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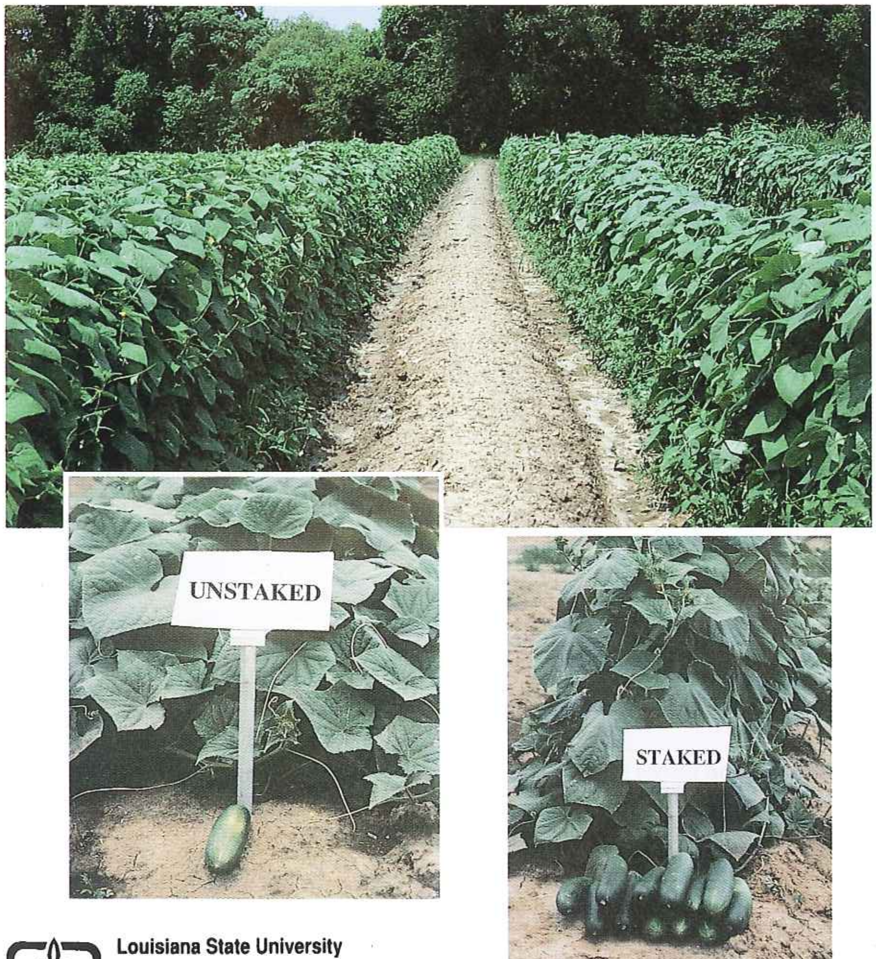

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H. Y. Hanna[1] and A. J. Adams[2]

Introduction

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 plants 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 from 1982 to 1991 at the Citrus Research Station, Port Sulphur, La. The objectives of these studies were: 1) to determine the influence of staking on yield, fruit quality, and related traits of cucumber; 2) to develop

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improved cultural techniques to enhance the yield of staked cucumber; and 3) to minimize the expense to vertically train the plants.

Materials and Methods

Objective 1

Studies to determine the influence of staking cucumber on yield, fruit quality, and related traits were conducted in 1982-1984. Thirteen cucumber cultivars were planted in June of 1982 and 1983. Two cultural methods were used: staked and unstaked treatments. In the staked culture, cucumber plants were tied to four levels of twine wrapped around reinforcing rods (5 feet x 0.5 inch).

Rods were spaced 3-4 feet apart, and the twine was tied off tightly to the far end of an anchor rod. The four levels of twine were vertically spaced at 15-20 inches above the soil surface. Plants were tied to the twine until they reached the top level using a Max Tapener Model HT B-2. Experimental design was 13 x 2 (cultivar x cultural method) factorial arranged in a randomized complete block with three and four replications in 1982 and 1983, respectively.

In the 1983 test, 10 female flowers were selected at random from each treatment and were tagged at the time of anthesis, and fruit set was recorded at harvest. In fall 1983, 'Dasher II' cucumber was planted in a randomized complete block design with four 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 the leaves, and the 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-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 four replications. The monoecious cultivar was included in the study because of claims that it is more stable under adverse weather conditions. Treatments were cultivars and cultural methods (staked and unstaked). The number of female flowers on the main stem in each treatment was recorded before the first harvest. Plant fresh weight was recorded after the last harvest.

Objective 2

Studies to develop improved cultural techniques for enhancing the yield of staked cucumber were conducted in 1983, 1985, 1987, 1989, 1990, and 1991. These studies included increasing plant population by reducing in-row spacing between plants, supplemental drip irrigation, preplant fertilization and postplant supplemental foliar fertilization with N-P-K, and mulching with black or white polyethylene mulch. For plant population studies, treatments were in-row spacing of 6 vs 12, 9 vs 18, and 12 vs 18 inches. Treatments for irrigation studies included supplemental drip irrigation and no irrigation.

Preplant fertilization treatments with N-P-K (13-13-13) were 0, 200, 400, 600, and 800 lb/acre. Postplant treatments were weekly supplemental foliar fertilization with N-P-K (Peters 27-15-12) at 5 lb/acre for eight weeks vs no foliar fertilization, and weekly foliar fertilization with a seaweed extract containing 9 percent N-9 percent P-7 percent K (Response 9-9-7, Ag Response, Inc.) at 0.2 gal/acre for eight weeks vs no foliar fertilization.

Mulching studies were conducted using black or white polyethylene mulch vs bare ground. Treatments were arranged in a randomized complete block or split plot design and replicated three or four times, depending on the test and the year of investigation.

In the irrigated treatments, water was supplied through half-inch diameter polyethylene distribution lines connected to the main water line with a pressure regulator with pressure set at 8 psi. In-line emitters were spaced 12 inches apart. Irrigation was based on soil moisture measurement with model R irrometers (Irrometer Co., Riverside, CA). Water was applied when soil moisture tension at a depth of six inches reached at least 30 centibars. Total rainfall from seeding to last harvest was 17, 20, 21.5, and 18 inches/acre during spring, summer, and fall of 1985 and spring of 1987, respectively.

Objective 3

Studies to minimize the expense to vertically train cucumber plants were conducted in 1988, 1989, and 1990. In these studies, cucumber was double-cropped with tomato or with cucumber. In the 1988 and 1989 studies, cucumber was planted on rows following a tomato crop without removing the tomato plants, stakes, or drip irrigation lines. After the last harvest, tomato plants were sprayed with glyphosate at 3 lb ai/acre.

The 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 staking expense and yield comparisons.

In 1990, two cucumber crops were planted in succession (double-cropped cucumber). The first cucumber crop was planted in the spring (April-June), and the second crop was planted in the summer (July-September). Cucumber plants from the first crop were treated with glyphosate at 3 lb ai/acre after the last harvest. Stakes, string, polyethylene mulch, and the skeleton of the first crop of cucumber plants were left in place to support the climbing plants of the second crop.

In all studies, plot size was 10 x 10 feet. Cultural practices other than procedures under investigation were standard commercial practices. Cucumber was harvested three times a week for a total of 3-4 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 premium yield. Total yield was the total of premium yield and No. 2 grade.

Results

Vertical training of cucumber plants significantly increased premium and total yield. In the staked treatments, yield was almost doubled in the 1982 season and increased substantially in the summer and fall seasons of

Table 1.--Influence of cultural method (staked vs unstaked) on the premium and total yields, percentage of culls, and number of rotted fruit of cucumber, 1982-1984

Treatment	Yield (bu/acre) Premium	Yield (bu/acre) Total	Culls %	No. rot/ acre
		Summer of 1982[z]		
Staked	436.8	627.8	15.2	---
Unstaked	182.9	338.5	23.3	---
Significance	**	**	**	
		Summer of 1983[z]		
Staked	580.6	745.3	10.9	1394
Unstaked	364.9	518.6	15.1	3136
Significance	**	**	**	**
		Fall of 1983[y] (Gynoecious)		
Staked	401.3	562.4	14.4	610
Unstaked	231.1	364.9	18.2	1742
Significance	**	**	**	**
		Spring of 1984[y] (Gynoecious)		
Staked	379.5	572.4	11.7	---
Unstaked	268.5	440.4	10.7	---
Significance	**	**	NS	
		Spring of 1984[x] (Monoecious)		
Staked	394.9	536.0	7.5	---
Unstaked	298.5	421.3	7.2	---
Significance	**	**	NS	

[z]Average yield of 13 cultivars.
[y]Yield of 'Dasher II' cucumber.
[x]Yield of 'A&C 1810' cucumber.
NS, ** Nonsignificant and significant at the 1 percent level by the F test, respectively.

1983 and the spring season of 1984. Staking cucumber reduced culls in three out of five growing seasons, and resulted in significant reduction in the incidence of fruit rot (Table 1).

Fresh weight of vertically-trained cucumber plants taken before the first and after the last harvest was 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 expressed as percentage of the number of flowers tagged at anthesis or total number of fruits per plant was greater on staked than unstaked plants (Table 2).

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	LSD 5%
	Fall 1983[y] (Gynoecious)		
Plant weight before 1st harvest	0.61	0.41	0.20
Plant weight after last harvest	1.71	0.99	0.17
Weight of leaves	0.20	0.16	0.04
Leaf length	4.72	3.94	0.39
Leaf width	5.51	5.12	0.39
No. female flowers[z]	13.00	12.00	NS
Fruit set %	44.23	29.81	7.99
	Spring 1984[y] (Gynoecious)		
No. female flowers[z]	12.88	12.85	NS
Fruit set (No. fruits/plant)	17.27	12.45	1.53
Plant weight after last harvest	2.18	1.71	0.20
	Spring 1984[x] (Monoecious)		
No. female flowers[z]	1.00	1.00	NS
Fruit set (No. fruits/plant)	16.10	10.80	1.90
Plant weight after last harvest	2.59	1.93	0.40

[z]Counted on the main stem only up to the time of first harvest.
[y]'Dasher II' cucumber.
[x] 'A&C 1810' cucumber.

Reduced in-row spacing between staked plants from 12 to 6 inches significantly increased premium and total yields in the fall of 1983, spring, summer, and fall of 1985 and spring of 1987, and increased the total yields in the spring of 1984. No change in the percentage of culls resulted from narrowing the spacing to six inches between plants, except in 1984 where plants in the 6-inch spacing produced significantly more culls. Cucumber plants spaced 9 or 12 inches produced higher premium and total yields than plants spaced 18 inches apart (Table 3).

Supplemental irrigation in the spring and summer of 1985 and spring of 1987 significantly increased the early and total yields (Table 4). The irrigated plots produced significantly less culls and longer fruits in the spring

Table 3.--Effects of in-row spacing (6 vs 12, 9 vs 18, and 12 vs 18 inches) on staked cucumber yield in six years

Treatment	Yield (bu/acre) Premium	Total	Culls %
		Fall 1983	
6 inches	345.8	496.0	15.8
12 inches	286.7	430.4	16.8
Significance	**	*	NS
		Spring 1984	
6 inches	336.7	530.5	13.7
12 inches	312.1	482.3	8.7
Significance	NS	*	**
		Spring 1985	
6 inches	799.0	1129.3	21.8
12 inches	646.1	943.7	21.9
Significance	**	**	NS
		Summer 1985	
6 inches	405.9	568.8	14.6
12 inches	325.8	477.8	13.9
Significance	**	**	NS
		Fall 1985	
6 inches	398.6	505.1	13.4
12 inches	290.3	345.8	12.7
Significance	**	**	NS
		Spring 1987	
6 inches	526.9	703.4	11.9
12 inches	473.2	617.9	10.7
Significance	**	**	NS
		Summer 1988[z]	
9 inches	260.3	302.1	5.4
18 inches	196.6	225.7	3.4
Significance	**	**	NS
		Summer 1989	
12 inches	342.2	434.1	10.3
18 inches	303.9	344.9	11.2
Significance	*	*	NS

[z]Low yield because of active hurricane season.

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

seasons of 1985 and 1987. Yield increase was substantial, especially in the spring seasons. No yield increase was obtained in the fall of 1985.

Preplant N-P-K fertilizer rates had greater effect on yield and fruit length in the 1987 spring season than in 1985 (Table 5). Plants fertilized with the highest rate (800 lb/acre) produced the highest yield in every category. However, in most cases, plants fertilized with 600 lb/acre produced yields not significantly different from plants fertilized with the highest rate. Also, plants fertilized with 600 lb/acre produced the longest fruit, but the only significant differences were from the control and plants fertilized with 200 lb/acre. Fertilizer rates had no significant effect on culls. Response to

Table 4.--Influence of supplemental drip irrigation on yield and fruit length of Sprint 440S staked cucumber in two years

Treatment	Early yield (bu/A) Premium	Early yield (bu/A) Total	Total yield(bu/A) Premium	Total yield(bu/A) Total	Culls %	Fruit length (inches)
			Spring 1985			
Irrigated	256.6	324.0	911.8	1262.2	19.5	7.7
Nonirrigated	187.5	245.7	533.3	810.8	24.2	7.4
Significance	**	**	**	**	**	**
			Summer 1985			
Irrigated	261.2	338.5	395.9	561.5	14.1	---
Nonirrigated	231.1	291.2	335.8	485.0	14.3	---
Significance	**	**	**	**	NS	
			Fall 1985			
Irrigated	158.3	186.6	322.1	408.6	12.4	---
Nonirrigated	162.0	183.8	347.6	443.2	13.6	---
Significance	NS	NS	NS	NS	NS	
			Spring 1987			
Irrigated	270.3	313.0	627.0	819.9	10.1	7.3
Nonirrigated	160.2	205.7	374.0	501.4	12.5	7.0
Significance	**	**	**	**	**	**

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

Table 5.--Effects of preplant N-P-K (13-13-13) rates on yield and fruit length of Sprint 440S staked cucumber in two years

Rates (lb/acre)	Early Yield (bu/acre) Premium	Early Yield (bu/acre) Total	Total Yield (bu/acre) Premium	Total Yield (bu/acre) Total	Culls %	Fruit length (inches)
			Spring 1985			
0 (control)	193.8 b[z]	253.0 b	695.2 a	1001.9 a	22.3 a	7.5 a
200	221.1 a	283.0 a	748.9 a	1066.5 a	22.2 a	7.6 a
400	236.6 a	295.8 a	718.0 a	1027.4 a	21.1 a	7.6 a
600	226.6 a	291.2 a	715.3 a	1029.2 a	22.4 a	7.5 a
800	291.1 a	301.2 a	735.3 a	1057.4 a	21.2 a	7.5 a
			Summer 1985			
0 (control)	236.6 a	300.3 a	339.4 b	478.7 b	14.4 a	---
200	259.4 a	324.9 a	384.0 a	533.3 ab	13.6 a	---
400	250.3 a	330.3 a	372.2 ab	542.4 a	13.0 a	---
600	244.8 a	314.0 a	366.7 ab	539.6 a	14.1 a	---
800	241.2 a	303.9 a	367.6 ab	524.2 ab	16.2 a	---
			Fall 1985			
0 (control)	164.7 a	186.6 a	314.9 b	392.2 b	13.2 a	---
200	152.0 a	180.2 a	323.1 ab	414.1 ab	12.3 a	---
400	162.9 a	191.1 a	340.3 ab	435.9 ab	13.8 a	---
600	157.4 a	183.8 a	330.3 ab	421.3 ab	13.1 a	---
800	165.6 a	185.6 a	364.0 a	465.9 a	12.7 a	---
			Spring 1987			
0 (control)	120.1 c	152.0 c	391.3 c	526.0 c	11.6 a	7.1 b
200	207.5 b	243.0 b	492.3 b	636.1 b	11.7 a	7.1 b
400	208.4 b	252.1 b	496.0 b	650.7 b	11.3 a	7.2 ab
600	253.0 a	308.5 a	538.7 ab	717.1 a	11.7 a	7.4 a
800	285.7 a	341.3 a	584.2 a	772.6 a	10.4 a	7.3 ab

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

fertilizer treatments was mixed in 1985. Only plants in the control produced significantly less yield in some yield categories in the three growing seasons of 1985.

Under irrigation, cucumber plants produced longer and wider leaves (Table 6). Plant spacing had no effect on leaf length and width. Plants fertilized with N-P-K at a rate of 200 lb/acre and higher had longer and wider leaves. N, P, and K contents of the leaves were influenced by irrigation and plant spacing. Irrigation reduced leaf N and increased leaf P significantly. Reducing spacing to six inches between plants reduced leaf P and K. The influence of fertilizer rates on leaf N, P, and K was not clear.

Table 6.--Influence of irrigation, in-row spacing, and fertilizer rates on leaf length, width, and N-P-K leaf contents of Sprint 440S staked cucumber, Spring 1985

	Leaf				
Treatment	Length (inches)	Width (inches)	N %	P PPM	K %
Irrigation					
Irrigated	6.6	8.5	0.799	742	0.351
Nonirrigated	6.2	8.1	0.852	614	0.361
LSD (0.05)	0.1	0.2	0.027	31	NS
Spacing					
6 inches	6.4	8.3	0.813	653	0.342
12 inches	6.4	8.3	0.838	702	0.371
LSD (0.05)	NS	NS	NS	31	0.015
Rates					
0-Control	6.2	8.0	0.823	687	0.348
200	6.4	8.4	0.846	710	0.359
400	6.5	8.3	0.804	648	0.346
600	6.5	8.4	0.811	685	0.372
800	6.4	8.3	0.843	660	0.357
LSD (0.05)	0.2	0.2	NS	49	0.023

There was a significant irrigation x preplant fertilization interaction for early yield (P = 0.0008) and total yield (P = 0.0264) in the spring of 1985 season. The same was true for the 1987 spring season (P = 0.0057 and P = 0.0045 for early and total yield, respectively). The correlation between leaf size and early and total yield was positive, above 0.5 and significant (Table 7).

Foliar spray with Peters Professional 27-15-12 foliar feed in 1983 did not increase premium or total yield and did not affect the percentage of culls. Foliar spray with Response 9-9-7 significantly increased premium and total 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 8).

Table 7.--Pearson correlation coefficients between yield and leaf length and width of Sprint 440S staked cucumber, Spring 1985

	Yield	Length	Width
Early			
	Premium	0.53[z]	0.51
	P > |R|	0.0001	0.0001
	Total	0.52	0.52
	P > |R|	0.0001	0.0001
Total			
	Premium	0.57	0.56
	P > |R|	0.0001	0.0001
	Total	0.57	0.56
	P > |R|	0.0001	0.0001

[z]Correlation coefficients.

Table 8.--Influence of supplemental foliar fertilization on yield of staked cucumber in four years

Treatment	Yield (bu/acre) Premium	Total	Culls %
	Fall 1983 (Peters 27-15-12)		
Fertilized	312.1	460.5	16.4
Unfertilized	320.3	465.9	16.2
LSD 5%	NS	NS	NS
	Spring 1989 (Response 9-9-7)		
Fertilized	422.2	479.6	9.0
Unfertilized	353.1	404.0	10.5
LSD 5%	30.0	30.9	NS
	Spring 1990 (Response 9-9-7)		
Fertilized	722.5	788.1	6.7
Unfertilized	653.4	713.4	7.7
LSD 5%	51.0	51.9	NS
	Spring 1991 (Response 9-9-7)		
Fertilized	733.5	793.5	8.9
Unfertilized	754.4	809.9	10.5
LSD 5%	NS	NS	NS

Black or white polyethylene mulch significantly increased premium and total yields over bare ground in four studies conducted in 1988 through 1991 (Table 9). Black polyethylene mulch produced slightly higher yields than white mulch, but the difference was not significant. Black polyethylene mulch produced significantly less culls than white mulch in one out of four years of study. Bare ground produced more culls in all of the four years of study, but the differences were significant in 1990 and 1991 only (Table 9).

An estimated 63 man-hours were needed to stake one acre of cucumber using the standard system, compared to 28 man-hours in the double-cropping system (Table 10). There was no significant difference in premium

Table 9.--Influence of polyethylene mulch and bare ground on staked cucumber yield in four years

Treatment	Yield (bu/acre) Premium	Yield (bu/acre) Total	Culls %
		Spring 1988	
Black	506.9 a[z]	603.3 a	15.0 a
White	498.7 a	591.5 a	14.1 a
Ground	202.9 b	266.6 b	21.0 a
		Spring 1989	
Black	417.7 a	464.1 a	8.9 a
White	407.7 a	472.3 a	8.2 a
Ground	333.1 b	387.7 b	10.0 a
		Spring 1990	
Black	738.9 a	804.4 a	6.4 c
White	724.4 a	791.7 a	8.2 b
Ground	526.9 b	599.7 b	10.2 a
		Spring 1991	
Black	801.7 a	870.9 a	8.2 b
White	807.2 a	863.6 a	9.9 ab
Ground	621.5 b	678.0 b	11.0 a

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

Table 10.--Estimates of man-hours needed to stake one acre of cucumber by two systems

Activity	Standard	Double-Cropping
Driving rods in ground (1500)	11	---
Tying string to rods (4 levels)	15	---
Tying plants to string		
1st time	10	12
2nd time	12	16
3rd time	15	---
Total	63	28

yield of cucumber staked by the two methods (Table 11). The standard system produced significantly higher total yield in both years. However, the increase in total yield resulted from more No. 2 fruits. There were no significant differences in percentage of culls between the two systems of staking cucumber, except in 1989. The standard system produced significantly more culls in 1989. Cucumber double-cropped with cucumber produced significantly less yield and more culls in the summer of 1990 (Table 12).

Discussion

Results of these studies indicate that substantial yield increases were obtained by vertical training of the cucumber plants. The increased yield

Table 11.--Yield of cucumber staked by the standard and double-cropping systems in two years

Treatment	Yield (bu/acre) Premium	Total	Culls %
		Summer 1988[z]	
Standard	196.6	233.0	7.4
Double-cropping	179.3	198.4	7.6
Significance	NS	**	NS
		Summer 1989	
Standard	491.4	595.1	15.2
Double-cropping	455.0	508.7	9.3
Significance	NS	**	**

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

Table 12.--Yield of two consecutive crops of cucumber planted on same rows without removing polyethylene mulch or stacking structures (double-cropped cucumber), 1990

	Yield bu/acre				Culls	
	Premium		Total		%	
Treatment	Spring	Summer[z]	Spring	Summer[z]	Spring	Summer[z]
Black	738.9 a[y]	434.1 b	804.4 a	491.4 b	6.4 b	16.8 a
White	724.4 a	376.7 b	791.7 a	431.3 b	8.2 b	18.1 a
Ground	526.9 a	335.8 b	599.7 a	397.7 b	10.2 b	24.9 a

[z]Second crop.
[y]Mean separation in rows by Duncan's Multiple Range Test, 5 percent level.

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. More female flowers set and developed into marketable fruits on vertically-trained plants than on untrained plants. Also, the fresh weight of vertically-trained plants was always greater and the size of the leaves was larger than those of unstaked plants.

These results indicate that the upward training of plants increased net photosynthesis, thus increasing assimilates that supported an increased number of fruits. The equal number of female flowers produced by the staked and unstaked cucumber plants and the more 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 set was almost equal for both cultivars, indicating that the

monoecious cultivar produced most of its female flowers on the lateral branches and pruning cucumber (removing lateral branches) would greatly reduce the yield.

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

The in-row spacing most often recommended for fresh market cucumbers is 12-18 inches between plants. In these tests, in-row spacing of six inches between plants increased premium and total yields significantly. The vertical training of plants may have lessened the competition between narrow spaced plants for light, improved other growing conditions, and contributed to higher yields.

The reduction of N, P, K contents of the leaf at 6-inch spacing indicates that higher plant population per unit area may need additional amounts of fertilizer to further enhance the yield. O'Sullivan (1980) reported that increased cucumber population in unstaked culture significantly increased yield.

In the four tests conducted during 1985-1987, supplemental drip irrigation significantly increased yield of Sprint 440S cucumbers in all but the fall season of 1985. The maximum increase in premium and total yields was obtained in the spring season of both years. Also, early yield, which is sold at premium prices, showed a substantial increase due to irrigation. Irrigation increased fruit length, a desired characteristic for marketing slicing cucumbers. Optimum moisture conditions in the root zone with drip irrigation helped reduce percentage of culls in both seasons.

The need for adequate moistúre for staked cucumbers was clearly illustrated in the spring tests. The 17 and 18 inches of rain that fell in the spring seasons of 1985 and 1987, respectively, were not sufficient, and additional irrigation contributed to the substantial increase in yield.

The increased leaf length and width in the irrigated plots and the positive correlation between leaf length and width and every yield category may indicate that additional irrigation increased leaf surface area, which, in turn, increased net photosynthesis, resulting in more assimilates that supported larger numbers of developing fruits.

Even though the summer 1985 test received 20 inches of rain, additional irrigation still significantly increased yield. The upward training of cucumber plants may have contributed to the need for more water in the root zone to compensate for water losses by transpiration and evaporation. The cucumber plants did not need additional irrigation when they received 21.5 inches of rain during the fall 1985 test.

The response to N-P-K fertilizer rates was not so clear in 1985 tests as in 1987. The soil samples taken from the test sites before conducting the experiments in 1985 revealed that the soil was very rich in all three elements. No soil analysis for N-P-K content was made before the 1987 test. However, the test site was not repeatedly planted with vegetable crops or frequently fertilized in previous years as in the 1985 test sites. The response to N-P-K rates in the 1987 test was significant, and 800 lb/acre applied before planting produced the highest yield. However, 600 lb/acre applied before planting had the next to the highest yield with no significant differences.

These results may indicate that preplant rates of N-P-K (13-13-13) ranging from 600 lb/acre to 800 lb/acre are sufficient to produce significantly higher yield of staked cucumbers grown in soils that are not rich in the three elements. The significant irrigation x fertilizer interaction for yield may indicate that yield increase was influenced by frequent irrigation if additional N-P-K was available to maintain higher soil fertility.

Foliar spray with seaweed extract fortified with N-P-K (Response 9-9-7) was more effective in increasing cucumber yield than N-P-K dissolved in plain water (Peter's 27-15-12). Published reports on the exact reasons explaining why this beneficial effect took place are rare. However, 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 cytokinin within the fruits of treated plants were associated with an increase in the dry mass of these fruits. The unusual excess of rainfall in the 1991 growing season may explain the lack of Response 9-9-7 effectiveness. Most of the spray material was washed away after application.

Polyethylene mulch significantly increased the yield of staked cucumber. Results of four years of investigation indicated that either black or white polyethylene mulch can be used to enhance staked cucumber yield. Early season warming of the soil, good retention of moisture, and less weeds under polyethylene mulch may have contributed to superior yields of cucumber. Also, more culls produced by cucumber grown on bare ground may have contributed to the differences between the two systems of culture.

As a warm season crop that produces well under summer conditions, cucumber can be planted following tomatoes in the same field after spraying tomato plants with a herbicide. Tomato skeletons and stakes already in place can provide support for climbing cucumber plants and minimize the cost of staking cucumber. Premium yields produced by cucumber staked by this system did not differ significantly from yields of cucumber staked by the

standard system. Staking cucumber by the standard system resulted in significantly higher total yields, but the increase resulted from more No. 2 cucumber produced by plants staked by the standard system. No. 2 cucumber was a small portion of the total yields.

Another way to minimize the expense of staking cucumber plants is to produce two crops of cucumber on the same staking system. The results of this study indicated that the yield of the second crop (397-490 bu/acre) was not as high as the first crop, but was still higher than the 175-225 bu/acre of unstaked cucumber grown in the summer (Boudreaux, 1991). The second crop was produced under heat stress, and the weather conditions may have contributed to the lower yield. However, polyethylene mulch, drip irrigation lines, stakes, string, and cucumber skeleton from the first crop already in place can reduce the cost of staking the second crop.

The goal of these experiments was not economic evaluation. However, studies conducted by Russo et al. in 1991 indicated that staking cucumber can increase the net profit per acre by $710-799. If polyethylene mulch and drip irrigation installations can be used in the production of more than one crop, reduction in cost can be added to the net profit.

Summary and Conclusions

A decade of research on staked cucumber production indicated that vertical training of plants increased their yields and improved their fruit quality. The increased yields were attributed to increased fruit set and development to marketable size and fruit rot reduction. In-row spacing between staked plants can be reduced to six inches to further increase the yields significantly. Results demonstrated that higher plant populations per unit area may need additional amount of fertilizer to further enhance their yields.

Supplemental drip irrigation proved to be a considerable factor in increasing the yields of staked cucumber, even when rainfall reached 20 inches per growing season. Fertilization with N-P-K (13-13-13) at 600-800 lb/acre was needed to produce significantly higher yields when cucumber was planted in less fertile soils. Less rates of fertilizer were needed when the soil was rich in the three elements. Foliar spray with seaweed extract fortified with N-P-K increased the yields of staked cucumber in two out of three years of investigation.

Black or white polyethylene mulch significantly increased the yields of staked cucumber over bare ground. Cucumber can be double-cropped with tomatoes to minimize the cost of staking cucumber without reduction in

premium yields. Another way to reduce the expense to train the plants up and produce reasonable yields was to plant two successive crops of cucumber on the same staking structure.

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