RESPONSE OF MELON PLANTS TO NITROGEN AND PHOSPHORUS APPLICATION

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ABSTRACT – There is interest in the acquisition of information about the fertilizing requirements of melon plants, explored at Pólo Agroindustrial Assú/Mossoró/Baraúnas, in the Rio Grande do Norte State, Brazil, aiming to obtain high productivity levels for quality fruits, reducing fertilizer wastes, and decreasing the environmental degradation. The objective of this work was to evaluate the effects of applications of some doses of nitrogen (urea, 45% N) and phosphorus (single superphosphate, 20% P_2O_5) on yield and quality of Gold Mine, yellow melon fruits under drip irrigation. The nitrogen doses (0, 50, 100, 150, and 200 kg N ha^{-1}) were combined in a factorial arrangement with phosphorus doses (0, 50, 100, and 150 kg P_2O_5 ha^{-1}). A completely randomized block design was used, with five replications. Nitrogen increased total and marketable fruit masses, reduced melon pulp firmness and soluble solids content, but did not influence total and marketable fruit numbers, or fruit shape index. Phosphorus had no influence on quantitative or qualitative melon traits.

Keywords: *Cucumis melo*, Brix, pulp firmness, urea, single superphosphate

RESPOSTA DO MELOEIRO À APLICAÇÃO DE DOSES DE NITROGÊNIO E FÓSFORO

RESUMO – Existe interesse em informações sobre as necessidades de fertilizantes para a cultura do meloeiro, explorada no Pólo Agroindustrial Assú/Mossoró/Baraúnas, Estado do Rio Grande do Norte, visando a obtenção níveis elevados de produtividade de frutos de qualidade, a redução do desperdício de adubos e a diminuição da degradação ambiental. O objetivo deste trabalho foi avaliar os efeitos de aplicações de doses de nitrogênio (uréia, 45% de N) e fósforo (superfosfato simples, 20% de P_2O_5) sobre o rendimento e a qualidade dos frutos do meloeiro Gold Mine, de frutos amarelos, irrigado por gotejamento. As doses de nitrogênio (0, 50, 100, 150 e 200 kg N ha^{-1}) foram combinadas em esquema fatorial com as doses de fósforo (0, 50, 100 e 150 kg P_2O_5 ha^{-1}). Adotou-se o delineamento de blocos completos casualizados com cinco repetições. O nitrogênio aumentou as massas total e de frutos comercializáveis, reduziu a firmeza e o teor de sólidos solúveis do melão, mas não influenciou os números total e de frutos comercializáveis, nem o índice de formato do fruto. O fósforo não influenciou as características quantitativas e qualitativas do melão.

Palavras-chave: *Cucumis melo*, Brix, firmeza da polpa, uréia, superfosfato simples

INTRODUCTION

The cultivated area with melon plants in Brazil is under expansion, especially in the Semi-Arid region, making the country a traditional melon exporter. Favorable climatic conditions (high luminosity, low precipitation and relative humidity indices) and improvements in cultivation techniques at that region have allowed the Brazilian production to improve in quality. In addition, production during the off-season of other countries has facilitated the expansion of the Brazilian market overseas. In the year 2000, the States of Rio Grande do Norte, Ceará, Bahia and Pernambuco accounted for 93% of the melon yield in Brazil, where the agricultural centers of Mossoró/Assu (RN) and Baixo Jaguaribe (CE) stood out as the main producing regions. In 2002, about 98 thousand tons of melon were exported through the Natal (RN) port alone, generating a *free on board* (FOB) income of approximately US$ 39 million (NEGREIROS *et al.*, 2003).

Despite the importance of this crop for the State of Rio Grande do Norte, adequate melon cropping recommendations are still scarce. As a consequence, many cultural practices are imported from other regions or adopted empirically. In case they prove satisfactory, these techniques are incorporated into the production process. If not, they are substituted and new attempts are made. With regard to fertilizations, large amounts of fertilizers are generally used, which results in expensive fertilizer wastes and higher use of labor and environmental pollution. In several producing areas of Rio Grande do Norte, inadequate N, P, K fertilizations cause nutritional imbalances, inducing deficiencies of elements such as calcium and probably boron, yielding fruits with deformities, abnormal color, and poor postharvest conservation (PEDROSA,1997).

Nitrogen (N) is the essential mineral element required in the greatest amount in plants, comprising 1.5% to 2% of plant dry matter and approximately 16% of total plant protein. Thus N availability is a major limiting factor for plant growth and crop production. There are also negative environmental consequences for the extensive use of N fertilizers in crop production because agricultural crops only retain about two-thirds or 50% (Loomis e Connor, 1992) of the applied N, and the unabsorbed N can subsequently leach into and contaminate water supplies. Because of the high costs of N fertilizer to agricultural production, and the deleterious effect of N fertilizer pollution on the environment, it would be desirable develop strategies to reduce N input while simultaneously maintaining productivity (FRINK *et al* ., 1999; TAIZ E GEIGER, 2002). After nitrogen, phosphorus is the second most limiting macronutrient in both terrestrial and aquatic ecosystems. The element is the least accessible nutrient required by plants, and its availability in native soils is rarely adequate for optimal growth. Consequently, assimilation, storage, and metabolism of phosphorus are highly regulated processes that directly affect plant performance (ABEL *et al* ., 2002).

The effects of nitrogen on the productivity and quality of melon fruits are conflicting, which increases the interest in their study. Some authors (COELHO *et al.*, 2001) verified an increased fruit productivity as the N rate applied increased, while others (BUZETTI *et al.*, 1993) verified a lack of response to N. Response to this element depends on genotypic (BUZETTI *et al.*, 1993) and environmental factors (FARIA *et al.*, 2000; Soares *et al.*, 1999). In some cases, nitrogen does not influence fruit quality attributes, like total soluble solids content (MONTEIRO *et al.*, 2003; PURQUERIO *et al.*, 2003) and pulp firmness (MONTEIRO *et al.*, 2003), but in others (FARIA *et al.*, 2000) it increases Brix. In a similar manner, the melon plant may either respond (FARIA *et al.*, 1994) or not (Hassan *et al.*, 1984) to P applications in terms of fruit yield. Phosphorus may positively influence melon total soluble solids content in some experiments (SRINIVAS & PRABHAKAR, 1984), but not in others (FARIA *et al.*, 1994).

The objective of this work was to evaluate the effects of applications of nitrogen and phosphorus rates on melon fruit yield and quality.

MATERIAL AND METHODS

The experiment was carried out in an area of the Agrícola Cajazeira company, located in the city of Icapui-CE, about 42 km away from downtown Mossoró-RN (latitude 5° 11'S, longitude 37° 20'W, and elevation 18 m). The experimental period comprised the months of December/00 and January/01. In December, the values for minimum and maximum temperature (°C), relative humidity (%), precipitation (mm), evaporation from a class A pan (mm/day), wind speed (m/s), and insolation (h/month) were 18.7, 35.9, 76, 9.3, 7.9, 4.9, and 263, respectively. The respective values for January were: 20.7, 37.4, 77, 11.8, 8.2, 5.5, and 249.

The soil chemical analysis (Brasil,1997) indicated: pH = 7.3; Ca = 2.7 $cmol_c\ dm^{-3}$; Mg = 0.70 $cmol_c\ dm^{-3}$; K = 0.33 $cmol_c\ dm^{-3}$; Na = 0.47 $cmol_c\ dm^{-3}$; Al = 0.00 $cmol_c\ dm^{-3}$; P = 23 mg dm^{-3}. The following values were obtained in the physical analysis: 550 g/kg coarse sand, 300 g/kg fine sand, 50 g/kg silt, 100 g/kg clay, with a moisture content at field capacity of 8.1 g/100g and 3.5 at permanent wilting point, and a bulk density of 1.36 g/cm^3. The water analysis gave: pH = 7.5; EC = 2.0 dS/m; Ca = 7.5 $Mcmol_c\ dm^{-3}$;

Mg = 3.5 Mcmol$_c$ dm^{-3}; K = 0.33 Mcmol$_c$ dm^{-3}; Na = 6.36 Mcmol$_c$ dm^{-3}; Cl = 14 Mcmol$_c$ dm^{-3}; HCO_3 = 2.9 Mcmol$_c$ dm^{-3}; CO_3 = 0.0 Mcmol$_c$ dm^{-3} and SO_4 = 0.0 Mcmol$_c$ dm^{-3}. The manure analysis gave: pH (water)= 8.3; Ca = 5.0 cmol$_c$ dm^{-3}; Mg = 6.5 cmol$_c$ dm^{-3}; K = 1.81 cmol$_c$ dm^{-3}; Na = 1.98 cmol$_c$ dm^{-3}; Al = 0.00 cmol$_c$ dm^{-3}; P = 997 mg dm^{-3}.

The Gold Mine, yellow-melon hybrid, was used in the experiment. The nitrogen doses (0, 50, 100, 150, and 200 kg N ha^{-1}) were combined in a factorial arrangement with phosphorus doses (0, 50, 100, and 150 kg P_2O_5 ha^{-1}). Urea (45% N) and single superphosphate (20% P_2O_5) were used as sources of N and P, respectively. A completely randomized block design was used, with five replications. Each plot consisted of a single row of plants measuring 6.0 m in length (24 plants). The harvest area was considered as that occupied by the 20 central plants in the row.

The area was ploughed, harrowed, and fertilized with 2 kg rotted cattle manure per linear meter. At planting, fertilization consisted of 1/3 of the N and all the P, plus 100 kg K_2O (potassium chloride) per hectare, besides the manure. The fertilizers were placed in furrows located beside the row of hills and below the seeding depth. The rest of the nitrogen was applied manually in two identical plots, at 20 and 40 days after sowing, in shallow furrows beside the plant rows. Seeding was done by hand, with one seed/hil. A 2.0 m spacing was used between rows and 0.5 m between drip emitters, with two plants/emitter. Planting was done on 11.30.00. A replanting operation was performed six days after sowing. Weedings and preventive control of pests and diseases were done as needed. Two harvests were performed, at 62 and 65 days after sowing.

Evaluations included the number and total mass of fruits; number and mass of marketable fruits; length (L), width (W), and L/W shape ratio; total soluble solids content (TSSC); and pulp firmness of marketable fruits. Fruits with evident defects in shape, size, bruises, color, and health were considered unmarketable. Four marketable fruits taken at random from each plot were used to determine total soluble solids content (TSSC) and pulp firmness. The fruits were sliced length-wise, and the juice from the fruit pulp was homogenized in a food processor and used in a model PR 100, Palette Atago, direct-reading digital refractometer, with automatic temperature compensation; the results were expressed as percentages. A McCormick model FT 327 penetrometer with an 8 mm diameter plunger was used to evaluate pulp firmness. The fruits were split longitudinally into two parts, and four readings were made at the equatorial region of each.

The data were submitted to analysis of variance (NORUSIS, 1990) and regression analysis (JANDEL SCIENTIFIC, 1991).

RESULTS AND DISCUSSION

There were no effects of the nitrogen doses × phosphorus doses interaction on the evaluated traits.

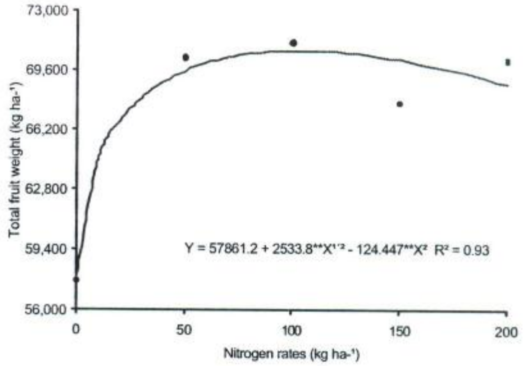

Figure 1 – Total fruit weight of Gold Mine yellow-melon hybrid as a function of nitrogen

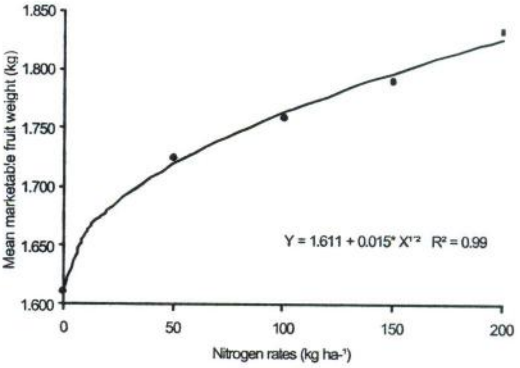

Figure 2 – Mean marketable fruit weight of Gold Mine yellow-melon hybrid as a function of nitrogen doses.

A nitrogen effect was observed on total mass of fruits (Figure 1) and on mean mass of marketable fruits (Figure 2). The positive influence of nitrogen on melon mass could be associated with hormones. Among mineral nutrients, nitrogen has the greatest influence on the production and export of cytokinins (MARSCHNER, 1995). For a long time, phytohormones have been thought to control plant development processes (McINTYRE, 2001). This role has been questioned, and it has been suggested (TREWAVAS, 2001) that tissue sensitivity to the hormone was the main limiting factor; this sensitivity would be determined by the number or receptivity of the receptors that interact with the hormone to induce the response. This hypothesis has not been demonstrated, and it has been postulated (MCINTYRE, 2001) that limitations in nutritional factors, especially water and nitrogen, play an important role in the regulation of some aspects of plant development, and may constitute an alternative to mechanisms based on the concept of hormonal control. Marschner (1995) conciliated both hypotheses by attributing the regulation of those aspects to hormonal factors which, in turn, would be under the influence of environmental factors, including fertilizers. Another manner by which nitrogen would positively influence the melon mass, as observed in the present work, would be by increasing the supply of photosynthates, due to their importance to the photosynthetic function. About 3/4 of the total N reduced in the leaf may be related to photosynthesis (GRINDLAY, 1997).

The maximum nitrogen response dose in melon plants, in curves that admit a maximum point, depend on the cultivars evaluated and on environmental factors. This would explain why different authors have obtained maximum yields at doses (CHANDLER and MANGAL, 1983; HASSAN *et al.*, 1984) that were different from those observed in the present work.

Nitrogen did not influence the total number of fruits, percentage of marketable fruits, based on the total number of fruits, and shape index (Table 1). It is possible that marketable fruits with higher mass (Figure 1), as determined by nitrogen, establish a competition for photosynthates, among all fruits produced by the same plant, so that some of them do not attain the commercial standard and are excluded. In tomato, an increase in the total number of flowers increases the competition for photosynthate and thus decrease fruit size (VAN RAVESTIJN and MOLHOEK, 1978). Based on the ratio between length (L) and width (W), melons are classified (LOPES, 1982) into: $L/W < 1.0$ = spherical fruits; $1.1 < L/W < 1.7$ = oblong fruits; $L/W > 1.7$ = cylindrical fruits. The mean value obtained in the present work was around 1.2, indicating slightly oblong fruits.

Table 1 – Mean marketable fruit percentage values (in relation to total number of fruits) and shape index of cultivar Gold Mine melon fruits in relation to N doses (means of four P_2O_5 doses and four replications).

Traits	N doses (kg ha^{-1})					Means
	0	50	100	150	200	
Total number of fruits ha^{-1}	38,400	42,200	43,700	41,300	41,400	41,400
% marketable fruits	79	81	80	77	82	79,7
Weight of marketable fruits (kg ha^{-1})	48,784	58904	62516	56,556	62406	58,833
Fruit shape index	1.24	1.24	1.25	1.25	1.25	1.25

Melon pulp firmness decreased as the applied nitrogen dose increased (Figure 3). The nitrogen fertilization effect on melon pulp firmness could be related to nitrogen compounds, such as enzymes. Extensive cell wall modifications occur during ripening and are thought to underlie processes such as fruit softening, tissue deterioration, and pathogen susceptibility (HADFIELD *et al.*, 1998). Pectins are a major class of cell wall polysaccharides. In melon substantial amounts of pectin depolymerization and solubilization take place during ripening (ROSE *et al.*, 1998). These modifications are regulated at least in part by the expression of genes that encode cell wall-modifying enzymes.

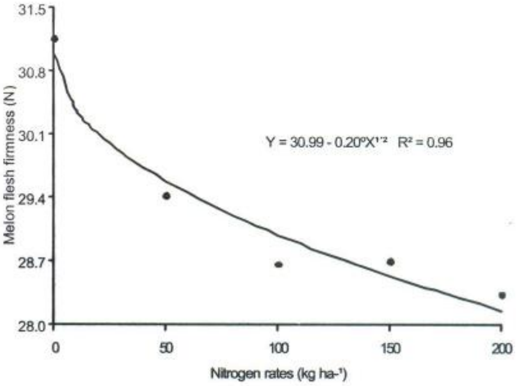

Figure 3 – Melon fresh firmness of Gold Mine hybrid in relation to nitrogen rates.

Total soluble solids content in marketable fruits decreased as nitrogen rate increased

(Figure 4). As previously mentioned, higher nitrogen doses increased fruit mass, and this must have increased the competition among fruits for photosynthates. The ripening process in fruit involves biochemical and physiological changes that are not completely understood (Dunlap *et al.*, 1996). Probably, the differences in distribution of soluble solids content may involve source-sink relations. Taiz and Zeiger (2002) argue that translocation toward the tissues in a sink depends on the position of the sink relative to the source, on vascular connections between source and sink and on competition between sinks. Growth regulators (cytokinins, auxins, ethylene, gibberellic acid, abscisic acid, etc.) have an important participation in the translocation process (SALISBURY and ROSS, 1991). In many cases, growth regulators not only can induce the formation of new growth regions (sinks), but also can be released from these new sinks and act as mobilization agents (SALISBURY and ROSS, 1991). A stronger sink can deplete the sugars content of sieve elements faster and increase translocation toward itself (TAIZ and GEIGER, 2002). This competition may reduce the photosynthate supply for marketable fruits, consequently reducing soluble solids content. The results observed in the present work with reference to the effects of nitrogen fertilization on soluble solids content are in agreement with those obtained by some authors (COELHO *et al.*, 2001), but are contrary to results obtained by Bhella & Wilcox (1989) and Yadav & Mangal (1984), who verified increases in soluble solids content as nitrogen dose increased.

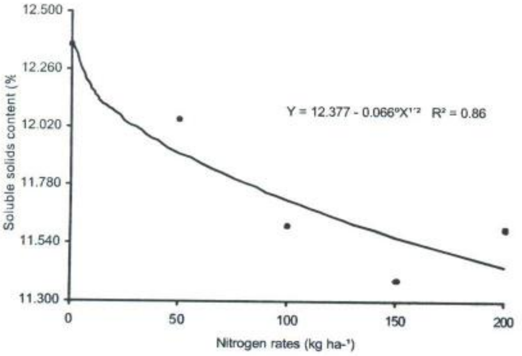

Figure 4 – Fresh soluble solids content of Gold Mine yellow-melon hybrid as a function of nitrogen doses.

An interesting aspect that can be verified in the present work refers to the effects, in a way antagonistic, of the same element, with regard to yield and quality traits. For example, N increased fruit mass, but reduced the quality of part of those fruits, at least when this quality is measured in terms of soluble solids content and flesh firmness. This indicates that quantitative and qualitative yield aspects must be taken into consideration in experiments such as the one herein described. Depending on the species and traits under study, it may occur that maximum quality could be obtained before or after maximum dry matter yield is reached.

Table 2 – Mean yield values (of five N doses and four replications) of cultivar Gold Mine melon fruits as a response to the application of P_2O_5 doses[1].

P_2O_5 doses (kg ha^{-1})	Total no. of fruits ha^{-1}	Total fruit mass (kg ha^{-1})	No. of marketable fruits ha^{-1}	Mean marketable fruit mass (kg ha^{-1})
0	40,560	64,601	52,104	1.736
50	43,440	69,602	57,799	1.680
100	40,640	67,972	55,337	1.792
150	40,960	68,187	52,605	1.770
Means	41,400	67,591	54,461	1.745
CV, %	18	19	11	22

[1] No regression model fitted the traits evaluated

Phosphorus did not have any effect on the evaluated traits (Tables 2 and 3). Differently from what was verified in the present work, some authors (FARIA *et al.*,1994) have observed a melon plant response to P doses in terms of fruit yield. They verified a response to P in two experiments, and concluded that the economic dose would be 114 kg P_2O_5 ha^{-1}, and attributed the existence of a response to low P levels in the soil (1.2 to 1.4 ppm) before application of the fertilizer. The soil where our work was carried out showed a P content of 23 mg/dm^3, therefore quite higher than the value in the soil evaluated by the above-mentioned authors. Other authors (HASSAN *et al.*, 1984), however, similarly as observed in this work, did not observe response

Table 3 – Mean (of five N doses and four replications) traits of cultivar Gold Mine marketable melon fruits as a response to the application of P_2O_5 doses [1].

P_2O_5 doses (kg ha^{-1})	Pulp firmness (N)	Shape index	Total soluble solids content (°B)
0	29.4	1.25	11.7
50	30.0	1.25	11.6
100	28.5	1.24	12.0
150	29.1	1.25	12.0
Means	29.3	1.25	11.8
CV, %	11	3	8

[1] No regression model fitted the traits evaluated

to P rates ranging from 0 to 90 kg P_2O_5 ha^{-1}, in a soil containing 19 ppm of available P.

CONCLUSIONS

Nitrogen increased total and marketable fruit masses, reduced melon pulp firmness and soluble solids content, but did not influence total fruit and marketable fruit numbers, or the marketable fruit length/diameter ratio. These nitrogen effects were independent from phosphorus doses applied, which did not influence the traits evaluated.

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