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BEIT ALPHA CUCUMBER—AN EXCITING NEW GREENHOUSE CROP

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Abstract. **'Beit Alpha' cucumbers (*Cucumis sativus* L.) are commonly grown in protected structures in the Middle-East and Israel, and are thus adapted to the warm climates of Florida. Traditionally, greenhouse cucumber cultivars grown in the U.S. are Dutch-types. Six Beit Alpha cultivars were compared to three Dutch-type cultivars over three seasons in Gainesville, FL. Seedlings were transplanted into perlite bags on 31 March 1999, 30 September 1999, and 16 February 2000 and were grown in a double layer polyethylene-covered greenhouse with passive ventilation. All six Beit Alpha cultivars produced more early and total marketable yield in all seasons than the Dutch cultivars. Total marketable fruit numbers among all Beit Alpha cultivars were greater in the spring than in the fall. Numbers of Dutch-type fruit produced were similar among cultivars in all seasons. Cull weight was greater in the spring than the fall, but was not significantly different among cultivars. Fruit length and diameter were significantly different between seasons and cultivars. The Dutch types were more wrinkled than the Beit Alpha types and uniformity was the same among all cultivars. Powdery mildew ratings were similar for both seasons when chemical fungicides were used. When powdery mildew was present and chemical control was not used, the Beit Alpha cultivar 'Alexander' and the Dutch cultivars 'Bologna' and 'Kalunga' had better tolerance than all other Beit Alpha cultivars. Beit Alpha cucumbers can be successfully grown year-round in Florida and offer an exciting new greenhouse crop for Florida producers. They will be a strong competitor for the traditional Dutch-type greenhouse cucumber once introduced in the market place.**

The number of greenhouse vegetable producers in Florida is increasing. In 1996, there were approximately 55 acres of vegetable greenhouses in Florida (Hochmuth, 1996). Today, there are approximately 84 acres throughout Florida. The largest areas for greenhouse production of vegetables are found primarily in three locations: southwest coast (Naples), southeast coast (Ft. Pierce), and north-central (Live Oak) Florida. With the rapidly growing population in Florida, demands for land, water, and other natural resources are increasing. Much of the urban development occurs in areas traditionally devoted to agricultural production (Gordon, 1998). Because of increased plant densities and longer growing seasons, hydroponic greenhouse production can provide yields greater than field-grown vegetable crops (Eversole, 1999, Johnson, B., 1999), thus, reducing the need for land, especially for crop rotation. The increase in the number of greenhouse vegetable producers in Florida could be because greenhouse vegetable production has been looked at as an alternative to using the soil fumigant methyl bromide (Anon., 1999). Greenhouse vegetables are commonly grown in sterile media such as perlite or rockwool that does not require chemical fumigation. Furthermore, greenhouses provide an excellent place to produce consistent, superior quality produce that brings a higher price at the market than field-grown produce (Johnson, G., 1999).

Vegetable producers in Florida have an advantage of being able to produce for the winter market, but must compete with other countries such as Canada, Holland, Mexico, and more recently, Spain and Israel (Cantliffe and VanSickle, 2000). The commodities of main competition are tomato, pepper, and cucumber. Florida, like Spain, has a major environmental advantage over Holland. For instance, although yields are nearly 3 times greater from Holland than Almería in Southeast Spain (i.e., tomato: 42 $kg \cdot m^{-2}$ compared to 12 $kg \cdot m^{-2}$, respectively), inputs are much greater in Holland for fossil fuels used to cool and heat their greenhouses (Costa and Heuvelink, 2000). Thus, warmer climates, such as Florida, have great savings advantages in production costs compared to Canada or Holland.

The lower yields reported from Almería, Spain may be due to the source of germplasm growers have available. Until recently, the majority of greenhouse vegetable seed has been from Dutch sources. This germplasm was developed for cooler environments with lower solar radiation than that found in such regions as Spain, Israel, or Florida. Israeli seed sources are now available worldwide and may be adaptable to Florida because of the similar climates of the two regions. Quite common to the European market are the 'Galia' melon and the 'Beit Alpha' cucumber. Both cultivars were developed in Israel especially for greenhouse or protected-agriculture cultivation.

New to the U.S. is the Beit Alpha cucumber, a major primary cucumber type grown in Israel and exported to Europe. The Beit Alpha cucumber originated on a Kibbutz in Israel and is now being distributed by several seed companies in the U.S. and Israel. Beit Alpha cucumbers are hybrids that are gynoecious and parthenocarpic, thus they do not need to be pollinated. The fruit is seedless and has a thin skin like the Dutch cultivars but does not require plastic wrap to prevent dehydration after harvest. Fruit production is prolific for Beit Alpha cultivars; many fruit set at each node and on the laterals. Yields can be compact (10 harvests or less) or continuous (more than 30 harvests) depending on season. Beit Alpha cultivars grow well under extreme environmental conditions, especially high temperature (35-40°C), but also continue to produce well at low temperatures (10-15°C).

As part of a Florida-Israeli Protected Agriculture Project, the Horticultural Sciences Department at the University of Florida and several Israeli agricultural companies are working together to promote and improve the greenhouse industry in the southeastern U.S. An important goal of the project is to adapt Israeli technology and especially new commodities for production in Florida. The objectives of this research were to identify suitable Beit Alpha cucumber cultivars for green-

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house production in Florida and compare yield and fruit quality to standard Dutch types commonly used in greenhouse production, potentially to introduce a new commodity for U.S. consumers and Florida producers.

Materials and Methods

Cucumbers were grown at the Horticultural Research Unit in Gainesville, Florida. The greenhouse structure (Top Greenhouses Ltd., P.O. Box 207, Rosh Ha'ayin 48101, Israel) was covered in double layer polyethylene with passive ventilation. The sidewalls were 3.6-m high and there was a 1-m roof vent at 8 m. Both sidewalls and roof vents were covered with 0.6 mm screen to prevent the movement of insects into or out of the greenhouse. Greenhouse temperature was not manipulated through either heating or cooling and cucumbers survived nights as low as 5°C and days as high as 43°C. Temperatures were measured every 15 minutes at various locations in the greenhouse using thermocouples and recorded by a datalogger (CR10, Campbell Scientific, Inc., 815 W. 1800 N. Logan, Utah 84321-1764) to have complete knowledge of temperature fluctuations (Jovicich, 2000).

Transplants were grown for 3 weeks in an evaporative pad-cooled glasshouse at temperatures of 28°C day and 22°C night. Transplant medium was a mixture of 60% peat and 40% vermiculite. Transplants were fertilized twice weekly with Peters Professional All Purpose Plant Food (Spectrum Group, P.O. Box 15842, St. Louis, MO 63114-0842). Six Beit Alpha cultivars and three Dutch-type cultivars were transplanted into 1 m × 0.32 m white-polyethylene sleeves (Agrodynamics, 10 Alvin Court, East Brunswick, NJ 08816) filled with perlite (Airlite Processing Corp. of Florida, 3505 65th St., Vero Beach, FL 32967) on 31 March 1999, 30 September 1999, and 16 February 2000. Beit Alpha cultivars were 'Alexander', 'Dishon', 'Sarig', and 'Suzan' from Hazera Seeds Inc. (745 Balboa St., Grover Beach, CA 93433), and 'Ilan' and 'Rambo' from Zeraim Gedera (P.O. Box 103, Gedera 70750, Israel). The Dutch-type cultivars were 'Long John' from Zeraim Gedera, 'Bologna' from Rijk Zwaan Export B.V. (P.O. Box 40, 2678 ZG DeLier, The Netherlands), and 'Kalunga' from Enza Zaden (407 Front St., Salinas, CA 93901).

Irrigation scheduling was based on plant need to achieve 15-20% daily leachate from the bag. A programmable timer, Sterling 12 (Superior Controls Co., Inc., 24950 Avenue Kearny, Valencia, CA 91355-2142) was used for irrigation. Plants were fertilized at each irrigation in accordance with University of Florida recommendations (Hochmuth and Hochmuth, 1996; Hochmuth, 1991). A complete nutrient solution was provided to the plants with nitrogen (N) levels increased from 100 ppm N at transplanting to 180 ppm at first harvest and maintained at 180 ppm N for the remainder of the crop in all seasons. Potassium (K) level was 150 ppm K throughout the season. Phosphorus, calcium, magnesium, sulfur and all micronutrient concentrations remained the same throughout the crop for all seasons at 50 ppm P, 135 ppm Ca, 50 ppm Mg, 65 ppm S, 3 ppm Fe, 0.2 ppm Cu, 0.8 ppm Mn, 0.3 ppm Zn, 0.7 ppm B, 0.06 ppm Mo. The pH of the nutrient solution was maintained between 5.5 and 6.5.

Plants were individually trellised on twine (Paskal Binding Accessories, Ltd., P.O. Box 54, Migdal Tefen 24959, Israel). The twine hung from a cable harnessed at a height of 3.6 m and was connected at the base of each plant with a plastic clip. As the plants grew, they were twisted around the twine for support. When fruit load caused the plant to slip down the twine, a clip was added under the fruit node for support.

Pruning of the two types of cucumber was different. All laterals and fruit were removed up to the 8th node for both types. The Dutch-type plants were grown in a single stem training system where only one fruit was allowed to develop at each node and the laterals were removed at the main stem. The Beit Alpha types were also trained to a single stem; however, the Beit Alpha types set many quality fruit at each node and set multiple fruit on the laterals, therefore, we did not remove the laterals. Information on how to prune Beit Alpha types was lacking, therefore, to avoid excess vegetative growth, the laterals were pruned at their second node.

Powdery mildew (*Sphaerotheca fuliginea*) was present during all three seasons. In spring and fall 1999, information on using biological control in our type of greenhouse was limited; thus, we did not use biological control for either insects or disease. Application of insecticides and fungicides were made as needed. In both spring and fall 1999, a once weekly application (rotated) of the insecticides M-pede (fatty acid soap, Mycogen Corp., 550 Oberlin Dr., San Diego, CA 92120), Dipel (*Bacillus thuringiensis*, subsp. *kurstaki*, Abbott Laboratories, Inc., North Chicago, IL 60064-6316), or XenTari (*Bacillus thuringiensis*, subsp. *aizawai*, Abbott Laboratories, Inc.) was made. Furthermore, a once weekly application of either Dithane (mancozeb, Rohm & Haas Co., 100 Independence Mall West, Philadelphia, PA 19106-2399) or sulfur fungicide was used. In spring 2000, Quadris (azoxystrobin, Zeneca Agricultural Products, 1800 Concord Pike, Wilmington, DE 19650) fungicide was applied twice after planting. Thereafter, a biological fungicide, AQ 10 (Ecogen, Inc., 2000 West Cabot Boulevard #170, Langhorne, PA 19047-1811), was used in the spring of 2000. Cultivars were rated at the end of each season for powdery mildew severity on a 1-10 rating scale, where 1 = <10% of leaves with powdery mildew, 2 = 20%, 3 = 30%, 4 = 40%, 5 = 50%, 6 = 60%, 7 = 70%, 8 = 80%, 9 = 90%, and 10 = 100% of leaves with mildew.

At the end of each season, each plot was rated for plant appearance to estimate plant vigor. Plant appearance ratings were on a 1-5 rating scale, where 1 = plants in full fruit production, 2 = green plants, partial fruit production, 3 = plants with yellow or pale green leaves, low fruit production, 4 = plants mostly yellow, very low fruit production, and 5 = no fruit production.

Insect pests were monitored using yellow sticky cards (Whitmire Micro-Gen, Research Laboratories, Inc., 3568 Tree Court Ind. Blvd., St. Louis, MO 63122) and daily scouting. NATUPOL bumblebees (*Bombus impatiens*, from Koppert Biological Systems, Inc., 28465 Beverly Rd., Romulus, MI 48174) were used for pollination of other crops in the greenhouse (but not for the cucumbers), thus, compatible pest control measures were necessary including biological control. In the spring 2000 season, approximately 3000 adult lady beetles (*Hippodamia convergens*, from IPM Laboratories, Inc., P.O. Box 300, Locke, NY 13092-0300) were released weekly for control of the green peach aphid (*Myzus persicae*). *Aphidius colemani* (from IPM Laboratories, Inc.), a parasitic wasp of the green peach aphid, was released as 500 adults for 3 weeks to establish a population. *Neoselius californicus* (from IPM Laboratories, Inc.), a predator mite which feeds on two-spotted spider mite (*Tetranychus urticae*) was released twice, first as 5000 adults and a week later as 10,000 adults. Unfortunately, the population of predator mites needed to control the two-spot-

ted spider mite could not be established at high temperatures. Approximately 250 *Geocris puncipes* nymphs (from Entomos, LLC, 4445 SW 35th Terrace, Suite 310, Gainesville, FL 32608) were released once to control the green peach aphid and the two-spotted spider mite.

The experiment was conducted using a randomized complete block design with three blocks. Each plot consisted of two lay-flat bags with three plants per bag. Planting, harvesting, and quality measurement dates are reported in Table 1. Dutch-type fruit were harvested and graded according to USDA grade standards for greenhouse cucumber (Anon., 1985). Beit Alpha fruit were harvested and graded according to recommendations from Israeli seed companies. Beit Alpha fruit were first harvested in spring 1999 when fruit diameter was approximately 6 cm. Upon the recommendation of representatives from Israeli seed companies during fall 1999, Beit Alpha fruit were harvested at approximately 4 cm diameter, which more closely resembles fruit sold in the European market. For all cultivars, fruit number and weight were recorded for each plot. Marketable fruit numbers were recorded using modified USDA grades of fancy, No. 1, and oversize. Fancy fruit were straight, uniform green color and no blemishes. No. 1 fruit could have a slight curve or bell-shape, uniform green color and no blemishes. Oversize fruit were fancy or No. 1 fruit that were harvested one or two days after full maturity. Fruit quality measurements (length, width, appearance) were conducted three times in spring and fall 1999, and twice in spring 2000. Five fancy grade fruit from each plot were measured for length and width. Total fruit per plot were rated for wrinkle of fruit skin and fruit uniformity. All treatments were compared side by side to develop a scale. Ratings were on a 1-5 scale: 1 = least fruit skin wrinkle (smooth skin) and 5 = most fruit skin wrinkle. Fruit uniformity was also rated on a 1-5 scale: 1 = least uniformity of fruit; all fruit were of different length, diameter, and shape, and 5 = most uniformity; all fruit were of similar length, diameter and shape (Hochmuth et al., 1996).

The data were subjected to analysis of variance and means were separated using Duncan's multiple range test, 5% level (SAS Institute).

Results and Discussion

Plants were harvested 23 times in spring 1999, 30 times in fall 1999, and 20 times in spring 2000. Early yield consisted of the first 8 harvests in spring 1999 and spring 2000, and the first 10 harvests in fall 1999 (Table 2). Marketable yield is the combined total of straight fruit with no blemishes (fancy), bell-shaped or slightly curved fruit with no blemishes (No. 1), and oversized fruit (fancy or No. 1 fruit harvested 1-2 days past full maturity). There was a significant two-way interaction between season and cultivar for marketable and fancy number and weight of cucumber fruit. While there were significant differences among cultivars, marketable and fancy number and weight of cucumber fruit for each cultivar did not differ between spring 1999 and spring 2000. Of all cultivars, 'Dishon' produced the greatest number of early fruit in the spring with 14 fruit per plant, but in the fall, 'Sarig' produced the greatest number of early fruit with 16 fruit per plant. 'Bologna' and 'Kalunga' produced more early fruit in the fall than the spring (6 and 8 fruit per plant compared to 3 and 2 fruit per plant, respectively), while production from 'Long John' was the same in both seasons (7 fruits per plant).

Average fruit weight was significantly different between seasons (Table 3). Because delivery of seeds from Holland was delayed, the Dutch cultivars were planted 2 weeks later than the Beit Alpha cultivars in spring 2000; therefore, there was no recorded yield during the first 8 harvests of those plots. Fruit weight of 'Long John' was greater in spring 1999 than fall 1999. This variation was attributed to differences in environment between the spring and fall seasons (it was not grown in spring 2000 because seed was not available). For the Beit Alpha cultivars, average fruit weight decreased over each of the three seasons. The reason for these differences is explained in the discussion of Table 6.

There was a significant interaction between season and cultivar for total marketable number and yield of cucumber fruit (Table 4). Total number of marketable cucumber fruit was greatest for all cultivars in spring 1999. Of the Beit Alpha cultivars, 'Ilan' and 'Rambo' yielded similarly in both fall 1999 and spring 2000 (33 and 36 fruit per plant, respectively). All other cultivars produced more marketable fruit in the spring than the fall. 'Sarig' produced superior yields over all Dutch cultivars in both spring 1999 and spring 2000 in which yield for 'Sarig' was approximately three times greater than the yield from the Dutch-types (66 and 44 fruit per plant, respectively, compared to 23 and 14 fruit per plant, respectively). The number of Dutch-type fruit produced was similar among Dutch cultivars for all seasons (12-23 fruit per plant depending on season).

Marketable fruit weight per plant was greatest in spring 1999 compared to either fall 1999 or spring 2000. There were no significant differences among cultivars for total marketable fruit weight per plant in spring 1999. The average marketable fruit weight per plant in spring 1999 from either the Beit Alpha-types or Dutch-types was approximately 11.7 kg. In fall 1999, marketable fruit weight per plant was significantly different among all cultivars. The greatest yields were from the Beit Alpha-types 'Ilan' and 'Rambo' with 8.6 and 8 kg fruits per plant, respectively, and the Dutch-type 'Kalunga' with 8.5 kg fruits per plant. The lowest yield in fall 1999 was from the Beit Alpha cultivar 'Alexander' at 5.5 kg of fruit per plant. In spring 2000, there was no significant difference in marketable weight per plant among Beit Alpha cultivars and they yielded more than the Dutch-types (6.1 compared to 4.3 kg per plant).

Table 1. Planting and harvesting dates for 3 seasons of greenhouse cucumber. Gainesville, Florida. Spring 1999, Fall 1999, and Spring 2000.

Dates	Spring 1999	Fall 1999	Spring 2000
Planting	31 March, 1999	30 Sept., 1999	16 Feb., 2000
1st Harvest	1 May, 1999	28 Oct., 1999	13 March, 2000
Last Harvest	1 July, 1999	26 Jan., 2000	28 April, 2000
Total Harvests	23	30	20
Quality Measurements	4 May, 20 May, and 10 June, 1999	8 Nov., 14 Dec., 1999 and 6 Jan., 2000	31 March and 14 April, 2000

Table 2. Means for early greenhouse cucumber yield for two spring seasons and one fall season. Gainesville, Florida. Spring 1999, Fall 1999, Spring 2000.

	Spring 1999/Spring 2000				Fall 1999			
Cultivar[z]	Market no.	Market wt. (kg)	Fancy no.	Fancy wt.	Market no.	Market wt. (kg)	Fancy no.	Fancy wt.
Beit Alpha				Yield per plant				
Alexander	12.7 ab	2.4 b	9.9 b	1.8 b	10.6 cd	2.2 cd	9.9 bcd	2.1 bc
Dishon	14.3 a	2.4 b	11.9 a	2.0 b	13.6 b	2.4 cd	12.0 b	2.2 abc
Sarig	12.0 b	2.0 b	9.7 b	1.5 bcd	16.2 a	2.7 bcd	14.4 a	2.4 ab
Suzan	12.6 b	2.2 b	10.0 b	1.7 b	12.3 bc	2.3 cd	11.1 bc	2.1 bc
Ilan	11.2 b	2.2 b	8.3 b	1.6 bc	9.6 de	2.2 d	8.5 de	2.0 bc
Rambo	12.3 b	2.5 b	8.8 b	1.7 b	1.7 cd	2.5 cd	9.6 cd	2.2 abc
Dutch-type								
Long John	7.4 c	3.9 a	6.0 c	3.4 a	7.7 ef	3.0 ab	5.1 fg	2.0 bc
Bologna	3.1 d	1.2 c	2.4 d	1.0 cd	6.3 f	2.7 bc	4.2 g	1.9 c
Kalunga	2.3 d	0.9 c	2.1 d	0.8 d	8.2 ef	3.2 a	6.6 ef	2.6 a
R-square	0.95	0.82	0.94	0.84	0.91	0.73	0.91	0.57

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.

Cull number or weight per plant did not differ between spring seasons, but were different between both spring seasons and the fall (Table 5). Cull numbers were low due to the continual removal of poor quality fruit before maturity. Removal of aborted flowers or poor quality fruit was a necessary procedure for sanitation and to insure a constant set of new flowers for production of quality fruit. More culls were recorded from four of the six Beit Alpha cultivars than the Dutch cultivars in both spring and fall seasons. Cull fruit may have been missed during pruning due to excess vegetation from Beit Alpha-type plants compared to Dutch-type plants; however, in most cases, cull numbers reported from the Beit Alpha cultivars were less than 10% of the total number of fruit harvested (compared to 20% of the total number of Dutch fruit harvested). For all cultivars, weight of cull fruit was less than one kilogram per plant per season.

Average fruit weight for each cultivar was different among the three seasons (Table 6). In all seasons, the average fruit weight for all Beit Alpha cultivars was less than half that of the Dutch cultivars. There were no significant differences in average fruit weight among the Dutch cultivars in either spring 1999 or fall 1999 (approximately 500 g per fruit in spring 1999 and 395 g per fruit in fall 1999). There was approximately a difference of 35 grams per fruit among average fruit weights of the Beit Alpha cultivars in fall 1999. Average fruit weight of 'Ilan' was greater than the other Beit Alpha cultivars, except 'Rambo', in fall 1999 (247 g per fruit compared to 156 to 189 g per fruit). In spring 2000, 'Ilan' fruit were heavier than 'Sarig', but other than that, there were differences in average fruit weight of Beit Alpha cultivars (approximately 134 g per fruit). Average fruit weight of the Dutch-type 'Bologna' was significantly greater than 'Kalunga' (310 g per fruit compared to 295 g per fruit, respectively) and the Beit Alpha-type cultivars. Through all seasons, 'Sarig' produced the lightest Beit Alpha-type fruit (10 to 20 g per fruit less than the next lightest Beit Alpha-type), although not always significantly different from the others.

The difference in average fruit weight between seasons may have been due to the uncertainty about when to harvest the Beit Alpha-type fruit. There is little information either in the scientific literature or seed catalogs regarding production

Table 3. Average fruit weight of greenhouse cucumber for early harvest. Gainesville, Florida. Spring 1999, Fall 1999, Spring 2000.

Cultivar[z]	Spring 1999	Fall 1999	Spring 2000
Beit Alpha		grams per fruit	
Alexander	211 b	216 d	131 ab
Dishon	186 b	183 e	125 b
Sarig	167 b	170 e	129 ab
Suzan	192 b	193 de	129 ab
Ilan	224 b	248 c	133 ab
Rambo	225 b	251 c	135 a
Dutch-type			
Long John[y]	522 a	391 b	—
Bologna	407 a	444 a	—
Kalunga	387 a	401 b	—
R-square	0.81	0.98	0.78

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[y]Not seeded in spring 2000.

Table 4. Means for total marketable greenhouse cucumber yield. Gainesville, Florida. Spring 1999, Fall 1999, and Spring 2000.

	Marketable number per plant			Marketable weight (kg/plant)		
Cultivar[z]	Spring 1999	Fall 1999	Spring 2000	Spring 1999	Fall 1999	Spring 2000
Beit Alpha						
Alexander	52.2 b	27.6 ab	39.7 ab	12.9	5.5 b	6.1 a
Dishon	52.2 b	32.2 a	42.9 a	11.5	5.8 ab	6.1 a
Sarig	66.8 a	36.7 a	44.2 a	12.9	6.0 ab	6.1 a
Suzan	45.1 b	31.6 a	42.2 a	10.1	5.7 ab	6.3 a
Ilan	46.7 b	33.0 a	34.3 c	12.3	8.6 a	5.9 a
Rambo	51.0 b	36.4 a	36.2 bc	13.8	8.0 ab	5.8 a
Dutch-type						
Long John[y]	22.6 c	16.8 c	—	11.6	4.5 ab	—
Bologna	19.5 c	15.6 c	12.7 d	10.2	6.8 ab	4.1 b
Kalunga	23.8 c	21.2 bc	14.3 d	10.1	8.5 a	4.4 b
R-square	0.46	0.79	0.97	0.46	0.48	0.91

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[y]Not seeded in spring 2000.

Table 5. Means of culls harvested for the season of greenhouse cucumber. Gainesville, Florida. Spring 1999/Spring 2000 and Fall 1999.

	Spring 1999/ Spring 2000		Fall 1999	
Cultivar[z]	Cull no.	Cull wt. (kg)	Cull no.	Cull wt. (kg)
Beit Alpha	Yield per plant			
Alexander	5.0 a	0.8	3.0 bc	0.5 bc
Dishon	4.9 a	0.6	2.8 c	0.3 c
Sarig	5.3 a	0.6	5.6 a	0.7 ab
Suzan	3.7 ab	0.5	4.7 a	0.7 ab
Ilan	3.5 ab	0.6	4.4 ab	0.7 ab
Rambo	4.3 a	0.5	5.2 a	0.8 a
Dutch-type				
Long John	2.4 bc	0.8	2.4 c	0.5 abc
Bologna	2.1 bc	0.6	2.7 c	0.6 ab
Kalunga	1.6 c	0.5	1.7 c	0.5 abc
R-square	0.65	0.70	0.80	0.60

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.

Table 6. Average fruit weight for total harvest of greenhouse cucumber. Gainesville, Florida. Spring 1999, Fall 1999, Spring 2000.

Cultivar[z]	Spring 1999	Fall 1999	Spring 2000
Beit Alpha	grams per fruit		
Alexander	238 bc	189 c	136 cd
Dishon	218 bc	173 c	133 cd
Sarig	188 c	156 c	122 d
Suzan	214 bc	172 c	131 cd
Ilan	249 bc	247 b	144 c
Rambo	256 bc	199 bc	137 cd
Dutch-type			
Long John[y]	509 a	376 a	—
Bologna	518 a	417 a	310 a
Kalunga	463 a	393 a	295 b
R-square	0.96	0.96	0.99

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[y]Not seeded in spring 2000.

practices and harvest procedures for Beit Alpha-type cucumbers, thus, fruit harvest was based on length and appearance. During the fall 1999 season, representatives from Hazera Seed Co. recommended harvesting the fruit 1 to 2 days earlier (to more closely resemble the fruit sold in the European market). The fruit were picked at their recommended size for each harvest during spring 2000. USDA grade standards for cucumber (field grown) set limits for a fancy fruit to be 7 cm in diameter and not less than 22 cm length (Anon., 1956). Beit Alpha-type cucumbers cannot be graded based on field-grown characteristics; they were developed to be a smaller size. Generally, Beit Alpha-type cucumbers should be harvested no more than 4 cm in diameter (personal communication from representatives of Hazera Seed Co.). There are no guidelines regarding fruit weight of Beit Alpha cucumbers.

Quality measurements were significantly different between seasons, time of season, and cultivars (Tables 7 and 8). There were no differences between spring 1999 and spring 2000 early season measurements of either fruit length or diameter (Table 7). Fruit length of Beit Alpha cultivars was one-half the length of the Dutch-type (15 cm compared to 30 cm). Fruit length increased from the IV harvest to the XVII harvest for all cultivars in spring 1999. 'Sarig' produced the shortest Beit Alpha fruit (15 cm), while the Beit Alpha-types, 'Alexander', 'Ilan', and 'Rambo' were generally 3-6 cm longer. Fruit diameters of Beit Alpha cultivars were 0.5 to 1 cm smaller than that of the Dutch-types. For the Beit Alpha cultivars 'Sarig', 'Suzan', 'Ilan', and 'Rambo' and the three Dutch-type cultivars, as fruit length increased more than 2 cm from early season to the middle of the season, diameter decreased as much as 0.7 cm. It may be that for certain greenhouse cucumber cultivars the fruit characteristics of length and diameter are dependent on plant age, and/or changes in the environment and thus fruit size varies during the season.

Fruit length of Beit Alpha cultivars in fall 1999 varied less than 2 cm over the season; while, depending on cultivar, fruit length varied 1-5 cm during the spring seasons (Table 8). For 'Dishon', 'Long John', and 'Kalunga', fruit length increased over the season from 17 cm, 31 cm, and 32 cm at the 4th harvest to 19 cm, 39 cm, and 37 cm, respectively, at the 21st harvest. As the fall season progresses, the average temperature is

Table 7. Means of cucumber fruit length and diameter over the season. Gainesville, Florida. Spring 1999 and Spring 2000.

	Length (cm)				Diameter (cm)		
Cultivar[x]	Early[z] 1999/2000	Mid 1999	Mid 2000	Late 1999	Early 1999/2000	Mid 1999/2000	Late 1999
Beit Alpha							
Alexander	17.2 de	19.9 de	17.2 d	20.9 c	4.0 c	4.0 de	4.4 c
Dishon	15.9 fg	19.0 e	16.1 d	17.7 e	4.0 c	4.1 cd	4.0 de
Sarig	15.3 g	16. 2f	14.5 e	14.9 f	4.1 c	3.8 de	3.8 e
Suzan	16.4 ef	18.4 e	16.0 d	19.5 d	4.2 c	4.0 de	4.2 cd
Ilan	17.8 d	21.9 c	18.9 c	19.7 cd	4.2 c	4.1 cd	4.4 bc
Rambo	17.3 de	21.2 cd	17.2 d	18.8 de	4.2 c	3.8 e	4.3 c
Dutch-type							
Long John	29.2 b	36.2 b	—	31.1 b	5.1 a	4.6 a	4.9 a
Bologna	31.5 a	39.3 a	28.9 a	35.1 a	5.2 a	4.5 ab	4.8 a
Kalunga	26.3 c	36.8 b	27.0 b	32.9 b	4.5 b	4.3 bc	4.6 b
R-square	0.92	0.95	0.89	0.95	0.75	0.57	0.56

[z]Spring 1999: Early = 4 May, Mid = 20 May, Late = 10 June, 1999. Spring 2000: Early = 31 March, Mid = 14 April, 2000.
[x]Means separation with each column using Duncan's multiple range test, $P \leq 0.05$.

Table 8. Length and diameter of cucumber fruit as measured throughout the season. Gainesville, Florida. Fall 1999.

	Length (cm)			Diameter (cm)	
Cultivar[z]	Early[x]	Mid	Late	Early	Mid/late
Beit Alpha					
Alexander	19.3 c	18.7 bc	19.4 c	4.5 bc	3.9 d
Dishon	17.1 d	18.9 bc	19.1 c	4.5 bc	4.0 cd
Sarig	14.3 e	17.7 c	16.4 d	4.3 cd	3.9 cd
Suzan	17.9 cd	18.9 bc	17.6 cd	4.5 bc	4.0 c
Ilan	17.9 cd	19.6 bc	19.5 c	4.6 bc	4.0 cd
Rambo	17.8 cd	20.3 b	18.8 cd	4.2 d	4.1 c
Dutch-type					
Long John	31.4 b	34.3 a	39.0 a	4.9 a	4.7 a
Bologna	37.2 a	35.9 a	36.0 b	4.7 ab	4.5 b
Kalunga	32.3 b	35.8 a	37.2 ab	4.6 ab	4.5 b
R-square	0.96	0.94	0.96	0.38	0.46

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[x]Quality measurements in fall 1999: Early = 8, Nov., Mid = 14 Dec., 1999 and Late = 6 Jan., 2000.

getting cooler and day length shortens, both factors which cause the fruit to develop more slowly which leads to longer fruit in some cultivars. Similar to the spring seasons, fruit length was longest during the middle of the fall season (14th harvest) for the Beit Alpha cultivars 'Sarig', 'Suzan', and 'Rambo'. Fruit length of 'Alexander' and 'Bologna' varied less than 1 cm over the season (approximately 19 cm and 36 cm, respectively). Fruit diameter of the Beit Alpha cultivars was greater during the early part of the season, 4th harvest, than the middle or end of the season, the 14th and 21st harvest (4.5 cm compared to 4 cm). Similar to both spring seasons, fruit diameters of all Beit Alpha cultivars were less than that of the Dutch-types.

Ratings for wrinkle of fruit skin and fruit uniformity were similar for each season (Table 9). All Beit Alpha cultivars were generally smoother than the Dutch-types. Using a scale from 1 to 5 (1 = fruit skin with the least amount of wrinkle, and 5 = fruit skin with the most amount of wrinkle), 'Ilan' had the smoothest fruit skin of all cultivars at 1.4 Of the Beit Alpha cultivars, 'Alexander' and 'Rambo' were rated with the most wrinkle of fruit skin (at 3.7 and 3.2, respectively). Also using a scale from 1 to 5 (1 = least uniform, and 5 = most uniform), Beit Alpha cultivars 'Sarig' and 'Suzan' and the Dutch-type 'Kalunga' were rated more uniform than the Dutch-type 'Long John'. The Beit Alpha cultivars 'Sarig' and 'Suzan' produced the most uniform fruit (4.2 and 4.3, respectively).

Table 9. Ratings for wrinkle of fruit skin and fruit uniformity throughout the season of greenhouse cucumber. Gainesville, Florida. Spring 1999, Fall 1999 and Spring 2000.

Cultivar[z]	Wrinkle[y]	Uniformity[x]
Beit Alpha		
Alexander	3.7 b	3.7 abcd
Dishon	2.7 cd	3.8 abcd
Sarig	2.0 de	4.2 ab
Suzan	2.1 de	4.3 a
Ilan	1.4 e	3.7 abcd
Rambo	3.2 bc	3.1 bcd
Dutch-type		
Long John	4.7 a	2.7 d
Bologna	4.8 a	3.0 cd
Kalunga	4.8 a	4.0 abc
R-square	0.81	0.42

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[y]Rating scale for wrinkle: 1 = least wrinkle, 5 = most wrinkle of fruit skin.
[x]Rating scale for uniformity: 1 = least uniform, 5 = most uniform fruit. Uniformity ratings considered length, diameter, and shape.

Cucumber plants were rated on a scale of 1 to 10 for susceptibility to powdery mildew at the end of each season. There was no difference in powdery mildew ratings between spring 1999 and fall 1999. Some differences among cultivars existed, but incidence of mildew was generally minor. Mildew ratings were significantly different among cultivars during spring 2000 (Table 10) when synthetic-chemical sprays were avoided to determine if the crop could be grown using no pesticides and biological control. Chemical fungicides were applied in both spring 1999 and fall 1999 and powdery mildew was low among all cultivars (usually less than 20%). Without chemical fungicides (spring 2000), powdery mildew was severe for most Beit Alpha cultivars (greater than 80%). The Beit Alpha-type 'Alexander' had significantly lower powdery mildew ratings in the spring 2000 than the Dutch-type 'Kalunga' that is labeled as powdery mildew resistant (30% compared to 50%, respectively). 'Alexander' seems to have some tolerance, if not resistance, to powdery mildew.

There was a significant interaction among seasons for plant appearance (Table 10). In all three seasons, the experiment continued as long as some plants in each plot had marketable fruit to harvest. In spring 1999 and fall 1999, fruit production by 'Dishon' and 'Suzan' declined earlier compared to all other cultivars. Based on plant appearance and fruit production at the end of each season, the Beit Alpha cul-

Table 10. Powdery mildew and plant appearance ratings at the end of the season for greenhouse cucumber. Gainesville, Florida. Spring 1999, Fall 1999 and Spring 2000.

	Powdery mildew[y]		Plant appearance[x]		
Cultivar[z]	Spring/Fall 1999	Spring 2000	Spring 1999	Fall 1999	Spring 2000
Beit Alpha					
Alexander	1.0 d	3.2 c	3.1 ab	4.5 a	3.7 a
Dishon	1.8 bcd	8.8 a	3.8 a	4.2 a	3.7 a
Sarig	1.9 bc	8.5 a	2.3 bc	2.7 bc	3.7 a
Suzan	1.8 bcd	9.5 a	3.8 a	3.8 a	3.7 a
Ilan	2.4 ab	8.8 a	2.7 bc	2.7 bc	3.0 ab
Rambo	1.7 bcd	8.3 a	2.7 bc	2.8 b	3.5 a
Dutch-type					
Long John[w]	2.9 a	—	3.7 a	2.3 bc	—
Bologna	1.2 cd	3.5 c	2.0 c	2.5 bc	3.0 ab
Kalunga	1.3 cd	5.0 b	2.5 bc	2.0 c	2.7 b
R-square	0.38	0.83	0.55	0.72	0.73

[z]Means separation within each column using Duncan's multiple range test, $P \leq 0.05$.
[y]Powdery mildew ratings: 1-<10% leaves with powdery mildew, 2-20% plant coverage, 3-30% plant coverage, 4-40% plant coverage, 5-50% plant coverage, 6-60% plant coverage, 7-70% plant coverage, 8-80% plant coverage, 9-90% coverage, 10-100% plant coverage.
[x]Plant appearance ratings: 1-still in full fruit production; 2-plant green, partial fruit production; 3-plant yellow with some green leaves, low fruit production; 4-plant mostly yellow, very low fruit production; 5-no fruit production.
[w]Not seeded in spring 2000.

tivars 'Sarig', 'Ilan', and 'Rambo' appeared to be the most vigorous cultivars. In spring 2000, fruit production was low for all cultivars at the end of the season because of two-spotted spider mite damage to the plant and fruit.

Conclusion

The Beit Alpha cucumber is an exciting new crop for the greenhouse industry in Florida. Some Beit Alpha cultivars yielded nearly three times greater than the Dutch cultivars. Due to the warm environment in Florida, Beit Alpha cultivars thrive and produce multiple high fruit yields with excellent fruit quality that exceed the standard Dutch greenhouse cultivars. The Beit Alpha cultivar 'Alexander' produced high yields in all three seasons and was resistant to powdery mildew. From personal communications (Brown's Fruit Stand, Waldo, FL), the Beit Alpha-type cucumber required less postharvest attention, and the flavor and texture were superior to the Dutch-type. Future challenges will be to introduce the Beit Alpha cucumber to the U.S. market and win consumer acceptance of the new product.

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