Proc. Fla. State Hort. Soc. 118:106-112. 2005.

NITROGEN FERTILIZATION SCHEDULING OF HYDROPONICALLY GROWN "GALIA" MUSKMELON

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Additional index words. Cucumis melo, greenhouse vegetable production, protected culture, soilless media, perlite

Abstract. **"Galia" muskmelons were originally developed for open-field cultivation in the desert regions of Israel. Nitrogen fertilization recommendations for 'Galia' production include altering N concentrations through four stages of plant growth: seeding to flowering, flowering to fruit set, fruit development, and fruit ripening through final harvest. It is unknown if those N recommendations for field production would be appropriate for 'Galia' muskmelon grown hydroponically in soilless media. In the present work, "Galia" muskmelons were grown in a passively ventilated greenhouse during three seasons in Gainesville, Florida using polyethylene-bag perlite culture. Nitrogen concentrations were applied with every irrigation at 80, 120, 160, 200, and 240 mg·L^{-1}. An alternating N (ALT-N) treatment that followed the four growth stages was also included (120-160-200-120 mg·L^{-1}). In all three seasons, there were no differences among the N treatments for average fruit weights or soluble solids content. In spring 2001, plants receiving N in relation to their growth stage produced the greatest number of fruit per plant and per square meter at 6.4 and 15.5 fruits, respectively. In fall 2001, plants receiving 80 and 120 mg·L^{-1} N produced significantly lower fruit numbers than those produced by all other N treatments. There was no difference among plants receiving 160, 200, 240 mg·L^{-1}, and the ALT-N treatment for fruit number per plant, each averaging 4.8 fruits. Petiole-sap NO_3-N concentrations during spring and fall 2001 suggested that optimal yields can be achieved if at least 3000 mg·L^{-1} NO_3-N was maintained through fruit maturation. When petiole-sap concentrations were less than 2500 mg·L^{-1}, as in the case of plants receiving 80 or 120 mg·L^{-1} N, significantly lower yields were obtained.**

Soilless culture enables growers to manage the supply of essential nutrients to crops more efficiently and accurately than traditional field systems (Jones, 1997; Resh, 1997; Schwarz, 1995). Plant nutrition in soilless culture systems can involve the application of soluble fertilizers every time the plants are irrigated, a method often referred to as fertigation or constant fertilization (Hochmuth, 1991; Jones, 1997). Experts believe that the basis for success with hydroponic and soilless culture systems is providing the plants with adequate concentrations of essential nutrients (Hochmuth, 1991; Hochmuth and Hochmuth, 2001; Resh, 1997). Management of the nutrient supply is one of the least understood aspects of soilless culture (Jones, 1997). There is a need for more research that focuses on the effects that specific essential elements, especially N, have on the production of soilless grown crops. This is especially important for the greenhouse industry in Florida, where production of new soilless grown crops like 'Galia' muskmelons may attract more interest from growers (Cantliffe and Shaw, 2001; Shaw et al., 2001).

The impact of N in soilless cultivated crops may be different than for field crops. The type of soil, N availability and rainfall can affect absorption of the element under field conditions (Rauschkolb and Hornsby, 1994). In protected soilless culture systems, crop production is much more intensive and climatic factors (e.g., air temperature, light intensity, relative air humidity) influence how plants grow (Stanhill et al., 1999) and respond to specific concentrations of elements such as N (Pardossi et al., 1994). For instance, light intensity and air temperature can lead to higher or lower water uptake by plants, thus affecting the plant's use of the nutrient solution (Pokluda and Kobza, 2001).

Some authors suggest that N may have a profound effect on cucumbers (*Cucumis sativus* L.) and other greenhouse crops grown in certain soilless culture systems (Altunlu et al., 1999; Resh, 1997; Starck and Okruszko, 1984). However, for crops such as 'Galia' muskmelons there is insufficient information available about the nutrition and water requirements for its production using soilless systems. Under field conditions, different N concentrations supplied to melons have been shown to affect fruit yield and quality (Dasgan et al., 1999; Feller and Fink, 1999; Hochmuth et al., 1991; Panagiotopoulos, 2001). But similar N concentrations and method of supply under soilless cultivation systems may give different results.

Over the years, N application recommendations for muskmelons under soil conditions in Florida have changed. Nitrogen recommendations in the 1980s for muskmelon production in Florida (subsurface and overhead-irrigation) were approximately 130 kg·ha^{-1} N (Kidder et al., 1989). In the 1990s, higher recommended rates (150 kg·ha^{-1} N) were suggested (Hochmuth and Hanlon, 1995). Currently, new recommendations have indicated that approximately 165 kg·ha^{-1} N applied half at pre-plant and half at mid-growth could result in better yields (Hochmuth and Cordasco, 2000). In the 1970s, when 'Galia' was produced under dryland farming conditions of Northern Israel, the soil was fertilized with N in the winter prior to rainfall and no N fertilizer was applied during the growing season when rain was scarce (Z. Karchi, personal communication).

In Southern Israel, the recommendations for 'Galia' muskmelon suggest that 50 to 120 kg·ha^{-1} N for sandy soils should be applied (Hecht, 1998). These N applications are based on the developmental stage of the crop (Hecht, 1998; Karchi, 2000), where the concentrations are generally adjusted during the season. In one hectare of production, 5, 10, 12, and <5 kg of N per day would be needed during stage one, two, three and four, respectively (Table 1). Under these conditions, melons are grown under different irrigation practices, such as rain-fed cultivation (no irrigation), complementary irrigation and complete irrigation. Irrigation intervals are determined by soil type, where irrigation is applied

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Table 1. General recommendations for proportional N supply in sandy soils or growing substrates in arid regions (Arava desert, Israel).

	N concentration in delivered nutrient solution	
Stage	mg L^{-1}	Level
1	50	Low
2	100	Medium
3	120	High
4	<50	Very low

Source: Hecht, 1998.

when 50-60% of the available water at 60 cm depth had been depleted. During establishment of the crop in the field, irrigation intervals are extended as much as possible to stimulate root development. During flowering and fruit set, plant water requirements increase. However, during fruit ripening, water amounts are generally reduced and irrigation intervals extended to improve fruit quality and avoid over-sized fruits. Most formulas for soilless crops, like tomatoes (*Lycopersicon esculentum*), peppers (*Capsicum annum* L.) and cucumbers call for the total N concentration in the nutrient solution to range from 100 to 200 mg·L^{-1} (Jones, 1997). For greenhouse muskmelons and similar to field practices, the supply of N in soilless systems frequently starts at a low level (<100 mg·L^{-1}), which is then increased as the growing crop matures (Jones, 1997). The objective is to minimize vegetative growth and to promote fruit initiation and development.

The nutritional status of crops such as melons may be monitored with sap testing (Hochmuth, 2003). Knowledge of plant N status could help to adequately manage N supply that matches plant growth-related demands (Simonne et al., 2002). Careful assessment of N via sap tests throughout the season and its effects on plant growth, fruit yield and fruit quality can provide the information needed to create a complete nutritional system for greenhouse muskmelons (Drews and Fischer, 1992). Testing the plant during the growing season, instead of the media or soil is preferable because the information can serve for diagnosing problems (Hochmuth, 2003).

The traditional field method of alternating N concentrations during the season to produce melons may not be necessary under greenhouse and soilless conditions. Maintaining a single N concentration throughout the season that results in optimized yields of 'Galia' could reduce input management decisions. The purpose of this work was to determine the effects of N concentration on yield and fruit quality of 'Galia' muskmelons grown in fertigated soilless culture under a passively-ventilated greenhouse in North Central Florida.

Materials and Methods

Separate experiments were conducted in fall 2000, spring 2001 and fall 2001 to evaluate the influence of different N concentration treatments on plant growth, yield and quality of 'Galia' muskmelons. Seedlings for all experiments were produced at the Horticultural Sciences greenhouse facilities in Gainesville, Fla., inside an evaporative-cooled fan and pad glasshouse. 'Galia' seeds (Hazera Seeds Ltd., Grover Beach, Calif.) were sown on 5 Aug. 2000, 23 Jan. 2001, and 21 July 2001. Polystyrene flats (Speedling, Bushnell, Fla.) with cell sizes of 2.25 cm^2 and 164 cells per flat were used. All seedlings were produced in a mixture of 70% potting mix (Terra Lite Plug Mix, Terra Asgrow, Apopka, Fla.) and 30% coarse vermiculite growing medium. Day and night temperatures inside the glasshouse were maintained at 28°C and 22°C for optimal seedling growth. Artificial lights (12 h·d^{-1}) were used to compensate for low light conditions and photoperiods less than 12 h.

The 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·L^{-1} N, 23 mg·L^{-1} P and 44 mg·L^{-1} K, as well as micronutrients (Mg, B, Cu, Fe, Mn, Mo and Zn). Once the seedlings had three or four fully expanded leaves (2.5 to 3 weeks after sowing), they were moved to the production greenhouse located at the Protected Agriculture Project (PAP) site in Gainesville, Fla. Seedlings were transplanted on 23 Aug. 2000, 14 Feb. 2001 and 6 Aug. 2001.

A single bay (266 m^2) within a seven bay passively-ventilated high-roof polyethylene covered greenhouse (Top Greenhouses Ltd., Barkan, Israel) was used for each experiment. Plants were protected from low temperatures (>15°C), strong winds, and rain by a double-layer polyethylene plastic roof cover (0.150 mm thickness, Ginegar Plastic Products Ltd., Israel). An ultraviolet 50-mesh insect screen (Klaymen Meteor, Petach Tikva, Israel) covered the sidewalls and roof vent and kept unwanted insect pests out and beneficial insects such as bumble bees and natural enemies inside the greenhouse. Sidewall polyethylene plastic curtains (same as roof cover) were opened to provide ventilation when temperatures rose above 25°C. When temperatures were expected to fall below 16°C, curtains were closed for better insulation. Additionally, diesel-fired heaters (Sundair, Baltic, S. Dak.) were used to prevent air temperature inside the greenhouse from dropping below freezing.

Growing containers were 1 m long × 0.10 m diameter resleeving polyethylene bags (Agrodynamics, East Brunswick, N.J.) filled with medium grade perlite (Airlite Processing Corp. of Florida, Vero Beach, Fla.). Plants were spaced at 0.30 m within the row and 1.2 m between rows (three plants per bag). Water and nutrients were supplied through a pressure compensated drip irrigation system (1.9 L·hr^{-1}) (Netafim USA, Longwood, Fla.). Nutrient solution was proportioned using two water-driven injectors (Dosatron DI 16, Clearwater, Fla.) and delivered to plants through the drip system each time plants were watered. Irrigation schedules throughout the growing season were programmed with an irrigation timer (Superior Controls Co., Valencia, Calif.) and based on 20-30% daily drainage from the growing bags (15-32 irrigations per day).

All three experiments were a randomized complete block design with four replications; each experimental plot was comprised of nine plants. In fall 2000, the N treatments were 120, 160, 200 mg·L^{-1} N and a N treatment which alternated N level with plant development (ALT-N). Excluding the alternating N treatment, plants in each treatment received the same N concentration at each irrigation event from transplant to final harvest. The ALT-N treatment was based on the traditional method used in Israel for field production, in which N concentrations were increased and lowered throughout the season based on plant growth stage (Z. Karchi, personal communication) and previous experiments conducted at PAP site in Gainesville, Fla. (Shaw et al., 2001). At the time of transplanting, plants in the ALT-N treatment were fertigated with 120 mg·L^{-1} N two weeks. The N concentration in the nutrient solution was increased to 160 mg L^{-1} N and then

gradually increased to 200 mg·L^{-1} N between the third and fourth week after transplanting (flower initiation and fruit set). Plants were kept at 200 mg·L^{-1} N until fruits had began to turn color (approximately eight weeks after transplanting). At this time, the N concentration was lowered to 160 mg·L^{-1} N and maintained until the crop was terminated. For the spring and fall 2001 experiments, two additional N concentrations (80 and 240 mg·L^{-1} N) were added to the study for a total of six N treatments (80, 120, 160, 200 240 mg·L^{-1} N and the ALT-N treatment). For all three experiments, P, K and all other essential elements were applied to each treatment at the same concentrations throughout the season (Shaw et al., 2001).

All plants were individually trellised on rollerhook twine (Paskal Binding Accessories, Migdal Tefen, Israel) hooked to a steel cable harnessed at four meters above each plant row. Plastic vine-clips (Paskal Binding Accessories) were added for support below the leaf petiole every 30 cm. All lateral branches below the ninth node were removed to allow optimum vegetative growth.

Lateral branches along with their female flowers above the ninth node were allowed to grow until fruit set. Fruits that set were of a dark green color and had the appearance of a small sphere (30 mm in diameter). Only one fruit per lateral branch was allowed to develop. The remaining portion of the lateral branch past the developing fruit was trimmed, leaving one leaf next to that fruit. Any lateral branches that did not have developing fruits were removed throughout the season to avoid excess vegetation that could harbor pests and diseases. Pollination was accomplished by bumble bees (*Bombus inpatiens*, Natupol, Koppert Biological Systems, Ann Arbor, Mich.), which were introduced in the greenhouse during the third to fourth week after transplant.

In fall 2000, spring 2001, and fall 2001, plants were harvested 25 Oct. to 12 Dec. 2000; 5 May to 8 June, 2001 and 3 Oct. to 3 Dec. 2001, respectively. All fruits were harvested at the full-slip stage, which was determined when the fruits had a golden-yellow color and were easily removed from the vine. Yields per plant were recorded at every harvest. Fruit quality was measured using soluble solids content (SSC) and the average width and length of the fruits. Soluble solids content were measured at every harvest on randomly selected fruits from every plot. Two core samples were extracted from opposite sides of the equatorial zone of the fruit. Samples were squeezed with a garlic press and the juice placed on a refractometer (AO 10430, AO Scientific Instruments, Keene, N.H.). Results were expressed in °Brix.

Petiole-sap nitrate-N concentrations (NO_3-N) were measured at different plant growth stages (Hochmuth, 2003). In fall 2000, petiole-sap NO_3-N was recorded at 6, 8, and 10 weeks after transplanting. In spring and fall 2001, petiole-sap tests were taken once each week. Samples were collected from two plants from each plot of the N treatments and from each block in the experimental design. Each sample consisted of two to four newly matured leaves (fully expanded) with their petioles. Petioles from samples in each treatment and each block were chopped in smaller pieces, so they could fit into a garlic press to squeeze the sap that would be used for the NO_3-N measurements. A hand-held ion meter (Cardy, Horiba, Inc., Kyoto, Japan) was used to measure petiole-sap NO_3-N concentration.

Greenhouse pests such as cotton aphids (*Aphis gossypii*), green peach aphids (*Myzus persicae*) and greenhouse whiteflies (*Trialeurodes vaporariorum* and *Bemisia argentofolii*) were common during the different growing seasons. In fall 2000 and spring 2001, aphids were the most common pest. Aphid populations in spring 2001 were above threshold levels despite the release of predators such as lady beetles (*Hippodamia convergens*), parasitic wasps (*Aphidius colemani*, IPM Laboratories, Inc.) and the presence of other native wasp species (*Lysiphlebus testaceipes*), many plants showed severe symptoms of aphid damage (corrugated leaves and sooty mold). Since no plants died from the aphid damage, it was possible to complete all harvests until the experiment was terminated.

The 'Galia' cultivar is highly susceptible to gummy stem blight (*Didymella bryoniae*). In fall 2001, approximately 20% of the plants in the experiment showed symptoms of the disease. Preventive applications of Azoxystrobin fungicide (Quadris, Zeneca Agricultural Products, Wilmington, Del.) every 15 d did not reduce the incidence of the disease. Curative applications using Chlorothalonil (Bravo; ISK Bioscience Corporation) every 12 d after the first symptoms were observed gave acceptable results, but was not entirely successful as approximately 12% of the infected plants eventually died. In most cases, it was possible to harvest all fruits from affected plants.

Data were analyzed within season using analysis of variance (ANOVA) to test for significant effects among N treatments (SAS, 2001). Orthogonal comparisons were done to compare differences between the ALT-N treatment and other N treatments on yield (fruit weight, fruit number and yield per unit area) as well as fruit quality parameters (width, length and SSC of fruits). Means were separated using the test of least significant difference (LSD), $P < 0.05$.

Results and Discussion

In fall 2000, fruit production was lower than yields previously reported for soilless culture in North Central Florida (Shaw et al., 2001; Waldo, 1999). Average fruit weight was not affected by N treatment, but plants that were constantly supplied with 200 mg·L^{-1} N, produced a greater number of fruits per plant, weight per plant and per unit area than the other treatments (Table 2). Regardless of N treatment, fruit quality, expressed as average width, average length and soluble solids content (SSC) was not affected by N treatment in fall 2000. Aphid populations were high and damage to young leaves and growing tips was visible in fall 2000. Although no quantitative data was taken regarding the level of damage in any N treatment, overall yields may have been lower than expected due to the influence of such pests.

Plants supplied with higher concentrations of N throughout the season also had higher NO_3-N concentrations in petiole-sap of the most recently matured leaf (Fig. 1). Petiole-sap NO_3-N concentrations increased during the season and peaked about seven weeks after transplant (WAT). In fall 2000, 7 WAT coincided with the time of fruit set and development. At 7 WAT, plants supplied with 200 mg·L^{-1} N had about 500 mg·L^{-1} higher petiole-sap NO_3-N concentrations than plants in the ALT-N treatment and about twice as much as plants receiving 120 and 160 mg·L^{-1} N. As fruits matured and were harvested (9 WAT), NO_3-N concentrations in petiole-sap of plants receiving the ALT-N and 200 mg·L^{-1} N treatments decreased from about 4,200 mg·L^{-1} NO_3-N to about 3,500 mg·L^{-1} NO_3-N. Similarly, in the 120 and 160 mg·L^{-1} N treatments, NO_3-N concentrations decreased from about 2,500 and 3,200 mg·L^{-1} NO_3-N to 2,000 and 2,800 mg·L^{-1} NO_3-N, respectively. This may be an indication that as plants age (vege-

Table 2. Total marketable yield and fruit quality of 'Galia' muskmelons grown with four different nitrogen treatments in soilless culture. Fall 2000.

	Total fruit yield[z]				Fruit quality		
N concentration (mg L^{-1})	Average fruit weight (kg)	No. of fruits per plant	Fruit weight per plant (kg)	Fruit weight per unit area (kg m^{-2})	Width (mm)	Length (mm)	SSC (Brix)
120	1.4	1.00	1.50	4.9	137	145	9.7
160	1.3	1.10	1.60	5.3	135	140	10.3
200	1.5	1.50	2.20	7.3	133	140	10.8
ALT-N[y]	1.3	0.90	1.30	5.4	130	148	10.8
LSD[x]	NS	0.25	0.31	1.8	NS	NS	NS

[z]Total yield = 9 harvests from 25 Oct. to 12 Dec. 2000.
[y]ALT-N = increasing and decreasing N concentrations throughout the season based on plant growth stage (120-160-200-120 mg·L^{-1}).
[x]NS = Non-significant or significant at $P < 0.05$.

tative to reproductive to senescence) the demand for N in vegetative parts (leaves and petioles) is reduced. Nitrogen is partly being utilized for production of assimilates transported to the developing fruits for seed maturation.

In spring 2001, fruits were harvested from 5 May to 8 June 8, 2001 (14 harvests). No differences were observed in average fruit weight or fruit quality regardless of the N treatment (Table 3). Orthogonal contrasts determined that the ALT-N treatment produced significantly more fruit per plant, weight per plant and weight per unit area compared to all other N treatments (6.4 fruits per plant, 4.7 kg per plant and 15.5 kg·m^{-2}, respectively). Compared to plants receiving 80, 120 and 160 mg·L^{-1} N, plants which received the ALT-N treatment produced on average 5 kg·m^{-2} more fruit per unit area.

Results from weekly petiole-sap tests in spring 2001 (Fig. 2) indicated that NO_3-N concentrations for all N treatments increased during the first seven weeks of crop growth (transplant to flowering and fruit set to fruit development). These responses suggest that the first five to seven weeks after transplanting is the period when N is required in greatest quantities for greenhouse produced muskmelon. When plants reached the fruit maturation stage, petiole-sap NO_3-N concentrations for all N treatments decreased until the end of the season. Despite higher NO_3-N concentrations in the 200 and

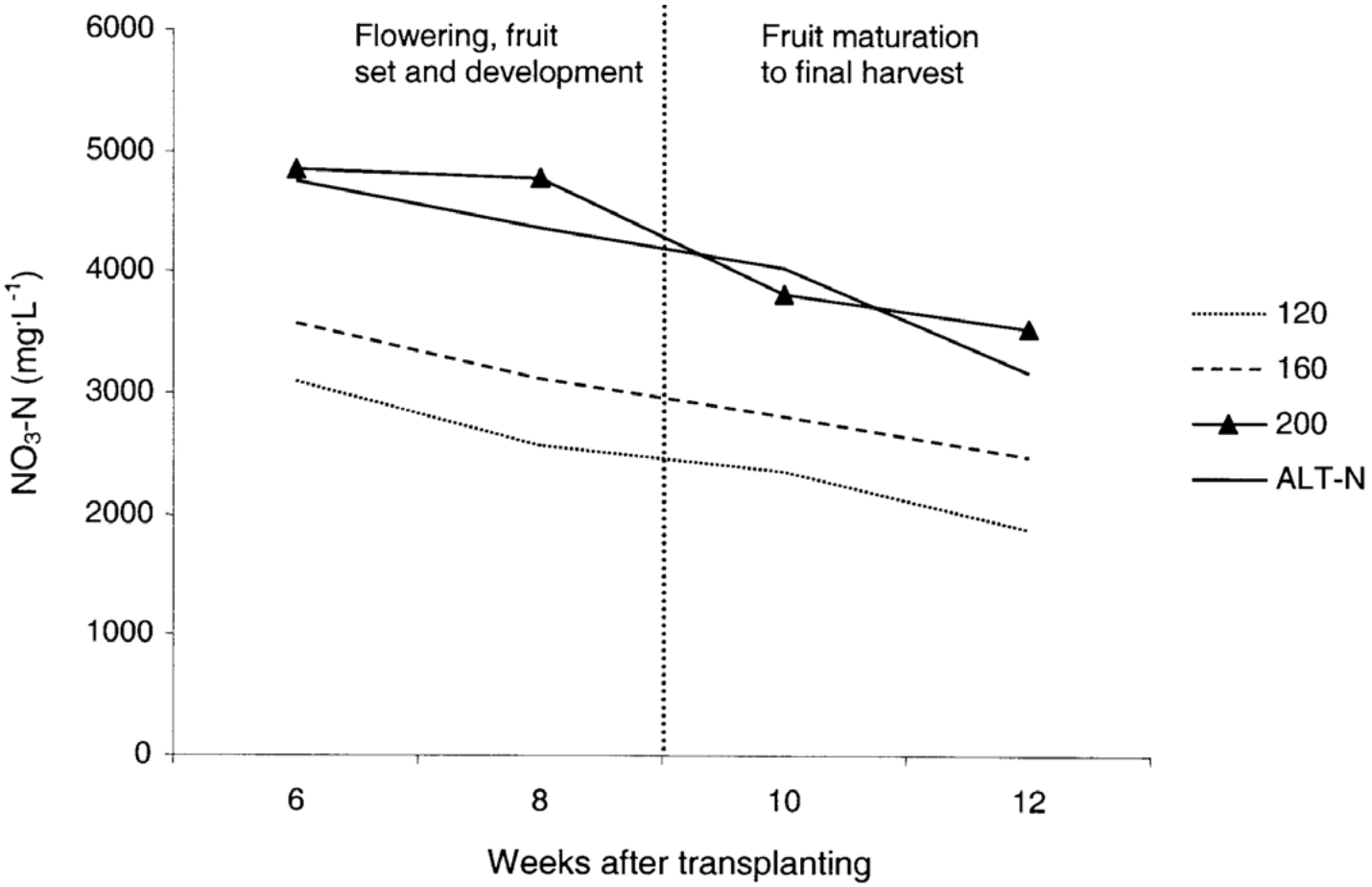

Fig. 1. Nitrate-nitrogen (NO_3-N) concentrations (mg·L^{-1}) in petiole leaf sap (of most recently matured leaf) of 'Galia' muskmelons cultivated in perlite with four different N treatments during different plant growth stages. Fall 2000.

Table 3. Total marketable yield and fruit quality of 'Galia' muskmelon grown with six different nitrogen treatments in soilless culture. Spring 2001.

	Total fruit yield[z]				Fruit quality		
N concentration (mg L^{-1})	Average fruit weight (kg)	Fruits per plant	Fruit weight per plant (kg)	Fruit weight per unit area (kg·m^{-2})	Width (mm)	Length (mm)	SSC (Brix)
80	0.60	5.1	3.1	10.5	104	110	10.0
120	0.58	5.7	3.1	10.2	100	107	9.0
160	0.75	4.9	3.7	9.2	102	110	10.0
200	0.74	4.8	3.7	13.8	100	109	10.2
240	0.78	5.3	4.1	14.1	101	108	10.0
ALT-N[y]	0.74	6.4*	4.7*	15.5*	95	103	10.1
LSD[x]	NS	NS	NS	NS	NS	NS	NS

[z]Total yield = 14 harvests from 5 May to 8 June 2001.
[y]ALT-N = increasing and decreasing N concentrations throughout the season based on plant growth stage (120-160-200-120 mg·L^{-1}). * = significant orthogonal contrast between the ALT-N treatment compared to all other N treatments.
[x]NS = Non-significant or significant at $P < 0.05$.

240 mg·L^{-1} N treatments than the ALT-N treatment, all three treatments produced the same yield. NO_3-N concentrations for the different N treatments ranged from 1,500 mg·L^{-1} (80 mg·L^{-1} N treatment) to 4,200 mg·L^{-1} NO_3-N (240 mg·L^{-1} N treatment). An increase in petiole-sap NO_3-N concentrations (from 4,500 to 5,000 mg·L^{-1} NO_3-N) in the 240 mg·L^{-1} N treatment at 9 WAT may have been due to higher absorption and accumulation of NO_3-N after fruits had been harvested. Petiole-sap test results could be used in future recommendations for measuring adequate NO_3-N concentrations for hydroponically produced 'Galia' muskmelons. Greatest yields were achieved in plants where petiole-sap NO_3-N concentrations were maintained between 3000 and 4000 mg·L^{-1}.

A final experiment was conducted during fall 2001 with a total of 12 harvests from 3 Oct. until 3 Dec. 2001. There were no differences among N treatments for average fruit weight (Table 4). Plants receiving 80 or 120 mg·L^{-1} N produced significantly fewer fruits per plant than those receiving 160, 200, 240 mg·L^{-1} N or the ALT-N treatment. Fruit weight per plant and per unit area was greatest from plants which received the ALT-N treatment, but not significantly different than those which received 160, 200 or 240 mg·L^{-1} N. Average fruit production per plant was 4.3 fruits. Average fruit per unit area was about 14.3 kg·m^{-2}. No significant differences were found in fruit quality (fruit width, fruit length and SSC) due to N treatments. Average SSC among all treatments was 10.6 °Brix.

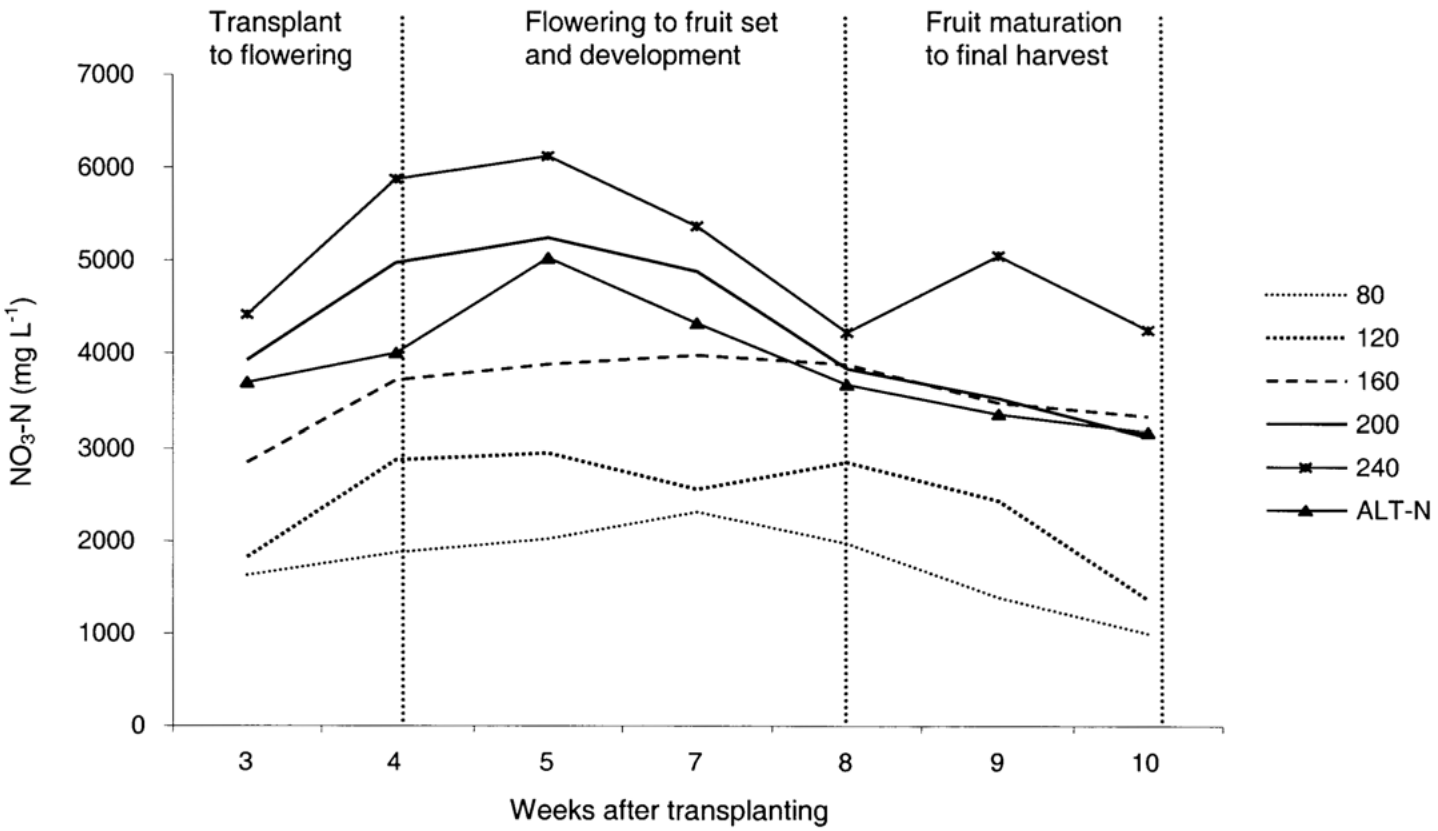

Fig. 2. Weekly nitrate-nitrogen (NO_3-N) concentrations (mg·L^{-1}) taken from petiole leaf sap (of most recently mature leaf) of 'Galia' muskmelons cultivated in perlite with six different N treatments during Spring 2001.

Table 4. Total marketable yield and fruit quality of 'Galia' muskmelon grown with six different nitrogen treatments in soilless culture. Fall 2001.

	Early fruit yield[z]				Fruit quality		
N concentration (mg L^{-1})	Average fruit weight (kg)	Fruits per plant	Fruit weight per plant (kg)	Fruit weight per unit area (kg m^{-2})	Width (mm)	Length (mm)	SSC (Brix)
80	0.97	3.90	3.80	12.5	113	120	10.8
120	0.98	4.10	4.00	13.1	115	123	10.5
160	0.93	4.70	4.30	14.3	116	125	10.9
200	0.90	4.90	4.30	14.4	110	119	10.4
240	0.90	4.70	4.20	14.1	110	118	10.5
ALT-N[y]	0.90	4.90	4.40	14.5	109	117	10.5
LSD[x]	NS	0.33	0.29	1.7	NS	NS	NS

[z]Total yield = 12 harvests from 3 Oct. to 3 Dec. 2001.
[y]ALT-N = increasing and decreasing N concentrations throughout the season based on plant growth stage (120-160-200-120 mg·L^{-1}).
[x]NS = Non-significant or significant at $P < 0.05$.

Optimal yields were achieved when a minimum of 3,000 mg·L^{-1} petiole-sap NO_3-N was maintained during all plant growth stages (Fig. 3). Yield per unit area of 14.3 kg·m^{-2} was achieved from plants receiving the ALT-N treatment as well as 160, 200, 240 mg·L^{-1} N and coincided with petiole-sap concentrations above 3,000 mg·L^{-1} NO_3-N. Plants in the 80 and 120 mg·L^{-1} N treatments had petiole-sap concentrations below 2,500 mg·L^{-1} NO_3-N and also significantly lower yields than the other N treatments. Plants in the 80 mg·L^{-1} N had the lowest petiole-sap NO_3-N concentrations of all N treatments (1,800 to 900 mg·L^{-1}) beginning 3 WAT through the end of the season.

Yields in spring and fall 2001 were similar though temperatures between the two seasons were different. Maximum day temperatures in the spring were on average 5°C lower than those recorded in the fall (Rodriguez, 2003). Previous experiments conducted at the PAP site by Shaw et al. (2001) suggested that spring may be the more favorable season for growing 'Galia' muskmelons in North Central Florida. Low temperatures below 15°C that occur at night or during winter months in Florida may delay plant growth, affect fruit set and development by restricting pollination (i.e., bumble bee activity), and restrict production and translocation of assimilates to fruits (Mitchell and Madore, 1992; Nerson, 2002). Furthermore, low temperatures may inhibit uptake of N in certain crops (Rauschkolb and Hornsby, 1994).

In spring 2001, average day temperatures of about 35°C during flowering, fruit set and development (March to April) were more favorable for fruit production than in fall 2001.

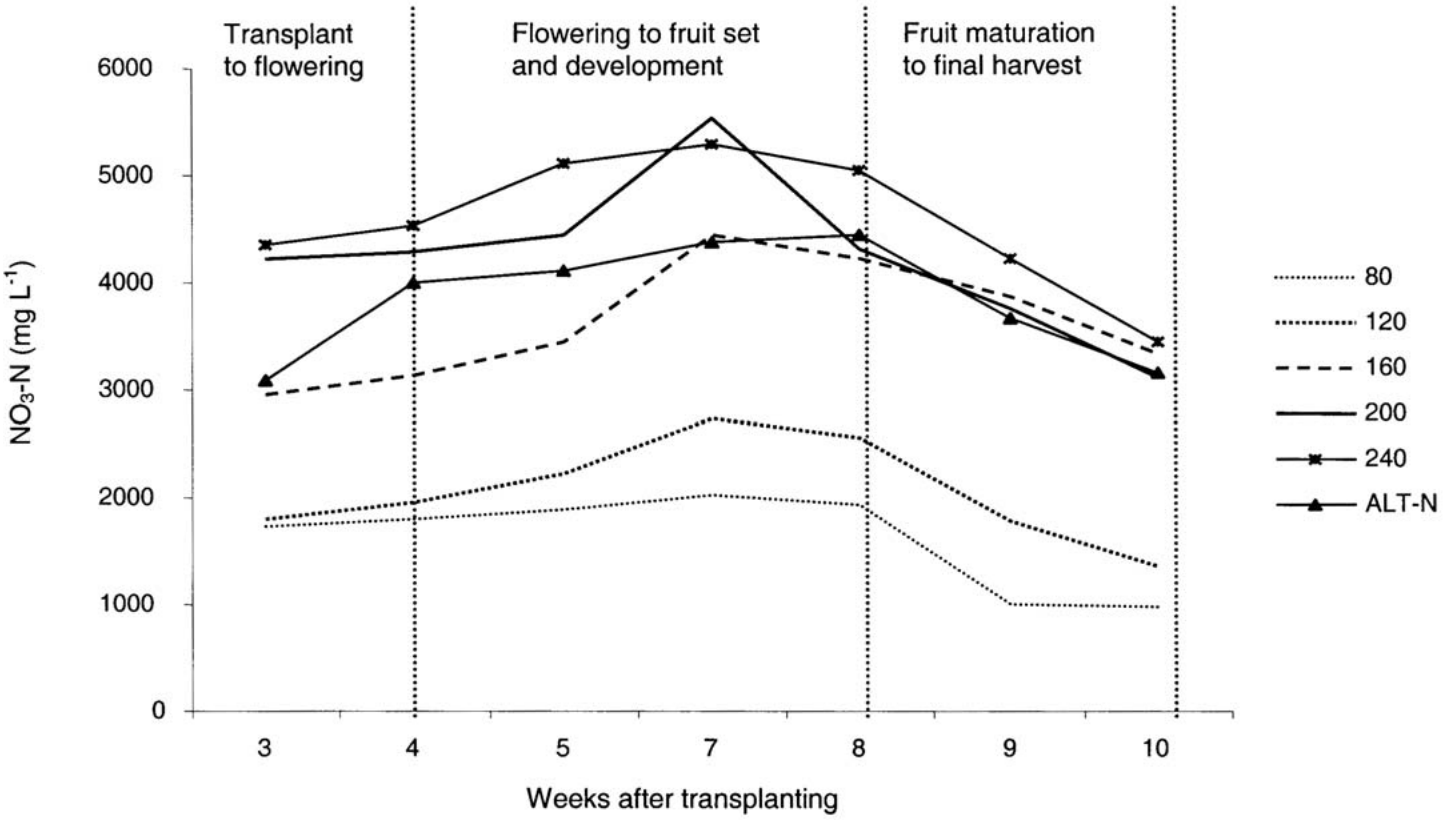

Fig. 3. Weekly nitrate-nitrogen (NO_3-N) concentrations (mg·L^{-1}) taken from petiole leaf sap (of most recently mature leaf) of 'Galia' muskmelons cultivated in perlite with six different N treatments and plant growth stages during Fall 2001.

Between September and October 2001 (flowering, fruit set and development stages), average day temperatures were about 40°C. Longer periods with night temperatures below 15°C were recorded in the fall than in the spring. Temperatures during fall in Florida tend to decrease between October and December. Nonetheless, the results obtained during the fall season suggest that maintaining N concentrations between 160 and 240 $mg \cdot L^{-1}$ N may result in comparable yields as using the recommended method of adjusting N during the season for 'Galia' melon.

Production of muskmelons during cool seasons (fall) as opposed to warm seasons (spring and summer) in Israel resulted in lower yields with larger, reduced quality fruit (Pasternak et al., 1996). Conditions of low radiation regimes and lower bee pollination during cool seasons are factors that could affect fruit weight and yields. Nonetheless, except for fruit weights, yields in spring and fall 2001 were in the expected range (10-15 $kg \cdot m^{-2}$) for 'Galia' muskmelons produced in soilless culture and passively ventilated greenhouses in Florida (Shaw et al., 2001; Waldo, 1999). Thus, it is recommended to use the ALT-N treatment of adjusting N concentrations in the fertilizer solution with the growth stage of the plant since this will reduce over-fertilization of the plants and follow the guidelines developed for commercial 'Galia' production in Isreal. Plants receiving excessive concentrations of N fertilizer in soilless culture do not utilize more than what is needed to support growth and fruit development. On the other hand, plants that received low N did not compensate through constant feeding of N (up to four times per hour). Petiole-sap testing is a suitable method to determine plant nutrient status and insure adequate N is being provided throughout plant growth. Petiole-sap NO_3-N concentrations should remain between 3000 and 4000 mg L^{-1} for hydroponic 'Galia' muskmelon production.

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