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YIELD AND QUALITY OF MELON FRUITS AS A RESPONSE TO THE APPLICATION OF NITROGEN AND POTASSIUM DOSES

Paulo Sérgio Lima e Silva
Departamento de Ciências Vegetais da UFERSA, Prof. Adjunto, Bolsista do CNPq, Caixa Postal 137, 59625-900, Mossoró-RN paulosergio@ufersa.edu.br (corresponding author).

Vera Lúcia Paiva Rodrigues
Departamento de Ciências Vegetais da UFERSA, Aluno do curso de Mestrado em Agronomia: Fitotecnia, Caixa Postal 137, 59625-900, Mossoró-RN.

José Francismar de Medeiros
Departamento de Ciências Vegetais da UFERSA, Prof. Adjunto, Bolsista do CNPq, Caixa Postal 137, 59625-900, Mossoró-RN – jfmedeir@ufersa.edu.br.

Boanerges Freire de Aquino
Departamento de Ciências do Solo da Universidade Federal do Ceará, UFC, *Campus* do Pici, Bloco 807, Pici, 60021-970, Fortaleza-CE – aquino@ufc.br.

Jaeveson da Silva
Centro Nacional de Pesquisa de mandioca e Fruticultura, CNPMF, da Embrapa, Pesquisador, Caixa Postal 007, 44380-000, Cruz das Almas-BA – jaeveson@cnpmf.embrapa.br

ABSTRACT – There is an interest in the knowledge about the fertilizing requirements of melon crops, explored at Pólo Agroindustrial Assú/Mossoró/Baraúnas, Rio Grande do Norte, Brazil, aiming at obtaining high productivity levels for quality fruits, reducing fertilizer wastes, and decreasing environmental degradation. The objective of this work was to evaluate the effects of applications of nitrogen (urea) and potassium doses (potassium chloride) on yield and quality of Gold Mine, yellow melon fruits under drip irrigation. Nitrogen doses (0, 50, 100, and 150 kg N ha^{-1}) were combined in a factorial arrangement with potassium doses (0, 50, 100, and 150 kg K_2O ha^{-1}) and applied in a randomized complete block design with five replications. Nitrogen increased the number and total mass of fruits, number of marketable melon fruits, and fruit length/width shape ratio; decreased pulp firmness; but did not change pulp total soluble solids content. These effects were independent from potassium doses, which did not influence the evaluated characteristics.
Keywords: *Cucumis melo,* yellow melon, Brix, flesh firmness, urea, potassium chloride

RENDIMENTO E QUALIDADE DE FRUTOS DO MELOEIRO EM RESPOSTA À APLICAÇÃO DE DOSES DE NITROGÊNIO E POTÁSSIO

RESUMO – Existe interesse no conhecimento das necessidades de fertilizantes para a cultura do meloeiro explorada no Pólo Agroindustrial Assú/Mossoró/Baraúnas, Rio Grande do Norte, visando níveis elevados de produtividade de frutos de qualidade e redução do desperdício de adubos e a degradação ambiental. O objetivo deste trabalho foi avaliar os efeitos de aplicações de doses de nitrogênio (uréia) e potássio (cloreto de potássio) 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 kg N ha^{-1}) foram combinadas em esquema fatorial com as doses de potássio (0, 50, 100 e 150 kg K_2O ha^{-1}) e aplicadas no delineamento de blocos completos casualizados com cinco repetições. O nitrogênio aumentou o número e a massa totais de frutos, o número de frutos comercializáveis do meloeiro e a relação comprimento/largura do fruto, reduziu a firmeza da polpa, mas não alterou o teor de sólidos solúveis totais dessa polpa. Esses efeitos foram independentes das doses do potássio, que não influenciaram as características avaliadas.
Palavras-chave: *Cucumis melo,* melão amarelo, Brix, firmeza da polpa, uréia, cloreto de potássio.

INTRODUCTION

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-third 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 (Taiz e Geiger, 2002). Potassium is characterized by high mobility in plant at all levels – within individual cells, within tissues, and in long-distance transport via the xylem and phloem. Potassium is an important macronutrient and the most abundant cation in higher plants. K^+ is essential for enzyme activation, protein synthesis and photosynthesis, and it mediates osmoregulation during cell expansion, stomatal movements and tropisms. Furthermore, K^+ is necessary for phloem solute transport and for the maintenance of cation:anion balance in the cytosol as well as in the vacuole. K^+ supply from soil can be rate-limiting for agricultural production. K^+ and its accompanying anions make a major contribution to the osmotic potential of cells and tissues of glycophytic plant species (Marschner, 1995).

Favorable climatic conditions in the semi-arid region (high luminosity, low rainfall and relative humidity indices) and improvements in cultivation techniques have allowed the Brazilian melon production to improve in quality in that region. In addition, production during the off-season of other countries facilitates the expansion of the Brazilian market overseas. In 2002, about 98 thousand tons of melons were exported through the Natal (RN) port alone, generating an income of approximately U$ 39 million (Negreiros *et al*., 2003). Despite the importance of this crop for the Mossoró/Assu, RN production center, adequate melon cropping technologies are still scarce. Many cultural practices are imported from other regions or are adopted empirically. In case they prove satisfactory, these techniques are then incorporated into the production process. If not, they are replaced and new attempts are made. In general, large amounts of fertilizers are 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, and 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.

The response of melon plants to N and K applications, in terms of productivity and fruit quality, varies with the cultivars evaluated and with the conditions of the environment. Some authors (Buzetti *et al*. 1993; Coelho *et al*. 2001) have observed productivity increases with the application of nitrogen, but in other studies (Bar-Yosef, 1997; Buzetti *et al*. 1993) no response has been obtained. Similar results have been observed in relation to potassium. That is, positive results can be found (Singh *et al*., 1997) or not (Coelho *et al*., 2001) in terms of fruit yield. In terms of fruit productivity, the interaction between nitrogen doses × potassium doses may (Buzetti *et al*. 1993) or may not (Coelho *et al*. 2001) exist. Both the nature and the magnitude of the response to the above-mentioned fertilizers may depend on cultivar (Buzetti *et al*.,1993).

In some cases, nitrogen does not influence fruit quality attributes, like total soluble solids content (Monteiro *et al*., 2003; Purquerio *et al*., 2003) and flesh firmness (Monteiro *et al*., 2003), but in others (Faria *et al*., 2000) it increases Brix. Similarly, potassium may increase melon total soluble solids content (Oliveira *et al*., 2003), or have no influence upon this trait (Srinivas & Prabhakar, 1984).

The objective of this work was to evaluate the effects of applications of nitrogen and potassium doses 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 5º 11'S, longitude 37º 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 (ºC), relative humidity (%), rainfall (mm), evaporation from a class A pan (mm/day), wind speed (m/s), and insolation (h/month) were 18.7,

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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. Nitrogen doses (0, 50, 100, and 150 kg N ha^{-1}) were combined in a factorial arrangement with potassium doses (0, 50, 100, and 150 kg K_2O ha^{-1}) and applied in a randomized complete block design with five replications. Urea (45% N) and potassium chloride (57 % K_2O) were used as sources of N and K, respectively. 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 holes 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/hole. 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 for 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 were made. 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 8mm diameter plunger was used to evaluate flesh 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 (Ribeiro Júnior, 2001) and regression analysis (Jandel Scientific 1991).

RESULTS AND DISCUSSION

There was no effect of the interaction between nitrogen doses and K_2O doses for the evaluated traits. This result is in agreement with other authors (Coelho *et al*., 2001).

Only nitrogen significantly influenced total number (Figure 1) and mass (Figure 2) of fruits,

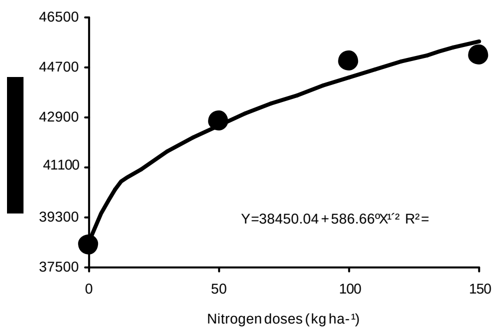

Figure 1 – Total number of fruits of melon cultivar Gold Mine as a response to the application of nitrogen doses (means of five replications and four potassium doses).

and number of marketable fruits (Figure 3). Fruit yield increases caused by higher nitrogen doses have also been observed by other authors (Buzetti *et al*. 1993; Coelho *et al*. 2001). The number of produced fruits depends on the number of produced flowers, and mineral nutrition may

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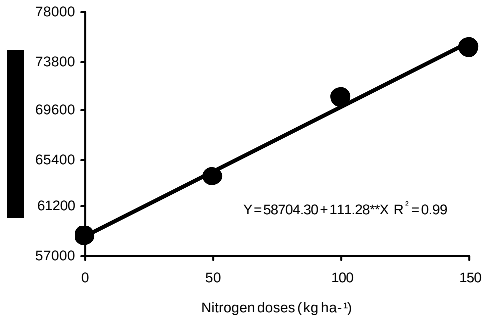

Figure 2 – Total fruit mass of melon cultivar Gold Mine as a response to the application of nitrogen doses (means of five replications and four potassium doses).

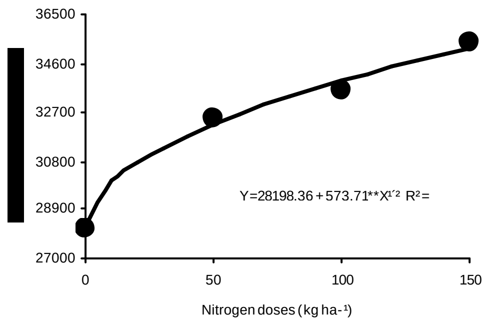

Figure 3 – Total number of marketable fruits of melon cultivar Gold Mine as a response to the application of nitrogen doses (means of five replications and four potassium doses).

influence this process in two ways. One of them would be by means of the levels of plant hormones in general, and cytokinins in particular (Morris, 1997). Among mineral nutrients, nitrogen has the most prominent influence on the production and export of cytokinins (Marschner, 1995). The other way would be by an increase in the supply of photosynthates. Nitrogen is important to crops, and its importance for the photosynthetic function should be highlighted. About 3/4 of the total N reduced in the leaf may be related to photosynthesis (Grindlay, 1997). However, the flowers formed must "set". In corn, grain abortion can be reduced by cytokinin applications or by fertilization with ammoniacal N which, in turn, increases the concentration of cytokinins in the plant (Smiciklas and Below, 1992). Although the physiological reasons for this nitrogen effect have not been clarified, it is certain that phytohormones, especially cytokinins and abscisic acid, are involved. A substantial supply of nitrogen increases the concentration of cytokinins and decreases the concentration of abscisic acid (Marschner, 1995).

Fruit length/width (L/W) ratio increased as N dose increased, i.e., the proportion of oblong fruits increases as nitrogen dose increases (Figure 4). Oblong fruits are preferred because they are

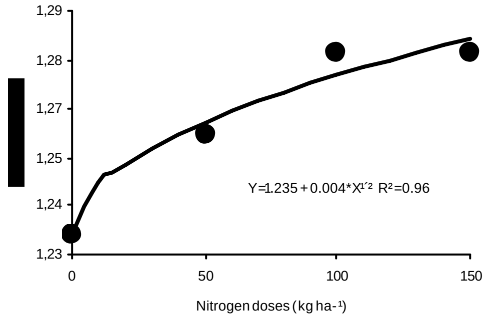

Figure 4 – Shape index of marketable fruits of melon cultivar Gold Mine as a response to the application of nitrogen doses (means of five replications and four potassium doses).

easier to transport, pack, and market. The results obtained in the present work are in agreement with other authors (Bhella and Wilcox, 1986), according to whom nitrogen also exerts an effect on melon quality, improving color and shape. The effects of nitrogen on the shape and size of plant organs are well known in cereals.

Nitrogen (Figure 5) reduced melon pulp firmness. The effect of nitrogen on melon pulp firmness could be related to nitrogen compounds, such as enzymes. Extensive cell wall

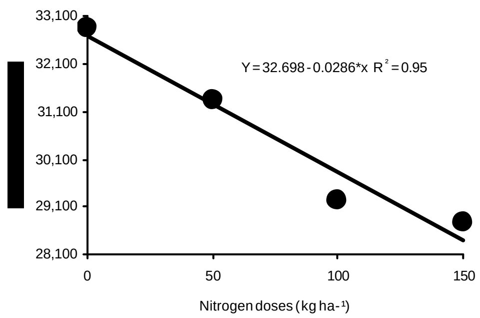

Figure 5 – Pulp firmness of marketable fruits of melon cultivar Gold Mine as a response to the application of nitrogen doses (means of five replications and four potassium doses).

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. These modifications are regulated at least in part by the expression of genes that encode cell wall-modifying enzymes (Rose *et al*., 1998).

There was no effect of nitrogen doses (N) on total soluble solids content. The mean value for this parameter was 11.93 °B. The results observed in the present work with reference to the effects of nitrogen fertilization on soluble solids content do not agree with those obtained by other authors (Bhella & Wilcox, 1989; Yadav & Mangal, 1984), who verified increases in soluble solids content as nitrogen dose increased.

An interesting aspect, which became evident in the present work, refers to the effects, in a way antagonistic, of nitrogen on yield and quality characteristics. For example, N increased total fruit yield, but reduced the quality of part of those fruits, at least when this quality is measured by pulp firmness. This indicates that quantitative and qualitative yield aspects must be taken into consideration in experiments such as the one described here.

Responses to potassium were expected in terms of fruit yield (Table 1) and quality (Table 2), since this element plays an important role in the transport of photosynthates to the fruits. One of the key factors controlling carbohydrate allocation to the various plant organs is the process of phloem loading. Photosynthetic carbon assimilation and sucrose synthesis take place within mesophyll cells of mature source leaves. The flow of sucrose is governed cell-to-cell transport through mesophyll cells and vascular tissues, after which sucrose is loaded into the companion cell-sieve element complex (van Bell, 1993). Structural studies have suggested two possible mechanisms for phloem loading. In most agronomically important crops, the transport of sucrose to the loading region is via symplasmic pathway, followed by an apoplasmic step to transfer sucrose into the companion cell-sieve element complex (van Bell, 1993; Turgeon, 1996). Cucurbits, however, are characterized by the presence of numerous plasmodesmata connecting the minor veins with the surrounding bundle sheath, suggesting a symplasmic pathway along the entire route from the mesophyll to the complex. Based on these structural observations and the fact that main translocated sugar in cucurbits is stachyose, an alternative model for phloem loading was developed (Grusak *et al*., 1996). According to this model, sucrose is synthetized in the mesophyll and then diffusses through the bundle sheath into the intermediary cells (a specific type of companion cell in minor veins of cucurbits plants) through the abundant plasmodesmata that connect the two cell types. Raffinose and stachyose are synthesized from sucrose in the intermediary cell. It is well established that phloem loading is enhanced by potassium. Of the mineral nutrients, potassium is usually present at the highest concentration in the phloem sap. Thus, potassium substantially contributes to the volume flow rates in sieve tubes. In plants well supplied with potassium, the concentration of potassium and the osmotic potential of the phloem sap, and particularly the volume flow rate, are all higher than in plants supplied with a lower level of potassium. Sucrose concentration

Table 1 – Means (of four N doses and four replications) for number and total mass of fruits, number and mean mass of marketable fruits of melon cultivar Gold Mine plants as a response to the application of K_2O doses[1] .

K_2O doses (kg ha^{-1})	Total n°. of fruits ha^{-1}	Total fruit mass (kg ha^{-1})	N°. of marketable fruits ha^{-1}	Mean arketable fruit mass (kg ha^{-1})
0	40,900	64,034	31,259	1.67
50	44,000	72,660	34,041	1.84
100	44,100	67,347	34,157	1.74
150	42,000	64,158	30,079	1.67
Means	42,775	67,050	32,384	1.73
CV, %	17	21	13	23

[1]No regression model fitted for the evaluated traits.

Table 2 – Means (of four N doses and four replicates) for flesh firmness, fruit shape index, and soluble solids content of marketable fruits of melon cultivar Gold Mine plants as a response to the application of K_2O doses[1]

K_2O doses ($kg\ ha^{-1}$)	Fruit pulp firmness (N)	Fruit shape index	Total soluble solids content (°B)
0	31.1	1.28	11.7
50	30.5	1.27	11.5
100	30.2	1.27	11.6
150	30.5	1.26	11.8
Means	30.6	1.27	11.7
CV, %	9	2	8

[1]No regression model fitted for the evaluated traits.

in the phloem sap remains more or less affected, and a high potassium supply increases the transport rate of sucrose in the phloem (Marschner, 1995).

Possibly, the lack of response to potassium is related to the high levels of this element in the soil (130 mg kg^{-1}), among others factors, such as K from irrigation water, estimated to be about 47 kg K_2O ha^{-1}, considering a total irrigation water depth of 300 mm. No melon plant response to K doses was obtained in a soil containing 57 to 68 mg kg^{-1} of this element (Coelho *et al*., 2001). Fruit yield and mean fruit weight were not influenced with the use of nutritive solutions containing potassium concentrations above 66 mg L^{-1} (Costa *et al*., 2004). However, other authors (Pinto *et al*., 1993) verified a response to this fertilizer, especially when potassium levels in the soil are low. Therefore, the K levels in the soil are relevant to indicate fertilizer doses aiming at increased fruit yield, and also because, in some cases (Kuznetsova and Agzamova, 1975), the application of K doses in excess may cause yield decreases.

CONCLUSIONS

Nitrogen increased the number and total mass of fruits, number of marketable melon fruits, and fruit length/width shape ratio; decreased melon pulp firmness; but did not change total soluble solids content. These effects were independent from potassium doses, which did not influence the quality and quantitative melon evaluated characteristics.

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