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HYDROPONICALLY GROWN 'BABY' SQUASH: GOURMET APPEAL FOR THE GREENHOUSE GROWER

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Abstract. **In the past few years, 'baby' vegetables have become a popular item for restaurant chefs and retail sales. In spring 2003, 18 squash cultivars, seven zucchini-types (three green, three yellow, and one round), five yellow summer squash-types, four patty pan/scallop-types, and two cousa-types, were grown hydroponically in a passive-ventilated greenhouse. Plants were grown from 14 February until 15 May 2003. Squash were harvested every other day starting 10 March 2003 (28 total) and graded as fancy or baby depending on size. Squash were graded as baby when they were less than 10 cm in length for zucchini and summer squash types and less than 4 cm diameter for round and patty pan/scallop types. Fruit larger than those considered baby-size were graded as fancy. Total marketable fruit was the combined total of baby, fancy, and No. 1 fruit grades. The cv. Sunburst (patty pan) produced the greatest number of baby-size fruit per plant at 67 while the cv. Bareket (green zucchini) produced the least: 16. The zucchini-types produced between 16 and 25 baby-size fruit per plant (Bareket, Revenue, and Raven were green while Goldy, Gold Rush, and Sebring were yellow). The yellow summer squash-types, Seneca Supreme, Supersett, and Yellowcrook produced on average 45 baby fruit per plant (50 to 84 total fruit per plant). The production of the patty pan/scallop-types (Butter Scallop, Sunburst, Patty Green Tint, and Starship) ranged from 50 to 67 baby-size fruit per plant depending on cultivar (70 to 80 total fruit per plant). Magda and HA-187 (cousa-types) produced 27 and 34 baby fruit, respectively. Squash can produce numerous high quality baby-sized fruit when grown hydroponically in a pesticide-free environment of a greenhouse where they can be harvested, packaged, and distributed to buyers daily with greatly reduced concerns for food safety.**

Demands for baby vegetables in the United States have been on the rise since the early 1990s when baby carrots (*Daucus carota* L.) were popularized in U.S. supermarkets. Along with baby carrots in today's supermarkets, other baby vegetables include sweetcorn (*Zea mays* L. var. *rugosa* Bonaf.), beets (*Beta vulgaris* L.), radishes (*Raphanus sativus* L.), zucchini type squash (*Cucurbita pepo* L.), eggplant (*Solanum melongena* L.), beans (*Phaseolus vulgaris* L.), artichoke (*Cynara scolymus* L.), onions (*Allium cepa* L.), cauliflower (*Brassica oleracea* L.), and many types of lettuce (*Lactuca sativa* L.; Bachman, 2002). The majority of baby vegetables are marketed as 'ready-to-eat', for example, gourmet lettuce mixes and microwavable pouches. Another large portion is handled within high-end specialty restaurants by gourmet chefs where they are used as side-dishes and garnishes (Stephens, 1996). In 2000, consumer food trends were surveyed and many Americans were found to be enjoying the experience of preparing gourmet meals at home (Associated Press, 2000). Consumers have turned their kitchens into social entertainment areas for friends and family to share in exotic cooking techniques from their favorite restaurants (Bachman, 2002).

While some baby vegetables are specific cultivars that have been bred to be a small size [such as King Richard leek (*Allium ampeloprasum* Tausch.) and Parmex carrot], others are merely common vegetables that have been produced under dense plant-spacing and harvested early and/or immature as in the case of baby squash (Bachman, 2002; Schmidt, 2003). These types of vegetables demand more intense production operations to insure high quality, and in turn, bring a higher return. Since baby squash is harvested at a delicate stage when flower blossoms have just opened for pollination (and sometime remain attached), having a clean, undamaged fruit is preferred for packaging. In the baby vegetable business, damaged fruit or 'seconds' cannot be sold (Stephens, 1996). For crops such as tomato (*Lycopersicon esculentum* Mill.), colored pepper (*Capsicum annuum* L.), and cucumber (*Cucumis sativus* L.), the desire for a superior product can easily be achieved through production inside a protected structure as compared with open-field cultivation (Cantliffe et al., 2001; Cantliffe et al., 2004). Furthermore, plants may be grown pesticide-free inside a greenhouse thus increasing the marketing potential of the product.

Currently, most baby squash sold in the U.S. is imported from South and Central American countries such as Guatemala (Thompson, 2004; FreshKing, Inc., Fla.). One Guatemalan vegetable grower-exporter, Agroexportadores San Lucas (ASL), exports between 150,000 and 200,000 4.5-kg boxes of snow peas (*Pisum sativum* L. var. *macrocarpon* Ser.) to the U.S. annually under the 'Baby Fresh' label. In addition, 65% of their total production is in baby squash and French beans. ASL focuses on the quality, consistency, and food safety of their product, which can be challenging for open-field systems (Thompson, 2004).

While baby squash is grown under protection in countries such as Italy, Spain, and Israel, it is unknown whether baby squash could be produced hydroponically in a passive-ventilated structure in Florida. There have been no cultivars selected for baby squash production and marketed as such via U.S. seed distributors and only few squash cultivars are marketed as greenhouse seed. The objectives of this study were to identify squash cultivars suitable for both the 'baby' squash market and those that could be successfully grown hydroponically in a greenhouse.

Materials and Methods

Squash types evaluated included green and yellow zucchini, straight and crookneck yellow summer, patty pan/scallop, and cousa types. Cousa is a middle-eastern type summer squash ('cousa' means 'squash' in Arabic). Cultivars for each type are listed in Table 1. Only Bareket, Goldy, and HA-187

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Table 1. Squash cultivars evaluated under hydroponic cultivation for baby squash production.

Type	Cultivar name	Description	Seed company[z]
Zucchini	Bareket	Dark green	Hazera Genetics, Inc.
	Eight Ball	Round, green	Hollar Seeds, Inc.
	Gold Rush	Deep yellow	Johnny's Selected Seeds
	Goldy	Yellow	Hazera Genetics, Inc.
	Sebring	Yellow	Hollar Seeds, Inc.
	Revenue	Medium green	Johnny's Selected Seeds
	Raven	Dark green	Johnny's Selected Seeds
Yellow summer	Seneca Supreme	Straightneck	Johnny's Selected Seeds
	Sunray	Straightneck	Johnny's Selected Seeds
	Supersett	Crookneck	Johnny's Selected Seeds
	Yellow Crookneck	Crookneck	Johnny's Selected Seeds
	Zephyr	Green blossom end, straightneck	Johnny's Selected Seeds
Patty pan/Scallop	Butter Scallop	Pale yellow	Johnny's Selected Seeds
	Patty Green Tint	Light green	Johnny's Selected Seeds
	Starship	Dark green	Johnny's Selected Seeds
	Sunburst	Deep yellow	Johnny's Selected Seeds
Cousa	HA-187	Mottled green	Hazera Genetics, Inc.
	Magda	Pale green	Johnny's Selected Seeds

[z]Hollar Seeds, Inc., P.O. Box 106, Rocky Ford, CO 81067, USA; Hazera Genetics, Inc., 2250 E. Imperial Highway, Suite 200, El Segundo, CA 90245, USA; Johnny's Selected Seeds, 955 Benton Ave., Dept. 5124, Winslow, ME 04901, USA.

were listed for tunnel or greenhouse production. On 23 Jan. 2003, seeds from each cultivar were sown in Speedling styrofoam 128 cell trays (Todd Planter flats, Speedling, Inc., Bushnell, Fla.) filled with a peat: vermiculite mix 60:40 v:v medium. Transplants were grown in Conviron E15 (Winnepeg, Canada) growth chambers at 25 °C constant temperature and a 14-h photoperiod for 3 weeks. Transplants were irrigated every other day and fertilized with 100 mg L^{-1} N-P-K fertilizer solution with micronutrients once cotyledons were expanded (Peters Professional All Purpose Plant Food, Spectrum Group, St. Louis, Mo.).

The experiment was conducted in a passive-ventilated high-roof greenhouse (Top Ltd., Rosh Ha'ayin, Israel) located at the Horticultural Sciences Department Protected Agriculture Project, part of the University of Florida Horticultural Research Unit in Gainesville. The sidewalls were 3.6-m high with a 1-m roof vent at an 8-m height. Both the sidewalls and roof vents were covered with 0.6 mm screen (Klaymen Meteor Ltd., Petah-Tikva, Israel) to prevent insect movement into or out of the greenhouse. The roof was covered with double-layer polyethylene plastic (Ginegar Plastic Products Ltd., Kibbutz Ginegar, Israel). Transplants (3-weeks old) were planted on 14 Feb. 2003 into 11-L, black polyethylene nursery pots (Lerio Co., Kissimmee, Fla.) filled with pine bark screened by the manufacturer (Elixson Wood Products, Starke, Fla.) to a size less than 2.54 × 2.54 cm^2 (Shaw et al., 2004). Pots were drilled 2.5-cm from the bottom with four equidistant 1.5-cm diameter holes for drainage. Squash plants were fertigated through individual pressure-compensating emitters (Netafim USA, Fresno, Calif.) at a flow rate of 33 mL min^{-1}. Fertilizer levels remained the same throughout the season at 120 mg L^{-1} N, 50 mg L^{-1} P, 150 mg L^{-1} K, 135 mg L^{-1} Ca, 50 mg L^{-1} Mg, 65 mg L^{-1} S, 3 mg L^{-1} Fe, 0.2 mg L^{-1} Cu, 0.8 mg L^{-1} Mn, 0.3 mg L^{-1} Zn, 0.7 mg L^{-1} B, and 0.06 mg L^{-1} Mo. The pH of the final solution remained between 5.5 and 6.5.

Each plant was individually trellised vertically on twine similar to that used for greenhouse cucumber production (Shaw et al., 2000). Since the stems of the squash plants were more than 2.5-cm in diameter, plastic clips used in cucumber production could not be used past the initial clip at the base of the plant to secure the squash plants to the twine. Therefore, horticulture twist ties were used. Twist ties were placed approximately every 15 cm to vertically secure the main stem of the squash plant. Laterals were removed from all cultivars to encourage indeterminate growth.

Bumble bees (*Bombus impatiens*, Koppert Biologicals, Inc., Romulus, Mich.) were used for pollination, but their presence in the greenhouse limited pest control measures. Pests were controlled with biological agents. Green peach aphids (*Myzus persicae*) were controlled using lady beetle larvae (*Hippodamia convergens*, Entomos, Gainesville, Fla.) and parasitic wasps (*Aphidius colemani*, IPM Laboratories, Locke, N.Y.). Few two-spotted spider mites (*Tetranychus urticae*) and thrips (*Frankliniella occidentalis*) were found during the season; however, both were controlled by releasing *Orius insidious* (Entomos) and *Ambelysius cucumeris* (Koppert Biologicals). Powdery mildew (*Sphaerotheca fuliginea*) was controlled using Nova (myclobutanil, Rohm & Haas Co., Philadelphia, Pa.) and sulfur dust. Nova was sprayed once, 4 weeks after transplanting, and sulfur dust was applied to non-experimental plants once per week beginning10 weeks after transplanting.

Plants were harvested three times per week. There were 28 harvests beginning on 10 Mar. 2003 and ending on 15 May 2003. Fruit were harvested per plot and graded by size and shape. U.S.D.A. grade standards for baby squash have not been published; however, current retailers market baby squash at weights of approximately 20-30 g per fruit (Schmidt, 2003). Zucchini, yellow-summer, and cousa-types were graded as 'baby' fruit if they were 10 cm in length or less. Fruit sizes up to 20 cm in length and uniformly shaped were graded fancy, other marketable fruit were graded No. 1, and all non-marketable fruit were culled. Patty pan/scallop-types and the round zucchini (Eight Ball) were considered 'baby' size if they were of 4 cm diameter or less. Fruit which were 4 to 8 cm in diameter and uniformly shaped were graded fancy, other marketable fruit were graded No. 1, and all non-marketable

fruit were culled. Marketable fruit was the combined total of baby, fancy, and No. 1 grade categories. Average fruit weight was calculated using marketable fruit number and weight.

The experiment was a randomized-complete block design with three replications. Data were analyzed within cultivar-type using the statistical software package SAS (Cary, N.C.) and means were separated using Least Significant Difference (LSD), 5% level.

Results and Discussion

Numbers of baby squash produced per plant were greatest for the patty pan/scallop-type cultivars and lowest for the zucchini-types (Table 2). Sunburst was superior in baby fruit number per plant at 67 fruit while Bareket produced the lowest number at 16. The production of baby fruit from the yellow and green zucchini-type cultivars was between 16 and 25 fruit per plant, however, there was no statistically significant difference between the cultivars Gold Rush, Raven and Revenue. Zephyr produced a significantly lower number of baby fruit of the yellow summer-type cultivars at 27 compared to an average of 43 between Seneca Supreme, Sunray, Supersett, and Yellow Crookneck. Except for Sunburst (67 fruit per plant), the other patty pan/scallop-type cultivars produced on average of 50 fruit per plant. The cousa cultivar, HA-187, produced significantly more baby fruit per plant than Magda: 34 compared to 27, respectively.

Weight of baby squash per plant followed the same trend as number of baby fruit per plant for the zucchini-type cultivars, and ranged from 379 to 679 g per plant (Table 2). However, the yellow summer-type Zephyr produced a significantly lower baby fruit weight (588 g) than the four other cultivars, which averaged 882 g per plant. Baby fruit weight was not different among the patty pan/scallop or cousa cultivars, averaging 1065 g and 922 g per plant, respectively. Baby fruit were harvested and graded by the size that was recommended for packaging and average baby fruit weight of all squash cultivars grown was between 18 and 30 g per fruit (can be calculated from Table 2).

Fancy fruit number and weight per plant were reported to show the potential loss of baby fruit numbers when harvesting was not done every other day, such as a Monday harvest after the weekend (Table 2). Revenue produced significantly more fancy fruit per plant (17 fruit weighing 1027 g per plant) than the other six zucchini-type cultivars, which may suggest this cultivar needs to be harvested on a daily basis rather than every other day. There were no significant differences among the yellow-summer-type cultivars or the cousa-types for fancy fruit number and weight, averaging 16 fruit weighing 663 g per plant and 15 fruit weighing 861 g per plant, respectively. Both Butter Scallop and Patty Green Tint produced significantly more fancy fruit number and weight than the other patty pan/scallop cultivars Starship and Sunburst: 26 versus 16 fruit weighing 1098 g versus 623 g per plant, respectively.

Table 2. Yield variables per plant for selected squash cultivars grown hydroponically. Gainesville, Fla.

Cultivar[z,y]	Avg. ft. wt. (g)	Baby fruit no.	Baby fruit wt. (g)	Fancy fruit no.	Fancy fruit wt. (g)	Cull no.	Marketable fruit no.	Marketable fruit wt. (kg/plant)
Zucchini								
Bareket	30.1 c	16 c	409.3 d	4 d	204.4 d	<1	22 c	0.7 d
Eight Ball	36.5 b	20 bc	546.0 bc	7 c	436.5 c	<1	28 b	1.0 c
Gold Rush	24.3 d	21 ab	434.8 cd	4 d	156.3 d	<1	27 bc	0.7 d
Goldy	26.4 cd	19 bc	420.1 d	5 d	187.7 d	<1	25 bc	0.7 d
Raven	34.8 b	25 a	631.4 ab	11 b	592.2 b	<1	34 a	1.3 b
Revenue	45.4 a	22 ab	678.8 a	17 a	1026.6 a	3	41 a	1.9 a
Sebring	27.2 cd	17 c	379.0 d	5 cd	203.1 d	<1	23 bc	0.6 d
LSD	3.8	4.1	119.9	2.3	112.5	NS	5.1	0.2
Yellow-summer								
Seneca Supreme	26.8 b	48 a	1015.2 a	22	870.0	1 b	74	2.0
Sunray	27.6 b	40 a	843.0 a	16	655.3	2 b	59	1.6
Supersett	25.1 b	43 a	850.4 a	15	592.5	4 b	59	1.5
Yellow Crookneck	24.4 b	42 a	819.9 ab	14	524.6	17 a	66	1.6
Zephyr	31.4 a	27 b	588.0 b	14	673.5	3 b	48	1.5
LSD	3.5	12.6	247.1	NS	NS	8.7	NS	NS
Patty pan/scallop								
Butter Scallop	26.1 b	51 b	960.7	26 a	1048.8 a	<2	80	2.1 ab
Patty Green Tint	28.9 a	50 b	1050.0	26 a	1146.7 a	<2	83	2.4 a
Starship	25.2 b	51 b	1022.4	17 b	682.7 b	<1	70	1.8 b
Sunburst	22.1 c	67 a	1228.5	15 b	562.9 b	<3	85	1.9 b
LSD	1.9	8.7	NS	7.1	223.6	NS	NS	0.4
Cousa								
HA-187	37.7	34 a	1004.5	13	738.9	<1	47	1.8
Magda	41.3	27 b	838.4	17	983.1	<1	44	1.8
LSD	NS	4.3	NS	NS	NS	NS	NS	NS

[z]Data were analyzed within cultivar-type and means were separated using least significant difference (LSD), 5% level.
[y]Yields are an accumulation of 28 harvests. Plants were grown from 14 Feb. to 15 May 2003 in Gainesville, Fla.
NS = non significant.

For growers who do not have a market for the fancy fruit, it is recommended that all cultivar-types grown should be harvested daily.

Culls were minimal for most squash cultivars evaluated (Table 2). However, Yellow Crookneck produced many misshaped fruit or fruit that remained green when harvested at a small size and could not be considered marketable as a 'baby squash'. In spite of the number of culls produced, Yellow Crookneck remained one of the higher yielding cultivars.

Total marketable fruit number and weight are the combined totals of baby, fancy, and No. 1 fruit grades. Raven and Revenue produced the greatest marketable fruit number of the zucchini-type squash: 34 and 41 fruit per plant, respectively. Revenue also produced the greatest marketable fruit weight: 1.9 kg per plant. There was no significant difference among the yellow-summer, patty pan/scallop, and cousa-type cultivars for marketable fruit number; average fruit numbers per plant were 61, 80, and 46, respectively. There was no significant difference among either the yellow-summer or cousa-type cultivars for marketable fruit weight; average fruit weight per plant was 1.6 kg and 1.8 kg, respectively. Both Butter Scallop and Patty Green Tint produced significantly greater marketable fruit weights per plant than the other patty pan/scallop cultivars Starship and Sunburst: 2.3 kg versus 1.8 kg per plant, respectively. The greatest marketable yield over all 18 cultivars (2.4 kg per plant) was produced by the patty pan/scallop type cultivar Patty Green Tint.

Currently baby squash sell in regional supermarkets for approximately $3.49/227 g pack (Publix Supermarkets, Lakeland, Fla.). The fruit are grown in open-field culture in South and Central American countries, packaged, and air-freighted to the U.S. With the advantage of proximity to market, greenhouse growers in Florida can successfully add the variety of baby squash to their greenhouse and table. Greenhouse growers can choose a cultivar based on yield and/or fruit characteristics for their individual marketing needs. The greatest fruit numbers per plant were produced by the patty-pan/scallop-types (Butter Scallop, Patty Green Tint, Starship and Sunburst), followed by the yellow summer-types (Seneca Supreme, Sunray, and Supersett). Though plant yields were less than for the other types, the zucchini-type (green or yellow) and the cousa-type squash grow well hydroponically and would diversify market ability. Hydroponic production of baby squash, especially under pesticide-free conditions, could increase market potential by adding the value of a clean product that can be harvested on a daily basis and specialized to the demands of both the consumer and chef.

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