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) ind... 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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but reduced leaf P and K. Increasing N-P-K rates from 0-0-0 to 52-22-44 lb/acre resulted in a linear increase in leaf length.

Vertical training or staking cucumber plants increases yield, enhances fruit quality and improves the control of foliar and fruit diseases as compared to the traditional method of growing cucumber on the ground (Baker, 1977; Hanna et al., 1987; Konsler and Strider, 1973). The uniform green color of the fruit makes it more attractive to consumers. As a result, demand for staked cucumber fruit is on the rise.

Producing staked cucumbers is more costly than cucumbers grown on the ground (Hanna et al., 1989). However, the increase in yield and superior quality of the fruit should outweigh the extra expense (Russo et al., 1991) and profitability can be enhanced by developing cultural techniques that further improve yields. The objectives of these studies were to evaluate the influence of supplemental irrigation, in-row spacing, and rate of preplant application of N-P-K on staked cucumber production.

Materials and Methods

'Sprint 440 (s)' cucumber was planted in a 2 × 2 × 5 factorial experiment conducted in the spring (Mar. to June), summer (June to Aug.) and fall (Aug. to Oct.) of 1985 and spring (Apr. to July) of 1987. Treatments were supplemental drip irrigation and no drip irrigation, in-row plant spacing of 6 and 12 inches, and preplant fertilization with N-P-K at 0-0-0, 26-11-22, 52-22-44, 78-33-66, 104-44-88 lb/acre. Treatment combinations were arranged in a complete randomized block design with 4 replications.

Water was supplied through half-inch diameter polyethylene distribution lines placed on the top of the rows and connected to the main water line with a pressure regulator and the pressure was set at 8 psi. In-line drippers or emitters were spaced 12 inches apart. Irrigation was based on soil moisture measurement with irrometers (Model R, Irrometer Co., Riverside, CA). Water was applied when soil moisture tension at 6 inch depth reached at least 30 centibars (cb) and stopped when it dropped to 0 cb. Total rainfall from seeding to the last harvest was 17, 20, 21.5 and 18 inches/acre during the 4 seasons, respectively. Fertilizer was applied preplant, broadcast, and disked in.

Rows were spaced 10 feet center to center. Plot size was 10 × 10 feet and included 10 or 20 plants depending on the plant spacing. Cucumber plants were staked by the standard system (Hanna et al., 1989). All plots received 34 lb/acre N (ammonium nitrate 34-0-0) as a side dress applied 4 weeks after planting. Cultural practices, other than irrigation, in-row spacing, and N-P-K rates, were standard commercial practices. Leaf samples collected from each treatment of the 1985 spring test before the first harvest were analyzed for N, P, and K. Cucumbers were harvested 3 times a week for a total of 13, 9, 9 and 10 times in the spring, summer, and fall of 1985 and spring 1987, respectively. Fruits were graded to U.S. Fancy, U.S. No. 1, U.S. No. 2 and culls. Fancy and No. 1 grades were combined and classified as Fancy + No. 1 yield. Marketable yield was the total of Fancy, No. 1, and No. 2 grades.

Soil sample analysis to determine N, P, and K contents was conducted before the 1985 test using Kjeldahl, Spectrophotometric, and Flame photometric methods, respectively (Horwitz, 1970). These analysis revealed that test locations contained at least .10 percent N, .16 percent P and .48 percent K.

Results and Discussion

Supplemental irrigation in the spring and summer seasons of 1985 and spring season of 1987 significantly increased the early and total yield (Table 1). Irrigation also enhanced the quality of the fruit, as was indicated by the increased yield of U.S. Fancy + U.S. No. 1 fruits. Cucumber in the irrigated plots produced significantly less culls and longer fruits in the spring seasons of 1985 and 1987. Yield increase was substantial, especially in the spring seasons. Yields were not affected by irrigation in the fall of 1985.

Table 1. Influence of supplemental drip irrigation on yield and fruit length of 'Sprint 440 (s)' staked cucumber.

	Yield (T/acre)					
	Early		Total			
Treatment	Fancy + No. 1	Marketable	Fancy + No. 1	Marketable	Culls (%)	Fruit length (inches)
			Spring 1985			
Irrigated	6.1	7.7	21.8	30.2	19.5	7.7
Unirrigated	4.5	5.9	12.8	19.4	24.2	7.4
Signif.	**	**	**	**	**	**
			Summer 1985			
Irrigated	6.3	8.1	9.5	13.4	14.1	—
Unirrigated	5.5	7.0	8.0	11.6	14.3	—
Signif.	**	**	**	**	NS	
			Fall 1985			
Irrigated	3.8	4.5	7.7	9.8	12.4	—
Unirrigated	3.9	4.4	8.3	10.6	13.6	—
Signif.	NS	NS	NS	NS	NS	
			Spring 1987			
Irrigated	6.5	7.5	15.0	19.6	10.1	7.3
Unirrigated	3.8	4.9	9.0	12.0	12.5	7.0
Signif.	**	**	**	**	**	**

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

Table 2. Effects of in-row spacing on yield and fruit length of 'Sprint 440 (s)' staked cucumber.

Spacing (inches)	Yield (T/acre) Early Fancy + No. 1	Early Market-able	Total Fancy + No. 1	Total Market-able	Culls (%)	Fruit length (inches)
			Spring 1985			
6	6.1	7.7	19.1	27.0	21.8	7.6
12	4.6	5.9	15.5	22.6	21.9	7.5
Signif.	**	**	**	**	NS	NS
			Summer 1985			
6	6.5	8.3	9.7	13.6	14.6	—
12	5.2	6.8	7.8	11.4	13.9	—
Signif.	**	**	**	**	NS	
			Fall 1985			
6	4.9	5.6	9.5	12.1	13.4	—
12	2.8	3.3	6.5	8.3	12.7	—
Signif.	**	**	**	**	NS	
			Spring 1987			
6	5.7	7.0	12.6	16.8	11.9	7.2
12	4.6	5.4	11.3	14.8	10.7	7.2
Signif.	**	**	**	**	NS	NS

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

Table 3. Effects of preplant N-P-K rates on yield and fruit length of 'Sprint 440 (s)' staked cucumber.

N-P-K (lb/acre)	Yield (T/acre) Early Fancy + No. 1	Early Market-able	Total Fancy + No. 1	Total Market-able	Culls (%)	Fruit length (inches)
			Spring 1985			
0-0-0	4.6	6.0	16.6	24.0	22.3	7.5
26-11-22	5.3	6.8	17.9	25.5	22.2	7.6
52-22-44	5.7	7.1	17.2	24.6	21.1	7.6
78-33-66	5.4	7.0	17.1	24.6	22.4	7.5
104-44-88	5.5	7.2	17.6	25.3	21.2	7.5
Signif.	L***, Q**[z]	L***	NS	NS	NS	NS
			Summer 1985			
0-0-0	5.7	7.2	8.1	11.5	14.4	—
26-11-22	6.2	7.8	9.2	12.8	13.6	—
52-22-44	6.0	7.9	8.9	13.0	13.0	—
78-33-66	5.9	7.5	8.8	12.9	14.1	—
104-44-88	5.8	7.3	8.8	12.5	16.2	—
Signif.	NS	NS	NS	NS	NS	
			Fall 1985			
0-0-0	3.9	4.5	7.5	9.4	13.2	—
26-11-22	3.6	4.3	7.7	9.9	12.3	—
52-22-44	3.9	4.6	8.2	10.4	13.8	—
78-33-66	3.6	4.4	7.9	10.1	13.1	—
104-44-88	4.0	4.4	8.7	11.1	12.7	—
Signif.	NS	NS	NS	L*	NS	
			Spring 1987			
0-0-0	2.9	3.6	9.4	12.6	11.6	7.1
26-11-22	5.0	5.8	11.8	15.2	11.7	7.1
52-22-44	5.0	6.0	11.9	15.6	11.3	7.2
78-33-66	6.1	7.4	12.9	17.2	11.7	7.4
104-44-88	6.8	8.2	14.0	18.5	10.4	7.3
Signif.	L***	L***	L***	L***	NS	L**

[z]Linear (L) or Quadratic (Q) effects significant at P = 0.05 (*), 0.01 (**), 0.001 (***), or nonsignificant (NS).

Reducing in-row spacing between plants from 12 to 6 inches increased early and total yields (Table 2). The increase was significant for Fancy + No. 1 and marketable yields in each of the 4 growing seasons. No change in the percentage of culls or in fruit length resulted from narrowing spacing to 6 inches between plants.

The N-P-K rates had greater effect on yield and fruit length in the 1987 spring season than in 1985. Increasing the rate of N-P-K in 1987 resulted in a linear increase in every yield category and fruit length (Table 3), with the highest yield obtained at 104-44-88 lb/acre and the longest fruit at 78-33-66 lb/acre. Fertilizer rates had no significant effect on the yield of culls. Yield response to fertilizer treatments was mixed in the three growing seasons of 1985. Early yield in the spring of 1985 and total marketable yield in the fall of 1985 increased linearly with the increase of N-P-K rates up to 52-22-44 lb/acre (Table 3).

With irrigation, cucumber plants produced longer and wider leaves (Table 4). Plant spacing had no effect on leaf length and width. Increasing the rate of N-P-K up to 52-22-44 lb/acre resulted in a linear increase in leaf length. The increase in leaf width was a linear as well as a quadratic response (Table 4). The N, P, and K contents of the leaves were influenced by irrigation and plant spacing. Application of irrigation reduced leaf N, increased leaf P significantly, and had no effect on leaf K. Reducing spacing to 6 inches between plants reduced leaf P and K, and had no effect on leaf N. The influence of fertilizer rates on leaf N, P, and K contents was not significant.

There was a significant irrigation × fertilizer interaction effect on early yield (F test, P = 0.001), total yield (F test, P = 0.026) in the spring of 1985 season. The same was true in the 1987 spring season (F test, P = 0.006 and F test, P = 0.005 for early and total yield respectively).

The correlations between yield and leaf length and yield and leaf width were positive, above 0.5, and significant (Table 5).

The results of these experiments demonstrated the need for adequate moisture for staked cucumbers. The 17 and 18 inches of rain which fell in the spring seasons of 1985 and 1987, respectively, were not sufficient, and additional irrigation contributed to the substantial increase in yield. Even though the 1985 summer 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. It was only with 21.5 inches of rain during the 1985 fall test that cucumber plants did not need additional irrigation.

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 number of developing fruits.

The in-row spacing most often recommended for fresh market cucumbers is 12 to 18 inches between plants. The vertical training of plants may have lessened the competition for light, improved other growing conditions, and contributed to higher yields when plants were spaced 6 inches apart. The reduction of N, P, K ontents of the leaf at 6 inch spacing indicates that higher plant population per unit area may need additional amount of fertilizer to further enhance th yield. O'Sullivan (1980) reported that increased cucumber population in unstaked culture significantly increased yield.

Analysis of soil samples taken from the test sites before conducting the experiments in 1985 revealed that the soil was high in all 3 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. Results of the fertilizer tests may indicate that preplant application of N-P-K at a rate of 104-44-88 lb/acre is necessary to produce significantly higher yields of staked cucumbers grown in soils that are not high in the 3 elements. The significant irrigation × 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.

Table 4. Influence of irrigation, in-row spacing, and fertilizer rates on leaf length, width, and N-P-K leaf contents of 'Sprint 440 (s)' staked cucumber, Spring 1985.

	Leaf				
	Length	Width	Concentration (%)		
Treatment	(inches)	(inches)	N	P	K
Irrigation					
Irrigated	6.6	8.5	0.799	0.074	0.351
Nonirrigated	6.2	8.1	0.852	0.061	0.361
Signif.	**	**	**	**	NS
Spacing (inches)					
6	6.4	8.3	0.813	0.065	0.342
12	6.4	8.3	0.838	0.070	0.371
Signif.	NS	NS	NS	**	**
N-P-K (lb/acre)					
0-0-0	6.2	8.0	0.823	0.069	0.348
26-11-22	6.4	8.4	0.846	0.071	0.359
52-22-44	6.5	8.3	0.804	0.065	0.346
78-33-66	6.5	8.4	0.811	0.069	0.372
104-44-88	6.4	8.3	0.843	0.066	0.357
Signif.	L**,Q*[z]	L*,Q*	NS	NS	NS

NS, ** Nonsignificant and significant at the 1% level by F test.
[z]Linear (L) or Quadratic (Q) effects significant at P = .05 (*), 0.01 (**), or nonsignificant (NS).

Table 5. Pearson correlation coefficients between yield and leaf length and width of 'Sprint 440 (s)' staked cucumber, Spring 1985.

	Leaf	
Yield	Length	Width
	Early yield	
Fancy + No. 1	0.53[z]	0.51
Marketable	0.52	0.52
Signif.[z]	***	***
	Total yield	
Fancy + No. 1	0.57	0.56
Marketable	0.57	0.56
Signif.	***	***

[z]Correlation coefficients were significant at P > .0001.

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SLOW RELEASE FERTILIZERS FOR STRAWBERRY FRUIT PRODUCTION

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Abstract. **Slow release N sources of methylene urea, oxamide, sulfur coated urea (SCU), isobutylidene diurea (IBDU), plus NH_4NO_3 and urea and combinations of these sources in the 1988-89 season and formaldehyde coated ammonium sulfate, methylene urea, and SCU in the 1989-90 season were applied to fruiting strawberry (*Fragaria* × *ananassa* Duch.). Nitrogen was applied at 224 kg/ha except for a control which received no N in 1989. Except for the zero N treatment in 1989, there were no significant seasonal differences either season because of N source for fruit yield, average fruit weight, and plant size or color. The 1:1 mixture of SCU and NH_4NO_3 produced the highest Dec. yield and the 3:1 oxamide/urea treatment produced the highest Apr. yield in 1989. During both seasons, leaf N contents varied little because of N source.**

Introduction

Slow release N fertilizer is usually included as a portion of the total N applied by most strawberry growers. The objective is to reduce the leaching that occurs with readily soluble N sources (Albregts and Howard, 1973; Volk, 1964). Generally, the slow-release N source is applied in various combinations with soluble N sources. If the fertilizer is banded properly (Albregts and Howard, 1984), leaching is reduced and the importance of the slow release fertilizer is diminished. A slow-release N source with a N release rate correlated to the plant's requirements may reduce the amount of N required to grow the crop as well as the amount leached. An N source that meets these requirements would be of economic and environmental value.

Studies reported here were conducted to evaluate the fruiting response of strawberry to several slow release N sources.

Materials and Methods

Strawberry was grown during the 1988-89 and 1989-90 winter seasons at AREC-Dover on a Seffner fine sand (sandy siliceous, hyperthermic, Quartzipsammentic Haplumbrepts) using the annual hill cultural system. For the 1988-89 and 1989-90 seasons, pre-fertilization pH was 6.6 and 6.2 and Mehlich I extractable nutrients were 46 and 36 ppm K, 296 and 303 ppm P, 1111 and 1428 ppm Ca, and 30 and 38 ppm Mg, respectively. A randomized complete block design was used the first season, and a factorial with a randomized complete block design was used the second season. Plots were 3 and 2.7 m long and 1.2 wide with 18 plants and 4 replicates and 16 plants and 5 replicates per treatment the first and second seasons, respectively. Fruit production beds were fumigated at 392 kg/ha of bed area with a mixture of 98% methyl bromide and 2% chloropicrin and mulched with black polyethylene. 'Chandler' transplants from Canadian nurseries were grown both seasons and Florida breeding line 79-1126 transplants from Florida nurseries were grown the second season. Treatments each season were N sources and the percent of N applied from each source. During 1988-89, treatments were oxamide 100%, oxamide 75% and urea 25%, oxamide 75% and methylene urea 25%, oxamide 50% and methylene urea 50%, methylene urea 100%, SCU 100%, SCU 50% and NH_4NO_3 50%, IBDU 100%, IBDU 50% and urea 50%, and no N applied. During 1989-90, N treatments were each from a single source. Treatments were SCU, formaldeyde coated ammonium sulfate, and methylene urea. Fertilizer was applied preplant at 224-28-206-33 kg/ha N-P-K-Mg plus 28 kg/ha of a micronutrient mix with 3% B and Cu, 7% Mn and Zn, and 9% Fe. Fertilizer was banded in the bed center 2 inches deep. Transplants were set on 18 Oct. 1988 and 16 Oct. 1989 with 2 rows/bed spaced 11 inches between plants and 12 inches between rows. Recently matured leaves were obtained on 7 Feb. and 5 Apr. 1989 during the first season and 12 Dec. 1989, 29 Jan. and 29 Mar. 1990 during the second season and were analyzed for N using the modified Kjeldahl method (Anonymous, 1980). Overhead sprinkler irrigation was provided for plant establishment, soil moisture, and freeze protection. Soil moisture was maintained between –5 and –20 cb. Fruit were harvested twice weekly from Dec. through Apr., graded, counted and weighed. Marketable fruit were those free of rot, not misshapen, and weighed 10 g or more. Plants were rated visually for size and foliage color (1 = yellow red, 6 = dark green) 3 times each season.

Results and Discussion

During the first season, total marketable fruit yield did not vary because of N source except for the no N treatment (Table 1). Monthly marketable fruit yield generally followed the same pattern (not presented). The seasonal average fruit weight was lowest with no N treatment. Strawberry fertilized with only oxamide or methylene urea as an N source produced fruit of greater size than with no N. The

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