

A New Crop for North American Greenhouse Growers: Beit Alpha Cucumber – Progress of Production Technology through University Research Trials

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Abstract

Starting in 1999, Beit Alpha (BA) cucumbers (*Cucumis sativus* L.) were introduced to greenhouse growers in the Southeastern U.S. through research trials at the University of Florida. Since then, growers in Florida, North Carolina, Canada, and Baja California, Mexico have successfully begun producing and marketing this cucumber which is historically grown in Mediterranean countries. BA cucumber types are parthenocarpic (seedless) and thus do not require bumble bees for pollination; they are one-half the length of European-type cucumbers and do not require to be individually shrink-wrapped to avoid water loss once harvested. Repeated trials have provided information on BA cucumber cultivars that can be grown in a passive-ventilated structure using hydroponic soilless culture. Cultivar selections can be based on fruit quality characteristics, plant yield, seasonal production, and powdery mildew resistance. The cultivar 'Sarig' has uniform fruit set and fruit size, with multiple fruit developing at every node throughout the season; yields equal 70 fruit (25 kg/m²) per plant. However, 'Sarig' is highly susceptible to powdery mildew. The cultivars 'Figaro' and 'Manar' show similar high quality and yield performance, as well as resistance to powdery mildew. BA cucumbers can be grown in a variety of media such as perlite and pine bark and produced year-round using integrated pest management methods and no insecticides. Also, new types of BA cucumbers are targeting niche markets as 'snack-size' cucumbers. 'Snack-size' cultivars yield nearly 40% more fruit per plant and can be produced with the same production techniques used for standard BA-types as they are only 45 g per fruit compared to 70 to 100 g per fruit for the standard types at harvest maturity.

INTRODUCTION

The most common greenhouse crops in the U.S. are tomato, pepper, and European cucumber. Greenhouse growers in the Southeastern U.S., especially Florida, must compete with field producers and imports of these same types of commodities. In order to help diversify market potential for greenhouse growers in the Southeastern U.S., the University of Florida (UF) conducted trials on new crops to the U.S. that are traditionally produced in greenhouses or protected structures in Israel and other Mediterranean countries. Successful research trials began in spring 1999 with the Israeli-type cucumber known as the Beit Alpha cucumber. Beit Alpha (BA) cucumber types are parthenocarpic (seedless) and thus do not require bumble bees for pollination. Most BA types are nearly one-half the length of European cucumbers (15 cm compared to 30 cm or more, respectively). Unlike the single fruit per node habit of European type cucumbers, BA fruit have a multiple fruit set habit that can be harvested repeatedly for four or more weeks depending on plant quality (Shaw et al., 2000).

BA type cucumbers are termed so by Israeli and other Mediterranean cultures, however, similar cucumber types now exist from Dutch and other seed sources and are being marketed as 'mini-cucumbers' (MC) (Shaw et al., 2003). For clarity purposes within this paper, 'BA' will refer to Israeli seed sources, while 'MC' will refer only to Dutch or other mini-cucumber seed sources.

In Florida's subtropical climate, BA and MC cucumbers can be produced year-round. Protected plants continue to produce fruit under the extreme heat conditions of summer (over 45°C) as well as during the cooler winter months (20°C/10°C average day/night) with less solar radiation. In early research trials of BA type cucumbers at UF, powdery mildew was a continuous problem that could not be controlled well with preventative fungicides (Shaw et al., 2000). Since many fungicides are not labeled for use in greenhouse structures, or are not compatible with integrated pest management systems cultivars with powdery mildew disease resistance were necessary (Shaw and Cantliffe, 2003).

While most greenhouse crops in Florida are grown in perlite media (Mitchell and Cantliffe, 2005), some growers prefer other media, such as pine bark. Pine bark is a by-product of sawmills and paper mills (Ingram et al., 1993). Pine bark has physical characteristics much like standard peat mixes used by ornamental growers, however, it is a renewable resource and costs about \$8.50/cu. m. In spring 2001 and 2002, research trials were conducted to compare plant growth, fruit yield, and irrigation use (irrigation drainage) of three types of media: coarse grade perlite, medium grade perlite, and pine bark (Shaw et al., 2004).

New types of smaller (than standard BA and MC) fruited BA cucumbers are now available. They are termed "snack-size" (SS) by the seed company (Nunhems Netherlands B.V., The Netherlands) because they are designed and aimed towards consumer conveniences in the form of snack-packs which are targeted for children and adults as healthy food items. Their fruits are one-half the length of most BA and MC types.

The purpose of the present study was to provide a summary of five years of University of Florida trials pertaining to production of a new crop for the greenhouse industry, Beit Alpha cucumber.

MATERIALS AND METHODS

Research conducted from 1999 through 2003 was located at the UF Protected Agriculture Project in Gainesville, Florida. The 0.20 ha greenhouse (Top Greenhouses Ltd., Barkan, Israel) had a passively-ventilated design with 3.6 m high sidewalls and a 1.2-m roof vent at 6 m for a total floor to roof peak of 7.2 m. The structure was covered with double layer polyethylene plastic (Ginegar Plastic Products, Ltd., Kibbutz Ginegar, Israel). Both the sidewall and roof vent openings were covered with 0.6-mm insect screen (Klaymen Meteor Ltd., Petah-Tikva, Israel) to prevent insect movement into or out of the greenhouse.

In 2004, experiments were conducted in a similar high-roofed, passively-ventilated greenhouse structure located at the new UF Plant Science Research and Education Center in Citra, Florida. The 0.41 ha greenhouse (Top Greenhouses Ltd.) had sidewalls 4.2 m high and a 1.5-m roof vent located at 4.2 m for a total roof to floor peak of 5.7 m. The structure was covered with single layer polyethylene (Ginegar Plastic Products, Ltd.). Sidewall and roof vent openings were covered in the same insect screen as previously mentioned.

Transplants were grown for 3 weeks either in an evaporative fan and pad-cooled glasshouse (1999-2001) or a Conviron E15 (Controlled Environments Inc., Asheville, North Carolina) growth chamber (2002-2004). Growth chamber temperatures were maintained at 28°C day and 22°C night with a 12-hr photoperiod. Seeds were sown into polystyrene trays (138 cm³ cell volume, Speedling Inc., Sun City, Florida) using a transplant medium of 60% sphagnum peat : 40% vermiculite (v:v). Once cotyledons were fully expanded, transplants were fertilized two or three times each week using a solution of 100 ppm N-P₂O₅-K₂O and micronutrients (Peters Professional All Purpose Plant Food; Spectrum Group, St. Louis, Mo.).

Planting dates and harvest periods for the four experiments are presented in Table 1. Each experiment consisted of a randomized complete block design with three or four replications. For all experiments plants were pruned, trellised, irrigated, and fertilized in accordance with Shaw et al. (2000). All plants were irrigated using a programmable timer

(Sterling 12; Superior Controls, Valencia, California) to provide adequate irrigation with 10-20% leachate. Plants in experiments 1 and 3 were grown in white-polyethylene-layflat bags (1 m x 0.32 m; Agrodynamics, East Brunswick, New Jersey) filled with coarse-grade perlite (Airlite Processing Corp. of Florida, Vero Beach, Florida). There were 3 plants per bag spaced 30-cm within row and 1.8 or 1.2-m between rows in Expt. 1 and 3, respectively. For Expt. 2 and 4, individual plants were grown in 11-L plastic nursery pots (Lerio Co., Kissimmee, Florida) drilled with four equidistant 2-cm holes at 5 cm from the bottom of the container for drainage. Expt. 2 was a soilless media evaluation, therefore growing media was either medium grade perlite, coarse grade perlite, or pine bark. Pine bark was used for growing media in Expt. 4. The pine bark used was screened by the manufacturer to a particle size less than 2.5 x 2.5 cm (Elixson Wood Products, Starke, Florida). Plants in Expt. 2 and 4 were spaced 25 cm within rows and 1.2 m between rows.

There were 6 BA cucumber cultivars trialed in Expt. 1: 'Alexander', 'Dishon', 'Sarig', 'Suzan', 'Ilan', and 'Rambo'. Only 'Alexander' was used for Expt. 2. Expt. 3 represented 13 cultivars, 7 were described by their seed company as MC while the other 6 were BA-types. The MC-types were: 'Aria', 'Diva', 'DeltaStar', 'Figaro', 'Manar', 'Sarawat', 'Tornac'; and the BA-types were: 'Ex1605', 'M-733', 'Meitav', 'Sarig', '9976', and '967'. There were 7 cultivars trialed in Expt. 4, 3 were described as SS while the other 4 were MC-types. The snack-size cultivars were: 'Silor', 'Nun3039', 'Nun3048'; and MC-types were: 'Alamir', 'Kian', 'Nun3048', and 'Tornac'.

RESULTS AND DISCUSSION

Cultivar Trial – BA Cultivars

Six BA-type cucumber cultivars were grown over three seasons, spring 1999, fall 1999, and spring 2000. There was a significant interaction between seasons and cultivar for marketable fruit number and weight per plant (Table 2). The greatest yields occurred in spring 1999 at 11.7 kg per plant with 'Sarig' producing the greatest number of fruit per plant at nearly 70 fruit. In fall 1999, the greatest yield was from 'Ilan' and 'Rambo' with 8.6 and 8 kg/plant, respectively. The lowest yield in fall was from the cultivar 'Alexander' at 5.5 kg/plant. All cultivars produced about 6.1 kg/plant in spring 2000. Average fruit weight was significantly different among seasons. In spring 1999, the correct size required to harvest BA fruit was not well understood by the researchers (Shaw et al., 2000) and fruit were harvested larger (average 200 g) than desirable by the traditional Mediterranean markets (110-120 g/fruit). Correct fruit size was harvested beginning the 12th harvest in fall 1999 and continued through spring 2000. Average fruit size in fall 1999 was 175 g and in spring 2000 was 130 g.

Media Trials

The BA cultivar 'Alexander' was grown over two seasons in three different media (data not shown). There were no significant differences between type of media and season. Furthermore, type of media did not affect yield or weight of any grade of fruit per plant of the BA-type cultivar 'Alexander'. Approximately 26 fancy fruit and 17 No. 1 grade fruit were harvested per plant (Shaw et al., 2004). Average fruit weight was not affected by media type and averaged 127 g. On average, 7 cull fruit were harvested per plant. Type of media significantly affected total marketable fruit number per plant. A greater number of marketable fruit were harvested from plants that grew in medium perlite compared to either coarse perlite or pine bark, 50 fruit/plant compared to an average of 46 fruit/plant, respectively. Marketable fruit weight/plant was not affected by media type and averaged 6 kg/plant. Though more marketable fruit were harvested from plants that grew in medium grade perlite, yields as weight were the same. These fruits are sold at retail by weight. Pine bark is a substantially lower cost media than perlite at \$8.50/m³ as compared to nearly \$45/m³. The cost for pine bark is \$2800/ha and for perlite is \$14,850/ha when using 11-L nursery pots at 3.3 plants/m². Pine bark is readily available in Florida and can be repeatedly used and easily disposed of when fully spent. Further,

multiple crops can be grown using the same media, thus, pine bark is a preferred media to perlite.

Cultivar Trial – Powdery Mildew Resistant Cultivars

In spring 2002, 7 BA-type cultivars and 6 MC-type cultivars were compared for yield and powdery mildew disease resistance (Shaw and Cantliffe, 2003). There were significant differences among the 13 cultivars for total yield and weight as well as powdery mildew resistance (Table 3). 'Figaro' produced the greatest number of marketable fruit/plant, 77, while 'Diva' produced the lowest, 43. 'Manar', 'Sarawat', and 'Meitav' were not significantly different than 'Figaro'. The remaining cultivars 'Aria', 'Diva', 'DeltaStar', 'Tornac', 'Ex1605', 'M-733', 'Meitav', 'Sarig', '9976' and '976', produced between 56 and 65 fruit/plant. Marketable weight was greatest for 'Manar', but not significantly different from 'Aria', 'DeltaStar', 'Figaro', 'Sarawat', 'M-733', and 'Meitav'. Marketable weight ranged from 6.0 kg/plant for 'Diva' to 8.8 kg/plant for 'Manar'. Cull fruit ranged from 0.6 to 1.3 kg/plant depending on cultivar. Average fruit weight ranged from 109 g for 'Figaro' to 128 g for 'Aria'.

Plants were rated for powdery mildew (*Sphaerotheca fuliginea*) susceptibility at the end of the season. The BA-types 'Meitav' and 'Sarig' were rated with 100% and 90% coverage with powdery mildew, respectively. 'Sarawat' was rated with 40% coverage and 'M-733' at nearly 30% coverage. All other cultivars were rated with either 10% or 20% powdery mildew coverage. 'Diva' produced the lowest yield, however, it was rated with the highest resistance to powdery mildew. Conversely, 'Meitav' produced one of the highest yields, but was rated with the least resistance to powdery mildew. Powdery mildew may be more of a visual problem for BA or MC greenhouse production than a contributor to yield losses (Shaw and Cantliffe, 2003).

Cultivar Trial – SS and MC Cultivars

New MC cultivars and SS-types were trialed in spring 2004 (Table 1). Average fruit weight was about 20 g lower for the SS cultivars compared to the MC cultivars (Table 4). Over 22 harvests, the SS cultivars 'Nun3039' and 'Nun9747' produced the greatest number of fancy and No. 1 category fruit at 36 and 33 fruit/plant, respectively. All cultivars produced less than 0.4 kg of cull fruit over 22 harvests. Total marketable fruit and weight/m² varied among cultivars. The SS cultivars 'Nun3039' and 'Nun9747' produced over 280 fruit/m². Total marketable fruit/m² ranged between 176 and 220 for the remaining cultivars. Total marketable fruit weight ranged from 17.1 kg/m² for 'Alamir' and 'Silor' to 22 kg/m² for 'Nun9747', 'Kian', and 'Nun3048'.

BA or MC cucumbers can be produced year-round in subtropical climates using biological control and integrated pest management methods especially when PM resistant cultivars are used. Containers and media may be the choice of the grower based on availability and cost. Plants may be grown in individual containers such as nursery pots or as multiples in lay-flat polyethylene bags. Pine bark media is recommended in Florida where it can be re-used for several consecutive seasons, but may not be readily available in other areas of the world where perlite is available. BA, MC, and SS cultivars are available world-wide, but certain cultivars may only be available in North America and Europe. Cultivars recommended in Florida are Manar, Sarawat, and Tornac.

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Tables

Table 1. Planting dates and harvesting periods for greenhouse Beit Alpha cucumber research at the University of Florida Protected Agriculture Project, 1999-2004.

Experiment	Experiment goal	Season	Planting date	Harvest period	Total harvests
1	Cultivar evaluation	Spring 1999	31 March 1999	1 May - 1 July	23
		Fall 1999	30 Sept. 1999	28 Oct. 1999 - 26 Jan. 2000	30
		Spring 2000	16 Feb. 2000	13 March - 28 April	20
2	Soilless media evaluation	Spring 2001	9 Feb. 2001	12 March - 3 May	21
		Spring 2002	11 Feb. 2002	14 March - 24 May	27
3	Cultivar evaluation for powdery mildew resistance	Spring 2002	11 Feb. 2002	13 March - 24 May	27
4	Cultivar evaluation	Spring 2004	15 Feb. 2004	15 March - 17 May	22

Table 2. Means for total marketable yield and average fruit weight of six Beit Alpha cucumber cultivars. Gainesville, Florida. Spring 1999, Fall 1999, and Spring 2000.

Cultivar ²	Marketable number/plant			Marketable weight (kg/plant)			Average fruit weight (g)		
	Spring 1999	Fall 1999	Spring 2000	Spring 1999	Fall 1999	Spring 2000	Spring 1999	Fall 1999	Spring 2000
Alexander	52.2 b	27.6	39.7 ab	12.9 a	5.5	6.1	238 b	189 b	136 c
Dishon	52.2 b	32.2	42.9 a	11.5 ab	5.8	6.1	218 c	173 b	133 de
Sarig	66.8 a	36.7	44.2 a	12.9 a	6.0	6.1	188 d	156 b	122 e
Suzan	45.1 b	31.6	42.2 a	10.1 b	5.7	6.3	214 c	172 b	131 d
Ilan	46.7 b	33.0	34.3 c	12.3 ab	8.6	5.9	249 a	247 a	144 a
Rambo	51.0 b	36.4	36.2 bc	13.8 a	8.0	5.8	256 a	199 ab	137 b
R-square	0.82	0.55	0.84	0.64	0.69	0.52	0.95	0.71	0.96

² Means separation for each column using Duncan's multiple range test, $P \leq 0.05$. Columns without Duncan's separation were not significantly different.

Table 3. Production and powdery mildew rating for 13 mini-cucumber cultivars. Spring 2002. Gainesville, Fla.

Cultivar	Avg. ft. wt. (g)	Mkt. no.	Mkt. wt. (kg)	Fancy no.	Fancy wt. (kg)	Cull wt. (kg)	Fruit/m ²	Tot. mkt. fruit wt. (kg m ⁻²)	PM rating (scale 1-10)
Aria	128 bc	62 cde	7.9 a-e	16 de	1.5 e	1.4 a	204 cde	26.1 a-e	2.0 cd
Diva	139 a	43 f	6.0 g	15 e	1.4 e	0.6 d	142 f	19.8 g	1.0 d
DeltaStar	135 ab	63 cde	8.5 abc	24 bc	2.3 bcd	0.9 cd	208 cde	28.0 abc	2.0 cd
Figaro	103 e	77 a	7.9 a-e	30 ab	2.5 bcd	1.2 abc	253 a	26.1 a-e	2.0 cd
Manar	122 cd	73 ab	8.8 a	33 a	3.2 a	0.8 cd	239 ab	29.1 a	2.0 cd
Sarawat	124 cd	68 abc	8.5 ab	28 abc	2.7 abc	1.1 abc	225 abc	28.1 ab	4.3 b
Tornac	121 d	62 cde	7.5 b-e	24 bc	2.2 cd	1.4 a	204 cde	24.7 b-e	2.0 cd
Ex1605	109 e	56 e	6.1 fg	22 cd	1.9 de	1.3 ab	185 e	20.2 fg	2.3 cd
M-733	124 cd	67 bcd	8.3 a-d	30 ab	2.9 ab	1.1 abc	221 bcd	27.4 a-d	2.7 c
Meitav	110 e	71 abc	7.8 a-e	27 abc	2.4 bcd	1.1 abc	233 abc	25.6 a-e	10.0 a
Sarig	110 e	64 b-e	7.1 d-g	29 ab	2.5 bcd	1.1 abc	213 b-e	23.4 d-g	9.3 a
9976	125 cd	58 de	7.2 c-f	24 bc	2.4 bcd	0.9 bcd	191 de	23.9 c-f	1.3 cd
976	108 e	63 cde	6.8 efg	28 abc	2.5 bcd	1.3 a	208 cde	22.6 efg	2.3 cd
R-square	0.92	0.84	0.76	0.78	0.76	0.64	0.84	0.76	0.95

^z Means within each column separated using Duncan's multiple range test, $P \leq 0.05$. Powdery mildew rating scale: 1 = no leaves with powdery mildew, 10 = all leaves with powdery mildew. Powdery mildew was rated on 9 May, 2002.

Table 4. Yields and average fruit weight per plant of 3 Snack-size (SS) and 3 Mini-cucumber (MC) cultivars. Citra, Florida. Spring 2004.

Cultivar ²	Avg. ft. wt. (g)	Fancy ft. no.	Fancy ft. wt. (kg)	No. 1 no.	No. 1 wt. (kg)	Cull wt. (kg)	Fruit/m ²	Tot. mkt. fruit wt. (kg m ⁻²)
<i>Snack (SS)</i>								
Silor	46 cd	27 b	1.3 d	25 b	2.0 b	.3 b	220 b	17.2 c
Nun3039	44 d	35 a	1.5 c	34 a	2.6 a	.2 b	283 a	21.1 ab
Nun9747	49 c	36 a	1.8 bc	32 a	2.6 a	.3 ab	281 a	21.9 a
<i>Mini (MC)</i>								
Alamir	66 b	30 b	2.0 b	20 c	1.9 b	.4 a	195 c	17.1 c
Kian	78 a	29 b	2.3 a	18 c	2.1 b	.2 b	202 bc	22.7 a
Nun3048	78 a	29 b	2.3 a	18 c	2.1 b	.2 c	198 bc	22.0 a
Tornac	76 a	26 b	2.0 b	17 c	1.8 b	.3 ab	176 c	18.2 bc
R-square	0.99	0.78	0.71	11.2	11.4	0.65	0.92	0.77

² There were 22 total harvests from 15 March through 17 May, 2004. Means within each column were separated using Duncan's multiple range test, $P < 0.05$.