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EVALUATION OF TWELVE GREENHOUSE CUCUMBER CULTIVARS AND TWO TRAINING SYSTEMS OVER TWO SEASONS IN FLORIDA

ROBERT C. HOCHMUTH AND LEI LANI C. LEON
Suwannee Valley Research and Education Center
University of Florida, IFAS
Live Oak, FL 32060

GEORGE J. HOCHMUTH
Horticultural Sciences Department
University of Florida, IFAS
Gainesville, FL 32611

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Abstract. **European seedless cucumber (*Cucumis sativus* L.) is a major greenhouse vegetable crop in Florida with approximately 40 acres grown annually. Twelve seedless cucumber cultivars from six seed companies were evaluated in two seasons in a double layer polyethylene covered greenhouse near Live Oak, FL. Cucumber crops were seeded in rockwool seeding cubes on 5 Sept. 1995 and 13 Feb. 1996. Cucumber fruit were harvested three times weekly and graded according to USDA standards for greenhouse cucumber. Data on fruit yield and quality, and plant susceptibility to powdery mildew were collected and analyzed. Total marketable yield in the fall trial ranged from 11.5 lb per plant for 'Aramon' to 15.2 lb per plant for 'Kalunga'. Total marketable yield in the spring trial ranged from 16.1 lb per plant for 'Discover' to 19.7 lb per plant for 'Marianna'. No significant differences were detected for early yield (first three harvests) in either trial. The highest level of powdery mildew was found in 'Futura', '90-0048', 'B1157', 'E1828', and 'Kalunga' considering both seasons. No significant difference was found in average fruit diameter in either season. Significant differences in fruit length were found in both seasons with lengths ranging from 12.1 inches for 'Fidelio' to 14.0 inches for '90-0048' in the fall; and 13.5 inches for 'Fidelio' to 14.5 inches for '90-0048' in the spring. Two different systems of training the crop were compared. In one training system (drape system), the apical meristem was not removed and the plant was draped over the top trellis wire. The second system (pinch system) required the apical meristem to be removed at the top cable and a side meristem to be trained over the wire. The drape system of training the crop always resulted in higher total yields than the pinch system.**

Introduction

The size of the Florida greenhouse vegetable industry was estimated in 1991 at 66 acres by the University of Florida (Hochmuth, 1991b). A 1996 survey showed the industry had declined to 55 acres (Hochmuth, 1996). The greenhouse cucumber acreage was 42 in both 1991 and 1996. Most of this acreage is represented by one operation on the east coast of Florida. The main greenhouse vegetable crop in North America is tomato. The demand for greenhouse tomatoes has been higher than most other vegetables, therefore creating easier entry into the market. During the early and mid 1990s, greenhouse tomato prices received by growers were very low. As a result, several North Florida growers stopped greenhouse production altogether, or at least were seeking alternative crops such as greenhouse cucumber. Very little information on cucumber cultivar performance has been recently published, especially for the southeastern United States. This trial was conducted to gain updated information on current cultivars and also to evaluate two cucumber plant training systems.

Materials and Methods

Cucumber trials were conducted at the Suwannee Valley Research and Education Center near Live Oak, FL. The greenhouse structure was a stand-alone 22 × 60 ft Quonset with 8-ft sidewalls and wholly covered with two layers polyethylene. The space between the two layers was continuously inflated with air. The greenhouse was heated with propane forced-air heaters and cooled with a fan and evaporative pad system. Minimum temperature was set at 62°F and maximum at 85°F. Even with maximum cooling, temperatures would reach 90 to 92°F during the late spring of 1996.

Seeds of twelve cucumber cultivars from six different companies (Table 1) were planted in rockwool seeding cubes (1.5 × 1.5 × 1.5 inches) on 5 Sept. 1995 and 13 Feb. 1996. Seedlings were grown for two to three weeks using water and a nutrient solution as needed, then transplanted into lay-flat bags of perlite on 19 Sept. 1995 and 7 March 1996. The crop was grown in accordance with the University of Florida perlite production practices (Hochmuth 1991a; Hochmuth and Hochmuth, 1996). Two plants per bag were used in both seasons and the layout provided approximately six square feet per plant. Water and nutrients were supplied by a microirrigation system with one emitter at the base of each plant (two emitters per bag). Irrigation scheduling was determined by a starter tray system to supply 1 to 3 quarts of nutrient solution daily based on plant needs. The starter tray has a probe in a reservoir of solution and when the level of solution drops below the probe, an irrigation event begins. A nutrient solution leachate rate of 15 to 20% was maintained. Leachate was collected and used on other outdoor crops such as turf and pot-

Table 1. Evaluation of twelve greenhouse cucumber cultivars for early (first three harvests) yield during fall 1995 and spring 1996 at Live Oak, FL.

		Early marketable yield (per plant)			
		Fall 1995		Spring 1996	
Cultivar	Seed source	lb	no.	lb	no.
Fitness	Asgrow	3.7	3.3	3.6	3.4
90-0048	Daehnfeldt	3.1	2.8	2.8	2.5
B-1157	Asgrow	3.0	2.8	2.3	2.2
E1828	Enza Zaden	2.8	2.7	2.8	2.6
Discover	DeRuiter	2.7	2.6	2.0	1.9
Millagon	DeRuiter	2.6	3.9	2.5	2.3
Marianna	Rijk Zwaan	2.5	2.5	1.9	1.9
Aramon	Rijk Zwaan	2.5	2.4	1.7	1.6
Futura	Daehnfeldt	2.5	2.4	3.0	2.9
Kalunga	Enza Zaden	2.4	2.3	1.8	1.8
Fidelio	DeRuiter	2.2	2.1	2.9	2.6
Bellissima	Nunhems	2.1	2.0	2.1	1.9
Significance[z]		NS	NS	NS	NS

[z]Treatment effects were not significant (NS) at 5% level of probability.

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ted flowering crops (Hochmuth, 1990). Nitrogen levels were increased from 70 ppm N at transplanting to 180 ppm N at first harvest in the fall and from 100 to 160 ppm N in the spring season. Potassium level was 200 ppm K during the entire season.

Several different cucumber pruning and training systems are used in North America (Johnson and Hickman, 1984; Straver, 1983). In this trial, all flowers on the main stem were removed from the lower 24 inches of stem. Any marketable fruits above 24 inches on the main stem were allowed to grow. Plants were trained up polypropylene twine to a horizontal cable at 8 ft. Upon reaching the top cable, one of two training systems was initiated. The "drape" system allows the main stem to drape over the cable and to grow down to the floor. In the drape system, the apical meristem is not removed. The "pinch" system requires the apical meristem to be removed (pinched out) once reaching the top cable. One side branch was allowed to grow over the top cable and back down to the floor. In both training systems, all other side branches were removed.

Insect pests were monitored by plant inspections and yellow sticky-traps. All incoming air vents, including the evaporative cooling pad, were screened to prevent entry of insects. Common pests included: silverleaf whitefly (*Bemisia argentifolii*), several aphid species, and thrips. Applications of insecticides were made as needed.

Diseases were managed by environmental controls, including horizontal air-flow and a floor-level air and heat distribution system via eight-inch diameter polyethylene tubes. Early season applications of mancozeb (Dithane M-45, Rohm and Haas Co.) were made as a directed spray to the main stems only (Simone, 1996). Powdery mildew was present in both seasons and disease severity ratings were made three times. The rating scale used was: 1 = no powdery mildew, 5 = 50% of leaves with significant mildew apparent, 10 = 100% of leaves with significant mildew apparent.

The experiment was a split-plot in randomized complete block design (two blocks) with cultivars as main plots and training systems as subplots. Treatment combinations were replicated two times and there were four plants per main plot. All fruits were harvested and graded according to USDA grade standards for greenhouse cucumber (Anon, 1985). Measurements of length, width, and weight of each fruit were also recorded. In addition, fruit quality observations were also made on 7 Nov. 1995. Quality comparisons and observations were made on fruit color, fruit wrinkle, and fruit uniformity. A random sample of six fruit from each cultivar was collected on 7 Nov., 1995 and placed on a large table for comparisons and observations. Fruit color ratings were made on a 1-5 scale: 1 = lightest green and 5 = darkest green. Fruit wrinkle ratings were made based on the appearance of the fruit skin. Ratings were on a 1-5 scale: 1 = least fruit skin wrinkle and 5 = most fruit skin wrinkle. The uniformity of the fruit length, diameter, and shape was also rated on a 1-5 scale: 1 = least uniformity of fruit and 5 = most uniformity. Fruits were harvested from 27 Oct. to 29 Dec. 1995 and from 11 Apr. to 5 June 1996.

Results and Discussion

Early marketable yield (first three harvest dates) was not significantly different among cultivars in either season (Table 1). Early yields were typically 2 to 4 lb per plant. Total marketable yield in the fall season was 11.5 to 15.2 lb per plant (Table 2). 'Kalunga', '90-0048', 'E1828', 'Futura', 'B-1157', 'Discover', 'Millagon', 'Fitness', 'Marianna', and 'Fidelio' total yields were not significantly different from each other. Lowest total marketable yield was found in 'Bellissima' and

Table 2. Evaluation of twelve greenhouse cucumber cultivars and two training systems for total season yield and fruit quality for fall 1995 season at Live Oak, FL.

	Yield per plant				
	Total marketable[z]		Fancy	No. 1	Cull
Cultivar	lb	no.	lb	lb	lb
Kalunga	15.2	14.4	9.3	4.0	0.8
90-0048	15.0	13.0	7.4	5.5	0.6
E1828	14.3	12.8	8.9	4.0	0.6
Futura	14.0	13.6	8.1	4.6	0.1
B-1157	13.9	12.8	7.9	4.9	0.8
Discover	13.4	12.4	8.2	4.1	0.2
Millagon	13.2	13.6	8.0	3.7	0.3
Fitness	13.2	11.6	7.8	3.9	0.6
Marianna	13.1	12.2	7.1	4.6	0.6
Fidelio	12.5	11.8	7.3	4.0	0.5
Bellissima	11.6	11.0	7.0	3.4	0.9
Aramon	11.5	11.0	6.4	3.2	0.4
Significance[y]	*	**	NS	NS	NS
LSD(0.05)	2.3	1.6			
Training System					
Drape	14.4	13.5	7.9	4.7	0.7
Pinch	12.4	11.6	7.7	3.6	0.4
Significance	**	**	NS	**	**

[z]Total marketable yield represents the sum of U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades according to United States Department of Agriculture standards for greenhouse cucumber.
[y]Treatment effects were significant at 5% (*) or 1% (**) probability levels or were not significant (NS).

Table 3. Evaluation of twelve greenhouse cucumber cultivars and two training systems for total season yield and fruit quality for spring 1996 at Live Oak, FL.

	Yield per plant				
	Total marketable[z]		Fancy	No. 1	Cull
Cultivar	lb	no.	lb	lb	lb
Marianna	19.7	15.2	10.9	6.0	0.3
Fitness	19.3	14.8	10.3	6.9	0.6
Aramon	19.0	14.1	11.2	5.6	0.3
Kalunga	19.0	14.5	11.3	6.1	0.5
90-0048	18.8	13.9	11.0	5.7	0.3
Millagon	18.6	14.0	11.0	5.4	0.1
Fidelio	18.5	13.6	12.4	4.2	0.3
E1828	18.2	13.8	11.8	5.1	0.1
B1157	18.2	14.2	13.1	4.0	0.6
Futura	18.0	14.2	11.4	5.5	0.2
Bellissima	18.0	14.1	10.0	6.6	0.1
Discover	16.1	12.6	10.1	4.3	0.3
Significance[y]	NS	NS	NS	NS	NS
Training System					
Drape	21.1	15.9	12.4	6.5	0.3
Pinch	15.8	12.2	10.0	4.4	0.3
Significance[y]	**	**	**	**	NS

[z]Total marketable yield represents the sum of U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades according to United States Department of Agriculture standards for greenhouse cucumber.
[y]Treatment effects were significant at the 1% (**) probability level or were not significant (NS).

Table 4. Comparison of average fruit weights for twelve cucumber cultivars and two training systems for fall 1995 and spring 1996 at Live Oak, FL.

	Average fruit weight			
	Fall 1995		Spring 1996	
Cultivar	Early[z]	Total	Early	Total
	(lb)			
Fitness	1.16	1.13	1.05	1.31
B1157	1.10	1.08	1.01	1.29
90-0048	1.08	1.15	1.09	1.34
E1828	1.06	1.12	1.05	1.31
Fidelio	1.05	1.06	1.10	1.36
Aramon	1.05	1.04	0.98	1.35
Bellissima	1.04	1.06	1.05	1.29
Kalunga	1.03	1.05	1.02	1.30
Discover	1.02	1.08	1.01	1.26
Futura	1.02	1.03	1.04	1.27
Marianna	1.01	1.07	0.99	1.30
Millagon	0.83	0.99	1.07	1.32
Significance[y]	NS	NS	NS	NS
Training System				
Drape	1.05	1.07	1.03	1.33
Pinch	1.02	1.07	1.05	1.29
Significance[y]	NS	NS	NS	**

[z]Early season averages were based on the first three harvest dates only.
[y]Treatment effects were significant at the 1% (**) probability level or were not significant (NS).

'Aramon', but were only significantly lower than 'Kalunga' and '90-0048'. Total number of fruit per plant ranged from 11.0 to 14.4, similar to the range among cultivars as in yield. No significant differences were found in fancy, No. 1, or cull yields in the fall season. Fancy yields ranged from 6.4 to 9.3 lb per plant, and No. 1 yields from 3.2 to 5.5 lb per plant.

The drape training system (Table 2) resulted in higher total marketable yields in the fall trial. Average total yield for the drape system was 14.4 lb per plant versus 12.4 for the pinch system. Likewise, a higher number of fruit (13.5 vs 11.6) was found for the drape system. Higher yields of No. 1 and cull fruit were also found in the drape system in the fall of 1995.

Higher total marketable yields ranging from 16.1 to 19.7 lb per plant with 12.6 to 15.2 fruit per plant were found during the spring 1996 trial (Table 3). This higher overall yield was expected due to the longer days and higher light levels during the spring fruiting season. Though higher overall yields were found, no significant differences were detected among cultivars for total marketable, fancy, No. 1, or cull yields, or total number of fruit. The overall yield in these trials was in the range of typical yields reported (Hochmuth, 1991 a; Johnson and Hickman, 1994).

The drape system again resulted in higher total marketable fruit yield and number, fancy yield, and No. 1 fruit yield in the spring. Total marketable fruit yields were at least 5 lb greater where the drape training system was used in the spring of 1996.

Average fruit weights were not significantly different among cultivars in either fall or spring (Table 4). Early average fruit weight in both trials was slightly over 1 lb per fruit. Total season average fruit weight in the fall was slightly over 1 lb per fruit. The total season average fruit weight in the spring was approximately 1.3 lb per fruit. A significant difference in total average fruit weight due to training system was detected only in the spring trial. The drape training system resulted in average fruit weights of 1.33 lb, and the pinch training system of 1.29 lb.

Fruit diameter was not affected by cultivar or training system in either season (Table 5). Fruit diameters were 1.9 inches in the fall and 2.0 inches in the spring. There were, however, significant differences in fruit length among cultivars in both seasons. Fruit lengths ranged from 12.1 to 14.0 inches in the fall and from 13.5 to 14.5 inches in the spring. Regardless of season, the longest fruit was found in '90-0048' and the shortest in 'Fidelio'. Average fruit lengths of 13 inches in the fall or 14 inches in the spring were common among cultivars. The training system affected only fruit length in the

Table 5. Effect of cultivar and trellis system on cucumber fruit length and diameter in fall 1995 and spring 1996 at Live Oak, FL.

	Fall season		Spring season	
Cultivar	Fruit length	Fruit diameter	Fruit length	Fruit diameter
	(inches)			
90-0048	14.0	1.9	14.5	2.0
Discover	13.4	1.9	13.8	2.0
Fitness	13.2	1.9	14.1	2.1
Kalunga	13.2	1.9	14.2	2.0
Belissima	13.1	1.9	14.1	2.0
Aramon	13.1	1.9	14.3	2.1
E1828	13.0	1.9	14.0	2.0
Marianna	13.0	1.9	14.0	2.0
Milligon	12.9	1.9	14.4	2.0
B1157	12.8	1.9	14.0	2.0
Futura	12.4	1.9	13.6	2.0
Fidelio	12.1	1.9	13.5	2.0
Significance[z]	**	NS	**	NS
LSD (0.05)	0.7		0.5	
Training System				
Drape	13.1	1.9	14.3	2.0
Pinch	13.0	1.9	13.7	2.0
Significance[z]	NS	NS	**	NS

[z]Treatment effects were significant at 5% (*) or 1% (**) probability levels or were not significant (NS).

Table 6. Susceptibility of twelve cucumber cultivars to powdery mildew in fall 1995 and spring 1996 at Live Oak, FL.

	Powdery mildew rating[z]		
	Fall season		Spring season
Cultivar	6 Nov.	16 Nov.	21 May
	Ratings (1-10)		
Futura	7.8	7.5	1.0
B1157	7.0	7.3	0.5
90-0048	7.0	6.3	3.0
E1828	6.5	4.5	3.5
Fitness	6.5	6.3	0.0
Millagon	5.5	5.0	0.0
Aramon	4.8	4.5	0.0
Kalunga	4.8	5.3	3.0
Marianna	3.0	3.8	0.0
Fidelio	2.8	4.0	0.0
Discover	2.5	3.0	0.0
Bellissima	2.3	3.3	0.0
Significance[y]	**	**	**
LSD (0.05)	3.2	2.5	1.1

[z]Powdery mildew rating scale; 1 = no mildew, 10 = severe mildew.
[y]Treatment effects were significant at 1% (**) probability level.

Table 7. Fruit quality observations of twelve greenhouse cucumber cultivars on 7 Nov. 1995 at Live Oak, FL.

Cultivar	Color[z]	Wrinkle[y]	Uniformity[x]
	Ratings (1-5)		
Bellissima	5	4	4
Kalunga	5	3	4
E1828	5	3	4
Millagon	4	3	4
Fidelio	4	2	3
Discover	4	3	5
90-0048	4	3	4
Aramon	4	5	4
Marianna	4	4	4
B-1157	4	5	5
Fitness	4	3	3
Futura	3	3	4

[z]Fruit color rating; 1 = light green, 5 = dark green.
[y]Fruit wrinkle rating; 1 = least skin wrinkle of fruit, 5 = most skin wrinkle of fruit.
[x]Fruit uniformity rating; 1 = least uniform fruit, 5 = most uniform fruit. Uniformity ratings considered length, diameter, and shape.

spring. Fruit were longer in the drape system (14.3 inches) than in the pinch system (13.7 inches).

Powdery mildew was present in both seasons, but, more prevalent in the fall (Table 6). Fall ratings ranged from 2.3 (least mildew) to 7.8 (most mildew). Lower ratings were found in the spring, ranging from 0 to 3.5. Powdery mildew ratings were very low for 'Bellissima', 'Discover', 'Fidelio', and 'Marianna' in either season. The highest fall ratings were found in 'Futura', 'B1157', '90-0048', 'E1828', and 'Fitness'. The highest spring ratings were found in 'E1828', '90-0048', and 'Kalunga'.

The darkest green fruit were found in 'Bellissima', 'Kalunga', and 'E1828' (Table 7). The lightest green color was found in 'Futura'. The highest level of fruit wrinkle or ridging was found in 'Aramon', 'B1157', with the least found in 'Fidelio'. The lower the level of fruit wrinkle or ridging, the smoother and more desirable the fruit appears. The most uniformity for size and shape among fruit was found in 'Discover' and 'B-1157'. The least uniformity for size and shape among fruit was found in 'Fidelio' and 'Fitness'.

Considering overall performance of the cultivars in terms of yield, quality, and disease tolerance, several cultivars performed satisfactorily for Florida conditions. It is difficult to determine consistencies across all cultivars in both trials, however, a few trends seemed to appear. 'Kalunga' had outstanding overall performance among the top four cultivars in yield and fruit length in both spring and fall. Additionally 'Kalunga' had the darkest green fruit color along with 'Bellissima' and 'E1828'. One concern was the high incidence of powdery mildew in 'Kalunga' during the spring. Another top performer was '90-0048'. A consistent problem with '90-0048' was the high susceptibility to powdery mildew in both trials. 'Futura' was similar in yield to several other cultivars, but it had shorter fruit than all cultivars, except 'Fidelio'. 'Futura' was also very susceptible to powdery mildew and had lighter green fruit color than all other cultivars. 'Fidelio', a long-time standard cucumber cultivar, produced the shortest fruit yet smoothest skin of those cucumbers evaluated. If a market prefers a shorter cucumber, 'Fidelio' may be a good selection.

Most other cultivars did not perform in a clear or consistent manner to allow an overall summary. It should be emphasized powdery mildew can be a serious production problem. '90-0048', 'E 1828', 'Futura', and 'B-1157' consistently had the highest level of powdery mildew disease in both seasons.

The summary of the comparisons of the two training systems used in these trials indicate the drape system produced higher yield and quality in most instances. The pinch system resulted in a delay in new growth before the side branch began to produce fruit.

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