesis, increasing assimilates that supported an increased number of fruits. More female flowers aborted and did not develop into fruits in the unstaked treatments relative to staked, possibly because of the need for more assimilates by the unstaked plants.

The reduction in fruit rot in staked plants was achieved by improved air penetration, which reduced humidity, lessened the chances of fungal survival, and allowed for effective fungicide penetration.

The spacing generally recommended for fresh market cucumber is 30 to 45 cm between plants within the row. It was possible with vertical training of plants to reduce spacing between plants in rows to 15 cm and to increase yield significantly per unit area of land.

The cucumber plant is not heavy with fruits at any given time during harvest. The developing fruit from the first fertilized flower has an inhibitory effect on the growth of subsequently pollinated fruits (9) and has to be harvested as soon as it reaches an acceptable size to allow new fruits to develop. The light weight of the plant makes it possible to use a hand-operated stapler and a tape to tie hundreds of cucumber plants in a short time. Also, the tendrils formed by the cucumber vine help to support the plants after two or three tyings. These factors make it feasible for cucumber growers to adopt this cultural technique to improve cucumber productivity.

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Effects of Nitrogen Fertilization on Production of Mechanically Harvested Snap Beans

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Abstract. **Nine snap bean (*Phaseolus vulgaris* L.) cultivars were evaluated at N fertilization rates of 17 and 67 kg·ha^{-1} during 1984 and 1985. Plant lodging was more severe at the high-N rate than at the low rate in both years, and pod decay was more severe at the high-N rate in 1984. 'Bush Blue Lake 47' was the only cultivar among those tested that did not have more lodging at the high-N rate than at the low-N rate. 'Flo' was the only cultivar with higher yields at the high-N rate. The cultivars evaluated showed the most favorable yield and growth responses at the N rate of 17 kg·ha^{-1}, which is lower than rates usually recommended for snap beans.**

Maximum yields of snap beans usually occur with N at 17 to 56 kg·ha^{-1} (1, 3–6). Responses to higher N rates have occurred only on very fine sandy soils (2, 4, 6). High N rates usually increase plant size but depress pod quality and mechanical harvester efficiency. Efficient harvest is characterized by a low percentage of pods left in the field (5% or less), low levels of trash in the harvested pods (5% or less), little pod breakage (<10%), and few clusters within the harvested pods. The results of several experiments in Pennsylvania showed that Bush Blue Lake-type snap beans produce maximum yields with N at 28 kg·ha^{-1} (5). Plant size, lodging, and difficulty of harvesting mechanically increased at higher N levels under a wide range of field conditions.

The objective of this study was to evaluate the effects of N rates on plant characteristics, productivity, and pod quality of nine snap bean cultivars harvested mechanically.

The experiments were conducted in 1984 and 1985 at the Plateau Experiment Station near Crossville, Tenn. Snap bean seeds were planted on 21 June 1984 on a Lily sandy loam. Soil test results indicated pH 5.9, P at 50 kg·ha^{-1}, and K at 200 kg·ha^{-1}. The site had been planted in soybeans and a winter wheat cover crop in the previous year. Prior to planting, *S*-ethyl dipropyl carbamothioate (EPTC) at 3.4 kg·ha^{-1} was broadcast and incorporated into the soil. The 1985 planting was on 17 June on a Lily sandy loam with soil test levels of pH 5.9, P at 20 kg·ha^{-1}, and K at 150 kg·ha^{-1}. After planting in 1985, 2-chloro- *N* -(2-ethyl-6-methylphenyl)- *N*-(2-methoxy-1-methylethyl)acetamide (meto-

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