Alternative Use of Pine Bark Media for Hydroponic Production of 'Galia' Muskmelon Results in Profitable Returns

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Abstract

Green-fleshed 'Galia' muskmelons (*Cucumis melo* L.) have been traditionally open-field cultivated in Mediterranean climates, but greater yields and higher quality can be achieved through protected cultivation. In Florida (USA), pine bark is a by-product of the lumber and paper industries and may be suitable for containerized soilless culture vegetable production systems that currently use perlite. In spring 2001 and 2002, 'Gal-52' plants were grown in a passively-ventilated plastic covered greenhouse using polyethylene re-sleeving bags or 11.4 L nursery pots filled with coarse perlite, medium perlite or pine bark. Data were collected and compared for effects of media-type on fruit yield and fruit quality. Type of soilless media or container did not affect fruit yield or quality in either season. Plants produced on average 6 fruits per plant or 32.5 kg/m^2. Average soluble solids were 10.5 °Brix. A sensitivity analysis was performed using five years of market data on Galia muskmelons sold at the New York terminal market to show potential losses and profits using bags or pots filled with either perlite or pine bark. An economic analysis determined that pine bark was nearly one-eighth the cost of perlite and could be reused for several consecutive crops leading to reduced costs of production and greater profits.

INTRODUCTION

'Galia' muskmelons are commonly grown under protected structures in Israel, Turkey, Morocco, Spain, and other Mediterranean countries, however, currently they are not produced commercially in greenhouses in the U.S. 'Galia' were originally bred for the desert region of Northern Israel where they were grown under dryland farming conditions. Therefore, these plants do not grow or produce well under high rainfall and high humidity conditions such as those found in Florida during the spring season. Growing 'Galia' using a high-roof passively-ventilated greenhouse structure, such as found throughout the Mediterranean, may provide a suitable climate for 'Galia' production in Florida.

Cultivar trials of 'Galia' and 'Galia-type' melons were done in spring 1999 and 2000 which provided evidence that 'Galia' could be successfully grown using soilless culture in a protected structure during spring in Florida. Yields ranged from 3 to 5 fruits per plant weighing an average of 0.7 to 1.6 kg each depending on season and cultivar (Shaw et al., 2001). Though market values of 'Galia' were reported in this study, the cost of production was not. Since expenses and income were not shown, the actual profit from a 'Galia' crop produced hydroponically could not be calculated. Jovicich et al. (2004) provided an extensive economic report on colored pepper production using similar hydroponic techniques as that used for 'Galia' production.

The purpose of this study was to identify the greatest economic returns for 'Galia' muskmelon produced hydroponically in soilless culture in a high-roof passively-ventilated greenhouse using different combinations of media and containers.

MATERIALS AND METHODS

Seeds of 'Gal-52' were sown in styrofoam flats (cell size: 2.5 cm^2, 164 cells; Speedling, Bushnell, FL) filled with a mixture of 70% potting mix and 30% coarse vermiculite on 5 Jan. 2001 and 22 Jan. 2002. Transplants were grown in an evaporativecooled pad and fan glasshouse for three weeks or until plants had four fully expanded leaves. Transplants were fertilized twice a week using a solution of 50 mg/L m NO_3-P_2O_5-K_2O with micronutrients (Spectrum Group, St. Louis, MO). Transplants were planted on 14 Feb. 2001 and 18 Feb. 2002 in a 0.20 ha high-roof passively-ventilated greenhouse (Top Greenhouses Ltd., Barkan, Israel) located at the Horticulture Research Unit, Gainesville, FL. The structure had 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. Plants were irrigated and fertilized via pressure-compensated drip-emitters (flow rate: 1.9 L/hr; Netafim USA, Longwood, FL) and scheduling was done using an irrigation timer (Superior Controls Co., Valencia, CA) to provide plant need plus 20-30% leachate.

The experiments were a factorial design with four replications. The treatments were type of container and type of media. Each plot consisted of nine plants. Plant spacing was 0.30 m between plants and 1.2 m between rows. The containers were either white polyethylene re-sleeving bags (34 L; Agrodynamics, East Brunswick, NJ) or 11.4 L black plastic nursery pots (Lerio Co., Kissimmee, FL). There were three plants planted per re-sleeving bag and one plant per nursery pot. The bags were able to leach through drainage slits cut below each plant and pots were able to leach through four 1.5-cm holes drilled equidistantly 5-cm from the bottom. The three media types used were coarse- and medium-grade perlite (Airlite Processing Corp., Vero Beach, FL) and pine bark (Elixson Wood Products, Starke, FL). The particle size and physical properties of the three media varied. For coarse perlite, 89% of the particle size of the media ranged between 1.2 and 5.1 mm while only 61% of pine bark was in the same range. The majority (91%) of the particle size of the medium-grade perlite ranged from 0.6 to 2.4 mm (Cantliffe et al., 2003). Many physical properties were similar between coarse perlite and pine bark (bulk density: 0.34-0.39 g/cm^3; moisture capacity: 17%; air porosity: 40-46%; and EC: 0.06 mS/cm) though pH was different (6.9 and 5.2, respectively). Medium grade perlite measured greater bulk density (0.58 g/cm^3) and moisture capacity (46%) than either coarse perlite or pine bark, but less air porosity (17%) and EC (0.04 mS/cm); pH was neutral at 7.0 (Cantliffe et al., 2003).

All plants were trellised and pruned in accordance to Shaw et al. (2001). A complete nutrient solution was provided to the plants with every irrigation. N concentration was raised from 120 mg/L two weeks after transplanting to 160 mg/L, then gradually raised to 200 mg/L and maintained from flowering to fruit maturation. During fruit maturation, the N concentration was lowered to 170 mg/L and maintained until the end of the season. Other essential element concentrations maintained throughout the season were P: 50 mg/L; K: 110-160 mg/L; Ca: 134 mg/L; Mg: 40 mg/L; Cu: 0.2 mg/L; Zn: 0.3 mg/L; Mn: 0.8 mg/L; B: 0.7 mg/L; Mo: 0.06 mg/L; and Fe: 2.8 mg/L (Rodriguez, 2003).

An integrated pest management approach was used to control pests and diseases since bumble bees (*Bombus impatiens*, Koppert Biological Systems, Romulus, MI) were used for pollination. Ladybugs (*Hippodamia convergens*, IPM Laboratories Inc., Locke, NY), big-eyed bugs (*Geocoris punctipes*, Entomos LLC, Gainesville, FL), and minute pirate bugs (*Orius* sp., Entomos LLC) were released weekly to control aphids, thrips, and two-spotted spider mites. Aphid parasitic wasps (*Aphidius colemani*, IPM Laboratories, Inc.) were released every two weeks for three releases.

Preventative applications of fungicides were begun four weeks after transplanting to control gummy stem blight (*Didymella bryoniae*) and powdery mildew (*Sphaeroteca fuliginea*). Azoxystrobin (Quadris; Zeneca Agricultural Products, Wilmington, DE) was sprayed three times at two week intervals. Chlorothalonil (Bravo; Syngenta Crop Protection, Inc., Greensboro, N.C.) was applied at six and eight weeks after transplanting. No gummy stem blight symptoms were observed in either season, however, powdery mildew appeared once harvesting began.

Fruit were harvested from 11 May to 25 June, 2001 and 28 April to 7 July, 2002. Fruit were harvested at full-slip when the rind was golden-yellow. Fruit were graded and weighed. Soluble solids measurements were taken the day of harvest. There were 16 harvests in spring 2001 and 19 harvests in spring 2002. Data was analyzed using Analysis of Variance to test for interactions between media and container as well as main effects (SAS Inst., Cary, NC).

Enterprise budgets were developed to estimate the net returns for a single 6-month crop (spring only) using the production systems and estimated yields of a traditional 'Galia' melon crop (Table 2). The enterprise budget will comprise of three main components, net returns, revenue and total costs, where:

Net returns = Revenue – Total costs
Revenue = Yield * (Market price – 20% transaction fee)
Total costs = Variable + Fixed costs

Variable costs include all inputs that will have to be added to the system each season. Variable costs include: media, containers, transplants, trellising string, plastic clips, fertilizer, fuel, fungicides, biological control, bumble bees, transportation of product, packing boxes, repairs and maintenance, and labor for pruning, mixing fertilizer, and harvesting. Fixed costs are those costs that remain constant regardless in changes in the crop production system, such as, loan payments (including depreciation and interest), a manager's salary, licenses, annual dues, office expenses, taxes and insurance. Positive net returns equal profit above total costs.

New York terminal market prices for 'Galia' muskmelon were averaged from 1999-2003 to determine a market price for use in the enterprise budget. The average price over the 5-year period was $1.80, however, approximately 20% is lost to transaction fees, and therefore the grower should receive about $1.50 per kg in revenue.

A sensitivity analysis was conducted to view potential financial scenarios when production systems, crop yields or market prices of 'Galia' muskmelon change. Conditions that changed included the choice of media (perlite or pine bark) and the type of growing container (polyethylene bag or plastic nursery pot). Crop yields ranged from 3 to 6 fruit per plant, or 9.9 to 19.8 kg/m^2. Market prices (after 20% transaction fee) used in the sensitivity analyses ranged from $0.75 to $2.50 per kg, values below and above the 5-year average, but received during that time. Net returns will be estimated using the data collected during the spring 2001 and 2002 trials with the 'Gal-52' cultivar.

RESULTS AND DISCUSSION

Season did not affect fruit yield or quality of 'Gal-52' muskmelon grown in spring 2001 and 2002, therefore, the data was combined over season. The container by media interaction was not significant, therefore the main effects are discussed (data not presented). There were no differences between types of container or types of media for fruit number per plant, fruit weight, marketable yield, or soluble solids. Regardless of type of container or media, 6 fruit weighing 1.65 kg each were harvested per plant, marketable yield was 32.5 kg/m^2, and soluble solids were 10.5 °Brix. Yield was nearly two times greater than the standard yield for 'Galia' melon (16.5 kg·m^{-2}). Under the growing conditions of the trial, the 'Galia-type' cultivar 'Gal-52', produced fruit with a larger average fruit weight than the F1 hybrid 'Galia' produced in previous trials (1.6 kg versus 0.7-1.4 kg, respectively) (Rodriguez et al., 2005; Shaw et al., 2001) or in Mediterranean areas (Guler et al., 1995). Thus, 'Gal-52' as compared with true 'Galia' would have greater marketable yields as weight per square meter.

The enterprise budget for a six-month season for production of 'Galia' muskmelon is based on the standard production system described in Table 1. For a spring season in North Florida, 'Galia' should be transplanted during the first two weeks of Feb. at a density of 3.3 plants/m^2. In a recent greenhouse survey, it was found that most growers still use perlite filled bags for tomato and cucumber plantings in Florida (Mitchell and Cantliffe, 2005), therefore, this container and media combination will be used for the enterprise budget (Table 2). A 'Galia' crop may last from 16-24 weeks with the last 5-8 weeks as the harvest period. Average production is five fruit per plant weighing approximately 1.0 kg each generating a yield per unit area of 16.5 kg/m^2. There is potential to have both a spring and fall crop of 'Galia' muskmelon in the same greenhouse. In this case, various items can be re-used during the second crop, such as the media-filled containers and other horticultural supplies which will greatly reduce labor expenses for washing and filling containers, as well as the supply cost. In turn, total costs over 12-months are significantly reduced and if production and market prices are similar to those in spring, returns from double-cropping 'Galia' muskmelon are nearly three times greater than those of a single 6-month crop (Shaw et al., 2004).

The enterprise budget describes seasonal variable costs for items such as: media, containers, labor (pruning, harvesting), transplants, production and harvesting supplies, and delivery of product (Table 2). The fixed costs include the manager's salary, taxes and insurance, and the depreciation and interest on initial construction loans for the facility. Total costs are estimated at $21.29 per sq. m. Revenue is based on the standard 'Galia' yield of 16.5 kg/m^2 and a market price of $1.50 per kg, for a value of $24.75 per sq. m. Revenue minus the total costs provides a net return of $3.46 per sq. m.

A sensitivity analysis was performed to determine the break-even points of yield versus market price and to view the potential losses and returns for 'Galia' and 'Gal-52' muskmelon when different combinations of container and media were used (Table 3). The containers used were either re-sleeving bags or plastic nursery pots and the media types included pine bark and perlite. Perlite is an imported material used for a variety of industrial purposes, including horticulture. Perlite costs about $40 per cu. m. and may be difficult to dispose of in landfill areas. Pine bark is a renewable product in Florida and is available for about $8.50 per cu. m. Pine bark can be easily disposed of since it is a natural, organic material. Nursery pots cost about $0.80 initially, but last up to 10 years with repeated use, on the other hand, re-sleeving bags cost $0.20 each, but must be refilled and replaced each season because they are not UV resistant and break-down under Florida's intense solar radiation, adding additional costs for media and labor. Nursery pots are $0.27 or 0.06 per sq. m. more expensive to use over one season than bags when filled with perlite and pine bark, respectively. However, when pine bark is used instead of perlite in either pots or bags, there is a savings of $1.17 and $0.96 per sq. m., respectively. The combination of pine bark and pots would be over a $10,000 savings per ha for the grower per season, and potentially double the savings if the media and pots were re-used for an additional season or longer. Since there were no differences in yield between the combinations of media and container, greenhouse growers in Florida are recommended to use pine bark and nursery pots for 'Galia' melon production.

To compare break-even prices, when yield of 'Galia' was 9.9 kg/m^2 (3 fruits per plant), a terminal market price of $2.25 per kg was required to have net profits. For yields of 13.2 kg/m^2, 16.5 kg/m^2 and 19.8 kg/m^2, net profits were gained at market prices greater than $1.75 per kg. However, when yields were on the higher end of 19.8 kg/m^2 (6 fruit per plant), net profits could be gained at market prices as low as $1.50 per kg. When the sensitivity analysis was developed using the recommended container and media combination of pine bark and nursery pots, the cultivar 'Gal-52' produced profitable yields at all market price levels when 6 fruit per plant were harvested (32.5 kg/m^2). Thus, with a yield of 32.5 kg/m^2 and a minimal market price of $2.25 per kg, a grower would gross $73.13/m^2 per crop. With two crops produced per year, a 1-ha greenhouse operation would gross nearly $1.5 million (US dollars).

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Tables

Table 1. 'Galia' muskmelon production system in a passively-ventilated greenhouse and soilless culture in North Central Florida.

Item	Unit
Structure (Top Greenhouses, Ltd.)	
Greenhouse area	1.0 ha
Dimensions	210 m x 60 m
Gutter height	4 m
Number of bays	14
Available area for growing crops	10,000 m^2
Crop system	
Production system	Coarse perlite bags
Polyethylene bags	1 m x 0.10 m
Perlite volume per bag	34 L
Plant density	3.3 plants/m^2
Planting date	Spring (31 Jan - 15 Feb)
Crop duration	16-24 weeks
Harvest period	5-8 weeks
Estimated marketable yields	
Number of fruits per plant	5 fruits/plant[1]
Average fruit weight	0.9-1.4 kg
Yield per unit area	16.5 kg/ m^2

Table 2. Enterprise budget for 'Galia' muskmelons produced in a passively-ventilated greenhouse during one 6-month season in North Central Florida.

Item	Unit	Quantity (1.0 ha)	Price ($)	Value/m^2 ($)
Revenue				
16.5 kg/m^2 at $1.50 per kg				24.75
Variable costs				
Perlite	m^3	300	40.00	1.20
Polyethylene bags	box	24	85.00	0.20
Labor filling bags	hours	150	7.00	0.11
Rollerhooks	box	60	200.00	0.60
Plastic clips	case	22	87.00	0.19
Transplants	plugs	33,000	0.33	1.10
Planting labor	hours	360	7.00	0.25
Pruning labor	hours	6,950	7.00	4.87
Fertilizer	liter	48,500	0.26	1.26
Labor for fertilizer	hours	45	7.00	0.03
Diesel[z]	gallon	7,000	1.45	1.02
Fungicides	liter	2.5	36.40	0.01
Biological control[y]			5,000.00	0.50
Bumble bees	hive	10	100.00	0.10
Boxes	each	13,750	0.70	0.96
Harvest and packing	hours	1,080	7.00	0.75
Transport	shipment	37	300.00	1.11
Repairs and utilities			5,000.00	0.50
Total variable costs				14.76
Fixed costs				
Manager's salary, etc.[w]				1.06
Depreciation and interest[x]				5.09
Taxes and insurance				0.38
Total fixed costs				6.53
Total costs				21.29
Net returns				3.46

[z] Fuel based on 60 (8 hr) nights with added heat (4.16 gal diesel x 28 heaters x 60 nights = 7000 gal).
[y] Biological control includes 2 releases each of *Neoseiulus californicus*, *Aphidius colemani*, and Lady beetle larvae.
[w] Annual manager's salary, $20,000; licenses and dues, $400; misc. office expense, $800.
[x] Annual depreciation, $71,802 plus 6.5% interest on unpaid balance of $463,778 (80% of initial investment costs).

Table 3. Sensitivity analysis for 'Galia' and 'Gal-52' muskmelon produced in different combinations of media and containers during one 6-month season.

Yield (kg/m^2)[z]	Prod. cost ($ per kg)	Terminal market prices ($ per kg)						
		0.75	1.00	1.50	1.75	2.00	2.25	2.50
		Net returns above total cost ($ per m^2)						
A) Perlite and polyethylene bags – 'Galia'								
9.9	21.80	-14.38	-11.90	-6.95	-4.48	-2.00	0.48	2.95
13.2	22.26	-12.36	-9.06	-2.46	0.84	4.14	7.44	10.74
16.5	22.72	-10.35	-6.22	2.03	6.45	10.28	14.40	18.53
19.8	23.18	-8.33	-3.38	6.52	11.47	16.42	21.37	26.32
B) Perlite and plastic nursery pots – 'Galia'								
9.9	22.07	-14.65	-12.17	-7.22	-4.75	-2.27	0.20	1.12
13.2	22.53	-12.63	-9.33	-2.73	0.57	3.87	7.17	10.47
16.5	22.99	-10.62	-6.49	1.76	5.88	10.01	14.13	18.26
19.8	23.45	-8.60	-3.65	6.25	11.20	16.15	21.10	26.05
C) Pine bark and polyethylene bags – 'Galia'								
9.9	20.84	-13.42	-10.94	-5.99	-3.52	-1.04	1.43	3.91
13.2	21.30	-11.40	-8.10	-1.50	1.80	5.10	8.40	11.70
16.5	21.76	-9.39	-5.26	2.99	7.11	11.24	15.36	19.49
19.8	22.22	-7.37	-2.42	7.48	12.43	17.38	22.33	27.28
D) Pine bark and plastic nursery pots – 'Galia'								
9.9	20.90	-13.48	-11.00	-6.05	-3.58	-1.10	1.37	3.85
13.2	21.36	-11.46	-8.16	-1.56	1.74	5.04	8.34	11.64
16.5	21.82	-9.45	-5.32	2.93	7.05	11.18	15.30	19.43
19.8	22.28	-7.43	-2.48	7.42	12.37	17.32	22.27	27.22
E) Pine bark and plastic nursery pots – 'Gal-52'								
32.5	22.28	2.10	10.22	26.47	34.60	42.72	50.85	58.97

[z] All data for 'Galia' muskmelon was based on yields of 3, 4, 5, and 6 fruit per plant weighing 1.0 kg each and a plant density of 3.3 plants/m^2. Data for 'Gal-52' muskmelon was based on yield of 6 fruit per plant weighing 1.6 kg each (32.5 kg/m^2), using the recommended container and media for Florida: pine bark and plastic nursery pot.