nutrients from the applied fertilizers. However, in greenhouse experiments, Smith and Harrison (1991) found that after 28 days of incubation, soil with polyacrylate gel, saturated with N from a KNO_3 source, retained less N than soil without gel treatment. In field experiments, 'Majestic' cauliflower yields were also similar with or without gel amendments (Orzolek, 1991).

Increasing gel rates reduced yields and fruit size (Tables 3 and 5). The reason for the yield reduction is not known, since phytotoxicity symptoms were not apparent on the pepper plants during the season and references for phytotoxic effects of gels were not found in the literature.

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STAKING FRESH MARKET CUCUMBER FOR HIGHER YIELDS: A LONG TERM RESEARCH REPORT

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Additional index words. Cucumis sativus, vertical training, in-row spacing, foliar fertilization, polyethylene mulch, double-cropping, standard system.

Abstract. **In field studies conducted from 1982 to 1991, substantial yield increases were obtained with staked cucumber plants (*Cucumis sativus* L.) over those unstaked. Both staked and unstaked plants had the same number of female flowers, but more female flowers set and developed into marketable fruits on staked plants than on unstaked plants. The fresh weights of staked plants before the first harvest and after the last harvest were significantly greater than that of unstaked 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. In-row plant spacings of 6 inches produced significantly higher yield than 12 inches. Nine or 12 inch spacing produced higher yield than 18 inch spacing. Weekly foliar fertilization with 27N-6.5P-10K (Peters Professional 27-15-12 foliar feed) at a rate of 1.4N-0.3P-0.5K lb/acre for 8 weeks did not increase yield over plants that did not receive foliar fertilization. However, weekly foliar fertilization with a seaweed extract (Response 9-9-7, Ag/Response, Inc.) that contained .09N-.04P-.06K at a rate of 0.2 gal/acre significantly increased yield in 2 of 3 years of the investigation. Black or white polyethylene mulch significantly increased yield of staked cucumber over bare ground. Data showed that it was possible to double crop cucumber with tomatoes and produce Fancy + No. 1 yield comparable to cucumber staked by the standard system. This cultural technique would result in producing staked cucumber more economically.**

Fresh market cucumber has been an important vegetable crop in southern states for many years. The heavy foliage cover formed by the vining habit of the cucumber plant restricts light penetration to lower leaves. The dense canopy also restricts air movement and promotes humid conditions favorable to the growth of fruit rot organisms. Even when plant populations are low, the dense canopy and vining habit prevents effective fungicide application. As a result, fruit rot disease is a severe deterrent to expanding production in southern states (Sciumbato and Hegwood, 1979; Sumner and Smittle, 1976).

One means of improving yields of cucumber would be to increase the photosynthesis process within the cucumber plant to provide more assimilates for developing fruits. Another would be to help reduce the incidence of fruit rot. The cucumber canopy can be efficient in absorption of sunlight and fungicides can be applied more effectively if the plants are positioned properly.

Since vertical training or staking of cucumber plants seemed to be a feasible cultural technique to address these problems, several studies were conducted since 1982 at the LSU Citrus Research Station, Port Sulphur, Louisiana. The objectives of these studies were to: 1) determine the influence of staking cucumber on yield and fruit quality, 2) develop improved cultural techniques to enhance the yield of staked cucumber, and 3) minimize the expense to train the plants.

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Mention of trade names is for information only and does not imply endorsement by the authors or LSU.

Materials and Methods

Studies to determine the influence of staking cucumber on yield were conducted in 1982 to 1984. Thirteen cucumber cultivars were planted in June of 1982 and 1983 with 2 cultural methods, staked and unstaked. Experimental design was a 13 × 2 (cultivar × cultural method) factorial arrangement of treatment in a randomized complete block with 3 and 4 replications, respectively. In 1983, 10 female flowers were selected at random from plants of each treatment at the time of anthesis, and were tagged using red 1 1/2 × 1 inch tags. Fruits with tags and tags without fruits were recovered at harvest. Fruit set was calculated when all the ten tags per treatment were recovered. In fall 1983, 'Dasher II' cucumber was planted in a randomized complete block design with 4 replications. Staked and unstaked cucumber treatments were included in this test. Five plants from each treatment were removed prior to the first harvest, and the average fresh weight per plant was recorded. Also, the fresh weight, length, and width of leaves and number of female flowers on the main stem were recorded. The average fresh weight per plant of the remaining 10 plants was recorded after the last harvest. In the spring (April to June) of 1984, 'Dasher II' and 'A&C 1810', a gynoecious and monoecious cucumber hybrid, respectively, were planted in a factorial experiment arranged in a randomized complete block design with 4 replications. Treatments were cultivar and cultural method (staked and unstaked). The number of female flowers on the main stem with each treatment was recorded before the first harvest. Plant fresh weight was recorded after the last harvest.

Studies to develop improved cultural techniques to enhance the yield of staked cucumbers were conducted in 1983, 89, 90, and 91. These studies include an increased plant population by reducing in-row spacing between plants, supplemental foliar fertilization with N-P-K, and mulching with black or white polyethylene. Treatments were in-row spacing of 6 and 12 inches in 1983 and 1984, 9 and 18 inches in 1988, and 12 and 18 inches in 1989, weekly foliar fertilization with 27N-6.5P-10K (Peters Professional 27-15-12 Foliar Feed) at a rate of 1.4N-0.4P-0.5K lb/acre for 8 weeks vs. no foliar fertilization, weekly foliar fertilization with a seaweed extract containing .09N-.04P-.06K (Response 9-9-7, Ag Response, Inc.) at a rate of 0.2 gal/acre for 8 weeks and no foliar fertilization, and black or white polyethylene mulch and bare ground. Treatments were arranged in a randomized complete block or split plot design and replicated 3 or 4 times depending on the test.

Studies to minimize the expense to train cucumber plants onto the stakes were conducted in 1988 and 1989. In these studies, cucumber was planted on same tomato rows without removing tomato plants, stakes, or drip irrigation lines. Tomato plants were sprayed with glyphosate at 3 lb/acre after the last harvest and tomato skeletons were left in place to support climbing cucumber plants (double-cropping tomatoes and cucumber). Treatments of cucumber staked by the standard system described by Hanna et al. (1989) were included for yield comparison.

In all studies, the plot size was 10 × 10 feet. Cultural practices other than procedures under investigation were standard commercial practices. Cucumbers were harvested 3 times a week for a total of 3 to 4 weeks. Fruits were graded to U.S. Fancy, U.S. No. 1, U.S. No. 2, culls and rots. Fancy and No. 1 grades were combined and classified as Fancy + No. 1 yield. Marketable yield was the total of U.S. Fancy, U.S. No. 1, and U.S. No. 2.

Results and Discussion

Vertical training of cucumber plants significantly increased Fancy + No. 1 and marketable yields (Fancy + No. 1 + No. 2). Yields of staked cucumber were almost doubled in the 1982 season and increased substantially in the summer and fall seasons of 1983 and the spring season of 1984. Staking cucumber reduced culls in 3 of 4 growing season and resulted in significant reductions in the incidence of fruit rot (Table 1).

Fresh weights of vertically trained cucumber plants taken before the first and after the last harvest were greater than the fresh weight 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. Fruit set percentages of the number of flowers tagged at anthesis or total number of fruits per plant were greater on staked than unstaked plants (Table 2).

Reduced in-row spacing between staked plants from 12 to 6 inches significantly increased Fancy + No. 1 and marketable yields in the fall of 1983 and marketable yields in the spring of 1984. Cucumber plants spaced 9 or 12 inches produced higher Fancy + No. 1 and marketable yields than plants spaced 18 inches apart. Plants spaced 12 inches apart produced significantly less culls than plants spaced 6 inches apart in 1984 only. Spacing had no effect on percentage of culls in the other growing seasons (Table 3).

Table 1. Main effect of cultural method on yield of cucumber grown in three years.

Treatment	Yield (T/acre) Fancy + No. 1	Yield (T/acre) Marketable	Culls (%)	Rot (no./acre)
	Summer of 1982			
Staked	10.5	15.0	15.2	—
Unstaked	4.4	8.1	23.3	—
Signif.	**	**	**	
	Summer of 1983			
Staked	13.9	17.8	10.9	1,393.9
Unstaked	8.7	12.4	15.1	3,136.3
Signif.	**	**	**	**
	Fall of 1983[z] (Gynoecious)			
Staked	9.6	13.5	14.4	609.8
Unstaked	5.5	8.7	18.2	1,742.4
Signif.	**	**	**	**
	Spring of 1984[z] (Gynoecious)			
Staked	9.1	13.7	11.7	—
Unstaked	6.4	10.5	10.7	—
Signif.	**	**	NS	
	Spring of 1984[y] (Monoecious)			
Staked	9.5	12.8	7.5	—
Unstaked	7.1	10.1	7.2	—
Signif.	**	**	NS	

[z]Yield of 'Dasher II' cucumber.
[y]Yield of 'A & C 1810' cucumber
NS, ** Nonsignificant and significant at the 1% level by the F test, respectively.

Table 2. Effects of staking cucumber on plant and leaf fresh weight (lb), leaf size (inch), number of female flowers and fruit set.

Measurement	Staked	Unstaked	Signif.
'Dasher II', Fall 1983			
Plant weight before first harvest	0.61	0.41	*
Plant weight after last harvest	1.71	0.99	**
Weight of leaves	0.20	0.16	*
Leaf Length	4.72	3.94	**
Leaf Width	5.51	5.12	*
No. female flowers to first harvest	13.00	12.00	NS
Fruit set %	44.23	29.81	**
'Dasher II', Spring 1984			
No. female flowers to first harvest	12.88	12.85	NS
Fruit set (no. fruits/plant)	17.27	12.45	**
Plant weight after last harvest	2.18	1.71	**
'A&C 1810', Spring 1984			
No. female flowers to first harvest	1.00	1.00	NS
Fruit set (no. fruits/plant)	16.10	10.80	**
Plant weight after last harvest	2.59	1.93	**

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

Foliar spray with 27-15-12 foliar feed in 1983 did not increase Fancy + No. 1 or marketable yield and did not affect the percentage of culls. Foliar spray with seaweed extract (Response 9-9-7) significantly increased Fancy + No. 1 and marketable yields of 'Dasher II' cucumber in 1989 and 1990. However, the same treatment did not influence yield in 1991. Percentage of culls was almost the same for treated and untreated plots. (Table 4).

Cucumbers grown on black or white polyethylene mulch produced significantly higher Fancy + No. 1 and marketable yields than cucumbers grown on the ground in 4 studies conducted in 1988 through 1991 (Table 5). Cucumber with black polyethylene mulch produced slightly higher yields than with white mulch but the differences were not significant. Cucumber grown on black polyethylene mulch produced significantly less culls than on white mulch in 1 of 4 years of study. Cucumbers on bare ground produced more culls in all of the 4 years of study but the differences were significant in 1990 and 1991 only (Table 5).

Tomato skeleton left in place to support climbing cucumber plants (double-cropping system) did not reduce Fancy + No. 1 yields significantly. However, marketable yields were significantly higher when the skeletons were removed (standard system) in both 1988 and 1989. Percentages of culls were higher when tomato skeletons were removed in 1989 (Table 6).

These studies demonstrated that the increased yield of staked cucumber plants can be attributed to the reduction of fruit rot, to an increase in fruit set, and increased growth of the vertically trained plants. The upward training of plants increased net photosynthesis, increasing assimilates that supported a larger plant and an increased number of fruits. The equal number of female flowers produced by the staked and unstaked cucumber plants and the more

Table 3. Effects of in-row spacing on staked cucumber yield.

Plant Spacing (inches)	Yield (T/acre) Fancy + No. 1	Marketable	Culls (%)
Fall 1983			
6	8.3	11.9	15.8
12	6.9	10.3	16.8
Signif.	**	*	NS
Spring 1984			
6	8.1	12.7	13.7
12	7.5	11.5	8.7
Signif.	NS	*	**
Summer 1988[z]			
9	6.2	7.2	5.4
18	4.7	5.4	3.4
Signif.	**	**	NS
Summer 1989			
12	8.2	10.4	10.3
18	7.3	8.3	11.2
Signif.	*	*	NS

[z]Low yield because of active hurricane season

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

Table 4. Influence of supplemental foliar fertilization on yield of staked cucumber.

Treatment	Yield (T/acre) Fancy + No. 1	Marketable	Culls (%)
Fall 1983 (27-15-12)			
Fertilized	7.5	11.0	16.4
Unfertilized	7.7	11.2	16.2
Signif.	NS	NS	NS
Spring 1989 (Seaweed 9-9-7)			
Fertilized	10.0	11.5	9.0
Unfertilized	8.5	9.7	10.5
Signif.	*	*	NS
Spring 1990 (Seaweed 9-9-7)			
Fertilized	17.3	18.9	6.7
Unfertilized	15.6	17.0	7.7
Signif.	**	*	NS
Spring 1991 (Seaweed 9-9-7)			
Fertilized	17.6	19.0	8.9
Unfertilized	18.1	19.4	10.5
Signif.	NS	NS	NS

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

Table 5. Influence of polyethylene mulch and bare ground on staked cucumber yield.

Treatment	Yield (T/acre) Fancy + No. 1	Marketable	Culls (%)
Spring 1988			
Black	12.1a[z]	14.4a	15.0a
White	11.9a	14.2a	14.1a
Ground	4.9b	6.4b	21.0a
Spring 1989			
Black	10.0a	11.1a	8.9a
White	9.8a	11.3a	8.2a
Ground	8.0b	9.3b	10.0a
Spring 1990			
Black	17.7a	19.3a	6.4c
White	17.3a	18.9a	8.2b
Ground	12.6b	14.3b	10.2a
Spring 1991			
Black	19.2a	28.0a	8.2b
White	19.3a	27.0a	9.9ab
Ground	14.9b	16.2b	11.0a

[z]Mean separation in columns by Duncan's Multiple Range Test, 5% level.

Table 6. Yield of cucumber staked by the standard and double-cropping systems.

Treatment	Yield (T/acre) Fancy + No. 1	Yield (T/acre) Marketable	Culls (%)
	Summer 1988[z]		
Standard	4.7	5.6	7.4
Double-cropping	4.3	4.7	7.6
Signif.	NS	**	NS
	Summer 1989		
Standard	11.8	14.2	15.2
Double-cropping	10.9	12.2	9.3
Signif.	NS	**	**

[z]Low yield because of active hurricane season.
NS, ** Nonsignificant and significant at the 1% level by F test, respectively.

fruit set on staked plants indicate that 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 gynoecious cultivar Dasher II produced almost 13 times more female flowers than the monoecious cultivar A&C 1810 on the main stem. However, fruit sets were almost equal for both cultivars indicating that the monoecious cultivar produced most of its female flowers on the lateral branches.

The reduction in fruit rot on staked plants was probably achieved by an improved air penetration and a reduced humidity that lessened the chances of fungal survival. Staking also allowed for a more effective fungicide penetration than on unstaked plants.

The spacing generally recommended for fresh market cucumber is 12 to 18 inches between plants within the row. It was possible with vertical training of plants to reduce spacing between plants in rows to 6 inches and to increase yield significantly per unit area of land. O'Sullivan (1980) reported that an increased cucumber population with unstaked culture significantly increased yield.

Foliar spray with seaweed extract fortified with N-P-K was more effective in increasing cucumber yield than N-P-K alone. Featonby-Smith and Staden (1984) indicated that spraying beans with seaweed concentrate resulted in higher levels of cytokinin in all tissues, particularly the fruits. Their results also showed that high concentrations of cytokinins within the fruits of treated plants were associated with an increase in the dry mass of these fruits. The unusual excess rainfall in 1991 growing season may explain the lack of seaweed effectiveness. Most of the spray material was washed away after spray.

Early season warming of the soil, good retention of moisture and less weeds under polyethylene mulch may have contributed to superior yield of cucumber. Also, more culls produced by cucumber grown on bare ground may have contributed to the differences between the two systems of culture.

Double-cropping cucumber and tomato is feasible. Tomato skeleton and stakes already in place can provide support for climbing cucumber and minimize the cost of staking cucumber (Hanna et al., 1989). The increase of marketable yield produced by cucumber staked by the standard system over double-cropping system resulted from more No. 2 cucumber. The yield of No. 2 cucumber was a small portion of the marketable yield.

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YIELD INCREASE OF STAKED CUCUMBER BY SUPPLEMENTAL DRIP IRRIGATION, REDUCING PLANT SPACING AND HIGHER N-P-K RATES

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Abstract. **Four experiments were conducted during a 2 year period to determine the influence of supplemental irrigation, in-row spacing, and preplant N-P-K rates on yield, fruit length, leaf size and leaf contents of N, P, and K of cucumbers (*Cucumis sativus* L.). Irrigation (drip) significantly increased U.S. Fancy + No. 1 and marketable yield (U.S. Fancy + No. 1 + No. 2) over unirrigated cucumber in all but the fall season of 1985 when rainfall exceeded 21 inches. Irrigation increased fruit length in the spring of both 1985 and 1987. In-row spacing of 6 inches provided increased yield over 12 inches spacing in all 4 seasons but had no effect on fruit length. The response to preplant N-P-K rates was mixed in 1985. However, yield of cucumber increased linearly with the increase of preplant application of N-P-K rates (0-0-0 to 104-44-88 lb/acre) in 1987. In the 1985 spring test, irrigation increased leaf length and width, reduced leaf N, and increased leaf P and had no effect on leaf K. Reducing spacing to 6 inches from 12 inches between plants had no effect on leaf length and width, and leaf N,**

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