Production of Galia-Type Muskmelon Using a Passive Ventilated Greenhouse and Soilless Culture

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Additional index words. *Cucumis melo*, perlite, pine bark, protected agriculture

Abstract
Galia-type muskmelons are the leading melon for consumer choice in Europe. The melon generally sells for U.S. $2 to $4 each and although Galia is currently found in some United States markets, it does not always possess the high quality consistent with that found in European markets. Achieving constant, high quality production has not been possible under normal field production in Florida, but can be done with protected structures. Evaluation of different nitrogen levels used in the complete nutrient solution recommended for soilless vegetable production, demonstrated that maintaining a single nitrogen concentration, instead of alternating various levels throughout the season, did not reduce yield and quality of Galia melon fruits. Furthermore, using locally available pine bark, a less expensive material than other available growing media such as perlite, may give growers an alternative that could lower their production costs and still obtain good yields and high fruit quality.

Traditional crops that once supported vegetable growers and their families in Florida are now less viable, due mainly to competition from foreign countries and the low economic feasibility of some of these commodities. It has become necessary to find alternatives to growing numerous vegetable crops in soil in many states such as Florida because good farmland is being urbanized at a rapid rate and the ever-increasing regulation and ban on the use of chemicals to control plant pests, weeds and soil pathogens (e.g. methyl bromide). Additional constraints, such as severe weather conditions (e.g. winds, rain and freezes) are especially pressing for vegetable growers in the United States. In many countries, the production of vegetables in greenhouses using soilless culture has already alleviated many of these production limitations. Imports of greenhouse vegetables, especially of tomatoes and colored peppers from countries, such as The Netherlands, Mexico and Canada into the United States have impacted local growers. Vegetable growers in Florida will eventually be forced to adapt to these changes to remain competitive and profitable (Cantliffe and Vansickle, 2001).

The use of protected structures along with new greenhouse crops and the use of soilless techniques could be incorporated into production systems that could help overcome the challenges previously mentioned. The term soilless culture applies to all methods and systems of growing plants without soil (Schwarz, 1995). The production of greenhouse vegetables using soilless culture is a growing industry in the United States. The total area of greenhouse vegetable production in Florida has increased from 25.8 ha in 1991 to 38.1 ha in 2001. Perlite is the preferred method of culture, accounting for 76.4% of the total area under production in the state (Tyson et al., 2001). Greenhouse vegetables produced in soilless culture could allow local growers to compete with foreign imports and obtain a profitable return to their investment. Implementing greenhouse and soilless technology to local conditions may be only part of the solution; finding a consistent market that can pay a premium price for the crops being produced, is as important as the methods use to produce them (Tyson et al., 2001). In Florida, besides the traditional greenhouse tomatoes and colored peppers, new crops such as Beit Alpha cucumbers (*Cucumis sativus* L.) and Galia muskmelons (*Cucumis melo* L.) could become additional greenhouse favorites (Cantliffe and Shaw, 2002; Shaw et al., 2001).

The Galia muskmelon is a green-fleshed fruit with a golden-yellow netted rind. Galia was developed in the early 1970's for production in the dry and warm conditions of desert areas in Israel (Karchi, 2000). Today, Galia is the number one melon in Europe and it is being grown in Spain, Morocco, Turkey, Egypt and the Middle East. The melon sells for U.S.$2 to $4 each in the European market. Although Galia is currently found in some United States markets, it does not always possess a high quality, due mainly to the way it is being produced and harvested. In most cases these fruits are field grown, without any protection from adverse weather, or imported from other countries where they are picked immature to maintain shelf-life (Cantliffe and Shaw, 2002). High quality Galia is harvested at peak ripeness and, like all melons, is very sensitive to rainfall during bloom and fruit set. Therefore, achieving constant, high quality production has not been possible under normal field production in Florida, but can be done with protected structures.

Because, Galia is not a crop traditionally grown in Florida, the objective of this research was to determine whether certain production management factors (plant nutrition, type of media and type of container) had any significant effect on fruit yield and quality of Galia muskmelons that were grown under a protected structure using soilless culture. The results obtained should serve as a base, which lead to optimum production practices that maximize yield and quality of

Galia muskmelons produced in soilless culture using a passive ventilated structure.

Materials and Methods

Trials were conducted to determine 1) the effect of nitrogen (N) levels on yield and quality of Galia and 2) to determine the effects of containers and media on yield and quality of 'Gal-152', a Galia-type muskmelon. These experiments were conducted in Spring 2001.

Seeds of 'Gal-152' were started on 23 January 2001 for the N experiment. All seeds were sown in polystyrene flats (Speedling Inc., Bushnell, Fla.) with cell sizes of 2.25 cm^2 and 164 cells per flat. A mixture of 70% Terra Lite Plug Mix (Terra Asgrow, Apopka, Fla.) and 30% coarse vermiculite was used as the growing media to produce the seedlings. Temperatures of 28°C day and 22°C night were maintained for optimal seedling growth for 3.5 weeks. Seeds of 'Gal-152' were sown on 12 February 2001 for the container and media experiment using the same procedures and type of materials used to produce seedlings for the N experiment.

After emergence and once the cotyledons were fully expanded, seedlings were fertilized twice a week using a 20% N, 8.8% P and 16% K soluble fertilizer (Spectrum Group, St. Louis, Mo.) to provide 50 mg $\cdot L^{-1}$ N, 23 mg $\cdot L^{-1}$ P and 44 mg $\cdot L^{-1}$ K, as well as the other essential nutrients. Once the plants had three or four fully expanded leaves, they were moved to the production greenhouse to begin the trials.

The experiments were carried out at the Protected Agriculture Project greenhouse, located at the Horticulture Research Unit in Gainesville, Fla. The greenhouse (7,300 m^2) is a passive-ventilated high-roof Israeli-type structure (Top Greenhouses Ltd., Barkan, Israel). The roof was covered with double layer polyethylene plastic to protect against strong winds and provide insulation during cold periods. The sidewalls could be raised or lowered at any time to provide additional air movement when temperature rose above 32°C or were expected to fall between 16°C. Both sidewalls and roof vents were covered with an ultraviolet 50 mesh insect screen to keep unwanted insect pests from entering, and to keep beneficial insects such as bumblebees and natural enemies inside the greenhouse. A pressure compensated drip irrigation system (1.9 liters $\cdot$ $hour^{-1}$) (Netafim USA, Longwood, Fla.) was installed to provide the plants with water and nutrients as needed. An irrigation timer (Superior Controls Co., Valencia, Calif.) was used to program all irrigation schedules throughout the season.

The experiments consisted of a randomized complete block design with four blocks, in which nine plants represented each experimental plot. Seedlings for the N trial were transplanted on 3 February 2001. All plants in the N experiment were spaced at 0.30 m between plants and 1.2 m between rows and transplanted in 1 m long x 0.10 m diameter resleeving polyethylene bags (Agrodynamics, East Brunswick, N.J.) filled with coarse perlite (Airlite Processing Corp. of Florida, Vero Beach, Fla.). Each bag contained approximately 34,000 cc of perlite. The plots were assigned randomly to one of the six N treatments (80, 120, 160, 200 240 mg $\cdot L^{-1}$ and the control). The control was based on the traditional method used in field production of increasing and lowering N concentrations throughout the season based on plant stage (Karchi, personal communication).

The plants for the media and container trial were transplanted 14 February 2001. These plants were also spaced at 0.30 m between plants and 1.2 m between rows. Containers used were either resleeving polyethylene bags (B) or in 11.3 L black plastic pots (P) (Lerio, Kissimmee, Fla.). The bags and the pots were filled with either coarse perlite (CP), medium perlite (MP) or a pine bark (PB) (Elixon Wood Products, Starke, Fla.). The resulting six treatments included all possible combinations of media and containers (CP-B, MP-B, PB-B, CP-P, MP-P, PB-P).

For both experiments plants were individually trellised on rollerhook twine (Paskal Binding Accessories, Migdal Tefen, Israel) which was hooked to a steel cable harnessed at 4 m above each plant row. In addition, plastic vine clips (Paskal Binding Accessories, Migdal Tefen, Israel) were added for support below the leaf petiole at different internodes (every 30 cm). During the first 4 weeks (vegetative stage), lateral branches were removed up to the ninth node to allow the plant to reach optimum growth so it may better support the eventual fruit load. All fruits were allowed to set above the ninth node (one fruit per lateral branch), however laterals without fruits were removed throughout the season to avoid excess vegetation that could harbor pests and diseases. Bumblebees (*Bombus inpatiens*) were introduced during the 3rd or 4th week after transplanting for pollination.

Daily irrigation schedules were programmed using the irrigation timer (Superior Controls Co., Valencia, Calif.) to allow a 20-30% leachate of the total irrigation volume per plant per day. The nutrient solution was proportioned using two Dosatron (DI 16-11 GPM) (Dosatron, Clearwater, Fla.), water-driven injectors and delivered to the plants through the drip system each time the plants were irrigated. For the N experiment, except for the N, all plants received the same concentrations of essential elements throughout the season. Excluding the control, all the N concentration treatments were supplied from transplant to last

harvest, never altering their concentration. For the control, the plants received 120 ppm N during the first 2 weeks after transplant. The concentration was increased to 160 ppm N during the 3rd week and gradually raised to 200 ppm N from flowering to fruit maturation then lowered to 160 ppm N when the fruits had began to turn in color and maintained at that level until the end of the season.

Plants were harvested for approximately 1.5 months for each of the growing seasons. The first harvest for the N experiment was done on 3 May 2001. Harvest initiated a week later (11 May 2001) for the media and container experiment. All fruits were harvested at the full-slip stage. This was determined when the fruits had a golden-yellow color and were easily removed from the vine. The following parameters were measured number of fruit per plant, size of fruit per plant, weight of fruit per plant and fruit quality (soluble solid content or ºBrix).

The data were subjected to analysis of variance (SAS Institute). All means were separated using the test of least significant difference, $P < 0.05$.

Results and Discussion

Comparisons between treatments in both experiments were based on yield and fruit quality. Plants in the N experiment had 14 harvests, while the plants in the media and container experiment had 16 harvests. The harvests were done three times a week. Problems with insect pests and diseases were more prevalent in the N experiment. Aphids were the most common insect pest and gummy stem blight was the most serious plant disease. It was observed that Galia was more susceptible to the disease than 'Gal-152'.

There were no differences in the average number of fruits per plant regardless of the N treatment (Table 1). The average fruit weight was less than 1.0 kg regardless of the treatment. This corresponds with the size of fruit preferred by European consumers of 0.7 to 0.9 kg. Most American consumers look for a slightly larger fruit when purchasing muskmelons (Maynard and Olson, 2000). This could be attainable by selecting cultivars with slightly larger fruit and/or managing irrigation and pruning methods (Shaw et al, 2001).

Previous research done by Shaw et al. (2001) also demonstrated that planting Galia for warm season production (e.g. spring) could potentially result in higher yields than when plants are grown during cooler periods (i.e. fall). Warmer temperatures and sufficient sunlight are extremely important for maintaining healthy plants that do not experience serious physiological stress due to cool temperatures and poor light quality. These higher yields also resulted in smaller

fruits than those obtained in fall 2000. The average fruit weight was between 0.6 and 0.8 kg regardless of the treatment. The average width and length of these fruits was approximately 99 mm and 112 mm respectively. The average soluble solids content was 10.0º brix (Table 2), which is slightly lower than those reported by Howe and Waters (1985) and Gomez (1996) of 12º brix for traditional field grown muskmelon cultivars.

The media and container trial, also evaluated during spring 2001, had marketable yields of more than four fruits per plant (Table 3). This yield is within the optimal economical yield for Galia reported in previous work (Waldo, 1999). Regardless of the type of media or container that was used, there were no significant differences in the average number of fruits per plant. This coincides with previous work in which cucumbers, peppers and strawberries were grown in different soilless media and evaluated for yield and quality. Cantliffe et al. (2000) report that greenhouse vegetables can be grown in various types of soilless media, as long as proper irrigation and fertilization is provided. The container and media treatments did not seem to affect the average weight of 'Gal-152' fruits (1.5 and 1.6 kg). As a result, yields of 7.5 to 8.7 fruits$\cdot$ plant^{-1} were obtained. The total marketable yield was between 24.4 and 28.7 kg$\cdot$ m^{-2}. This yield is much higher than those obtained in Israel, where Galia can generally yield 50 metric tons $\cdot$ ha^{-1} (5 kg $\cdot$ m^{-2}) when grown in the soil (Shaw et al., 2001). This yield is also higher than the 19 metric tons $\cdot$ ha^{-1} (1.9 kg $\cdot$ m^{-2}) obtained in low-tunnels and perlite by Waldo (1999). Average fruit width and length was also not significantly affected by the treatments. The average width of each was approximately 130 mm, while the length was 136 mm. The average soluble solids content was 10.3% regardless of container or media used (Table 4).

The key factors in obtaining good yields and high quality fruits in the production of Galia muskmelons grown in greenhouses using soiless culture are the management of season, irrigation, fertigation, proper pruning and adequate training of plants. Because in most countries where it is produced, Galia is grown in soil, it has been necessary to evaluate the effects that soilless media may have on the yield and quality of this crop. Nutrient supply and water are especially important in soilless culture, since these cannot be managed as when growing in soil. Thus the importance of evaluating specific essential elements (i.e. nitrogen) and most economical types of media than the traditional materials commonly used (e.g. perlite and pine bark).

Evaluation of N treatments demonstrated that although N supply may have a profound effect on yield of some crops grown in certain soilless media (Altunlu et al., 1999; Resh 1998), in the case of Galia muskmelons and under the conditions

in which these experiments were performed, maintaining a single nitrogen concentration, instead of the standard practice or alternating various levels, did not significantly affect yields and quality of fruits. The benefits of maintaining one single N level during the growing season, could result in less input cost and thus higher returns.

Artificial soils and/or soilless mixes were developed to satisfy several needs and to help with production problems of the horticulture industry (Boodley, 1998). The use of passive ventilated structures and soilless culture can be an economically viable means of growing vegetables (Cantliffe et al., 2001; Schwarz, 1995). Although there are several commercial soilless media, key factors in choosing the correct one will depend on its availability, ease of handling and disposal, and most importantly, cost. When two different grades of perlite and a local grade of pine bark were compared, yields were not affected regardless of the media or container that was used. Pine bark is a less expensive material at close to $8 per cubic meter compared to $40 per cubic meter for perlite. Economically, pine bark is a better choice when locally available.

Further research should focus on the evaluation of other essential elements (e.g. K and Ca) and their effects on yield when maintaining a single N concentration throughout the season. In addition, other media could be evaluated to investigate the influence that different irrigation practices may have on the production of Galia or Galia-type cultivars.

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Table 1. Means for total marketable yields per plant of 'Gal-152' melons grown at six different N treatments. Spring 2001.

	Marketable yield[Y]			
Treatment	Number of fruits per plant	Average Fruit weight (kg)	Total fruit weight per plant (kg)	Total marketable yield ($kg \cdot m^{-2}$)
80 ppm N	5.1[z]	0.60	3.2	10.5
120 ppm N	6.4	0.58	3.1	10.2
160 ppm N	4.7	0.70	3.3	10.9
200 ppm N	4.8	0.84*	4.2	13.8
240 ppm N	5.3	0.78	4.3	14.1
Control	6.4	0.74	4.7	15.5
Significance	NS	*	NS	NS

[Z] $P < 0.05$. Test of Least Significant Difference (LSD). SAS Institute.
[Y] Marketable yield = all fruit harvested except cull fruit.

Table 2. Means for quality parameters of 'Gal-152' melons grown at six different nitrogen treatments. Spring 2001.

	Fruit		Soluble Solids
Treatment	Width (mm)	Length (mm)	(%)
80 ppm N	106	102*[z]	9.8
120 ppm N	102	105*	10.2
160 ppm N	102	115	10.0
200 ppm N	99	119	9.7
240 ppm N	98	119	10.2
Control	91	115	10.3
Significance	NS	*	NS

[Z] $P < 0.05$. Test of Least Significant Difference (LSD). SAS Institute.

Table 3. Means for total marketable yields per plant of 'Gal-152' melons grown in different containers and different media. Spring 2001.

	Marketable Yield[y]			
Treatment	Number of fruits per plant	Average Fruit weight (kg)	Total fruit weight per plant (kg)	Total marketable Yield (kg . m^{-2})
Coarse pelite bag	4.7[z]	1.64	7.7	25.4
Medium perlite bag	4.5	1.68	7.5	24.7
Pine bark bag	4.7	1.68	7.8	25.7
Coarse pelite pot	5.0	1.64	8.2	27.0
Medium perlite pot	5.2	1.68	8.7	28.7
Pine bark pot	4.7	1.58	7.4	24.4
Significance	NS	NS	NS	NS

[z] $P < 0.05$. Test of Least Significant Difference (LSD). SAS Institute.
[y] Marketable yield = all fruit harvested except cull fruit.

Table 4. Means for quality parameters of 'Gal-152' melons grown in different containers and different media. Spring 2001.

Treatment	Width (mm)	Length (mm)	Soluble Solids (%)
Coarse pelite bag	132[z]	140	10.1
Medium perlite bag	129	138	10.3
Pine bark bag	129	136	10.3
Coarse pelite pot	128	135	10.3
Medium perlite pot	129	136	10.5
Pine bark pot	127	134	10.2
Significance	NS	NS	NS

[Z] $P < 0.05$. Test of Least Significant Difference (LSD). SAS Institute.

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