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# EFFECT OF NITROGEN AND POTASSIUM FERTILIZERS ON MELON PLANT PRODUCTIVITY

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## ABSTRACT

The objective of this investigation was to evaluate the effect of different doses of nitrogen and potassium fertilizers on some production parameters of melon plants. The experiment was carried out in San Roque, which is 24 km from the city of Concepción, Paraguay, at the coordinates 57°14´10.29´´ South and 23°19´12.05´´ West. The study design was the completely randomized block with three replications in a split plot scheme 4 x 4. The dose used in the main plot was of N (0, 50, 100 and 150 kg $ha^{-1}$) and in the sub-plot, K (0, 95, 190 and 285 kg $ha^{-1}$). A light harrow was carried out to prepare the soil, seedlings were produced in 1500 $cm^3$ pots of 60-micron thickness and the transplant was carried out when the seedlings had between 4 and 6 true leaves at 30 days after planting. Urea with 45% N was used as the source of nitrogen and potassium chloride 60% was used as the source of potassium. Fertilisation was carried out in September 2017 on two occasions: at 15 and 30 days after transplanting. The spacing used was of 1.5 m between rows and 1.5 m between plants, giving a total of 4356 plants $ha^{-1}$. Harvesting began 90 days after planting and was carried out three times as the fruits reached commercial ripeness. The variables that were measured were average fruit weight (AFW), total soluble solids (TSS), polar diameter (PD), equatorial diameter (ED), fruit weight per plant (FWP). The data of the evaluated variables were subjected to the analysis of variance using the Fisher test where significant differences were found in: AFW, TSS, PD, ED and FWP. Subsequently, the regression analysis was performed (AFW, TSS and PD) and response surface (ED and FWP). The dose combination that produced the best values for equatorial diameter and fruit weight per plant was 71.9495 kg $ha^{-1}$ of N and 160.554 kg $ha^{-1}$ of K, 77.5921 kg $ha^{-1}$ of N and 147.369 kg $ha^{-1}$ of K, respectively.

**Key words:** *Cucumis melo* L., fertilizer application, nitrogen, potassium, dose, weight, diameter, productivity

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## INTRODUCTION

The melon plant (*Cucumis melo* L.) is a herbaceous species that is very well adapted to Paraguay's agroecological conditions. Production in Paraguay is highly seasonal: there is abundant supply in November, December and January, while melons practically vanish from the market during the other months of the year [1].

Nitrogen is the element that is second most needed by garden plants [2]. Adding nitrogen to the soil through complimentary mineral fertilizer application below the requirements of the plants. This produces chlorotic leaves with low photosynthetic efficiency, which categorically affects production. On the other hand, excess nitrogen results in more vegetative growth at the expense of yield components [3].

The potassium dose applied through supplementary fertilizer must not be lower or higher than the crop's requirement as this may significantly reduce productivity [4]. Potassium deficiency affects metabolism and consequently lowers nutritional quality and resistance to pests and diseases [5]. In contrast, excessive levels of this nutrient can be toxic for the crop [6].

Nitrogen and potassium are macronutrients that influence the physical and chemical property of melon fruits. They influence characteristics such as productivity, fruit size, soluble solid content and total titratable acidity [7].

Records indicate increases in the number and weight of melon fruits when using nitrogenated fertilizers [8, 9]. It has been observed that increasing nitrogen dose produces fruits with better physical quality, although with reduced levels of soluble solids [10]. The importance of adjusting levels of nitrogen and potassium fertilizers to promote the production of flowers and high yields was demonstrated by Grazia [11]. Likewise, they concluded that potassium could be a limiting factor for the full maturity of fruits [11].

The objective of this study was to evaluate the effect of different doses of nitrogen and potassium fertilizer on some production parameters of melon plants.

## MATERIALS AND METHODS

This study was carried out in San Roque Culantrillo in the District of Concepción, Paraguay, at the coordinates 57°14´10.29´´ South and 23°19´12.05´´ West. The experimental trials were planted in August 2017 and the harvesting was done in November 2017, during the summer season.

Northern Paraguay has a predominantly warm, temperate, sub-tropical climate; winter is the dry season. Annual rainfall is around 1200 mm and the summer months are when most rain is experienced. During the course of the study, the maximum temperature recorded was 32.71 °C and the minimum was 18.62 °C [12].

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The soil is characterised by a sandy-clay texture with 1.67% organic material content in the depth of 0 to 20 cm. The pH is lightly acidic with values of 5.67. Phosphorous levels are 28.92 cmol/Ls. Potassium, calcium and magnesium levels are 0.19, 5.03 and 1.27 cmol/Ls, respectively, according to soil analysis carried out by the Soil Laboratory at the Universidad Nacional de Asunción, Facultad de Ciencias Agrarias (UNA/FCA).

The study design was the completely randomized block with three replications in a split plot scheme 4 x 4. Nitrogen was used in the main plot, with application levels of 0, 50, 100 and 150 kg $ha^{-1}$. In the subplots, potassium was used with levels of 0, 95, 190 and 285 kg $ha^{-1}$. There were 48 experimental units, each of which covered a surface of 22.5 $m^2$ (3 m x 7.5 m). The total surface area used for the experiment was 1.080 $m^2$, using distances of 1.5 m between rows and 1.5 m between plants, giving a population density of 4.355 plants per hectare.

Seedlings were produced in 1500 $cm^3$ pots of 60-micron thickness. The pots contained a substrate based on a 3:1 mixture of cow manure and coarse sand. The substrate was disinfected using thermal treatment (80 ˚C for 20 minutes). One Gaucho variety melon seed was planted in each pot. Following sowing, watering was carried out manually and was repeated daily two times. Emergence was observed from the eighth day onwards. The pots were kept below shade cloth until transplant to the field.

While marking the boundaries of the plot, soil samples were taken and sent to the laboratory of the UNA/FCA for analysis. The doses of nitrogen and potassium fertilizer used in the study were determined and prepared in accordance with the recommendations of this analysis. The other nutrient applied was phosphorus with the dose 120 kg $ha^{-1}$ uniformly for all experimental units. The soil in the experimental plot was lightly harrowed twice to prepare it for planting. Following this preparation, the experimental units were marked out. Before transplanting, a dose of 4 kg per meter of cow manure was applied on the surface of the areas where the crop rows would be placed.

The transplanting was carried out when the seedlings had between 4 and 6 true leaves at 30 days after planting. Urea with 45% N was used as the source of nitrogen while potassium chloride (60%) was used as the source of potassium. Fertilizer application was carried out on two occasions: at 15 and 30 days after transplanting. It was delivered locally at a distance of 10 cm from the plants and at a depth of approximately 8 cm.

Irrigation was carried out using a drip system with an irrigation tape for each crop row. Water was applied generally twice daily at dawn and at sunset in accordance with evaluation of the needs of the crop.

To control pests and diseases, fungicide (Metil Tiofanato 70% WP, 50 gr in 20 litres of water) was applied once a week for prevention. An insecticide (Cipermetrina, 20 ml in 20 litres of water) was applied once every 15 days until flowering begun. Weed control was carried out with a hoe. The plots were weeded four times throughout the cycle.

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Harvesting began 90 days after planting and was carried out three times as the fruits reached commercial ripeness. Measurements were carried out by selecting five plants from each experimental unit. Data was taken on (1) A*verage fruit weight* in kg/fruit using precision scales. (2) *Total soluble solids* (ºBrix) where five fruits were selected per experimental unit and a handheld refractometer was used to measure pulp samples extracted from the fruits. (3) *Polar diameter* (cm/fruit) and *equatorial diameter of fruits* (cm/fruit) were measured on every fruit harvested. Two rigid rulers were placed at two tangential points exactly opposite one another and a third ruler showing centimetres was then used to measure the distance between the two points. (4) *Fruit weight per plant* (kg/fruit/plant) was measured using precision scales.

An analysis of variance (ANOVA) was carried out for all the variables using Fisher's exact test. Subsequently, the regression and response surface analysis was performed.

## RESULTS AND DISCUSSION

The ANOVA showed that nitrogen and potassium doses produced significant effects at 5% on the variables studied. While interactions between the two factors showed significant effects for equatorial diameter and average fruit weight per plant, this was not the case for the other variables that were evaluated (Table 1).

### Average fruit weight

For the variable of average fruit weight (Figures 1A & 1B), nitrogen and potassium doses fit the quadratic regression model. An increase in nitrogen levels produces an increase in the average weight of fruits. A maximum efficiency of 1.68 kg was reached at levels of 76.60 kg ha$^{-1}$. Higher levels show a tendency to reduce weight. For potassium dose, maximum efficiency of 1.70 kg was reached at a dose of 152.54 kg ha$^{-1}$. Higher levels produce reduction in fruit weight.

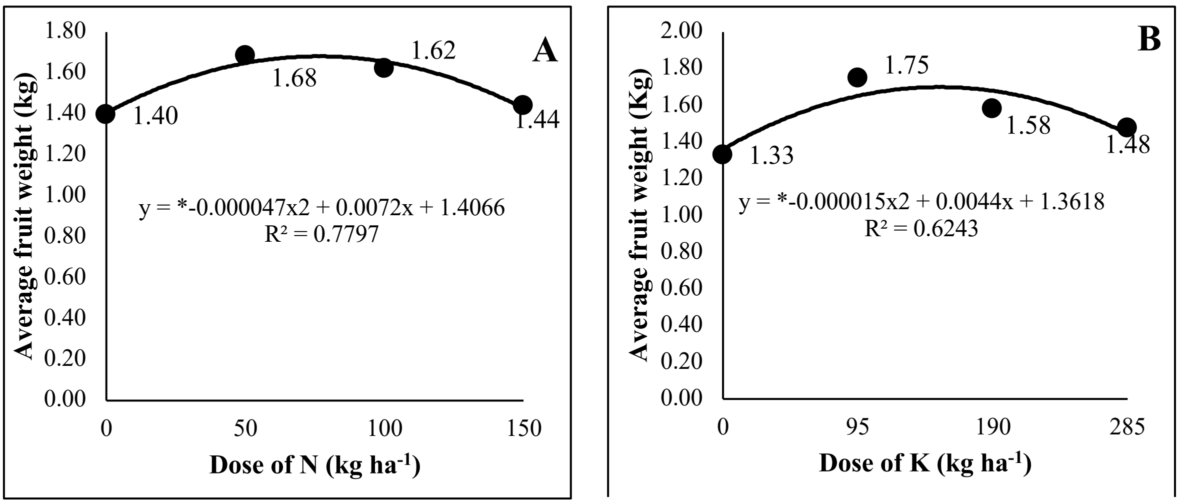


**Figure 1: Average fruit weight as a function of nitrogen and potassium dose (NS) not significant; (*) significant at 5% probability**

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**Total Soluble Solids (TSS) and polar diameter (PD) of fruits**

No significant interaction between nitrogen and potassium doses was detected for total soluble solids. However, individual effects of each of the nutrients studied were observed. For potassium, the maximum value for total soluble solids (6.79 ºBrix) was reached at a dose of 147.83 kg ha$^{-1}$. A 23.27% difference was obtained in relation to the control (5.21 ºBRIX) (Figure 2B). For nitrogen dose (Figure 2A), regression analysis fits the quadratic model, giving a maximum value of 6.53 ºBrix for a dose of 93.22 kg ha$^{-1}$. For maximum values of total soluble solids, the difference between the two nutrients studied was 0.26 ºBrix.

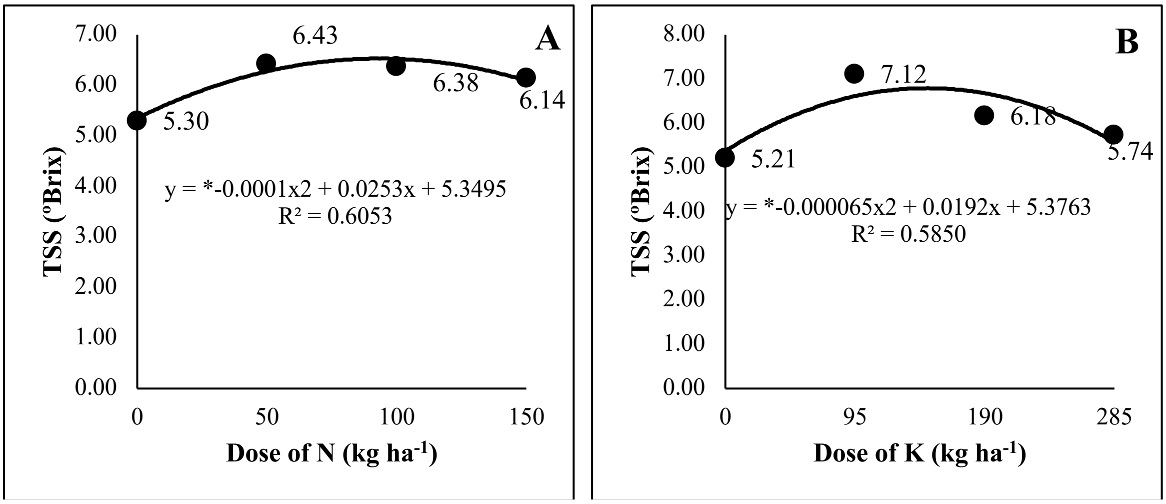


**Figure 2: Total soluble solids of fruits as a function of nitrogen and potassium doses (NS) not significant; (*) significant at 5 % probability**

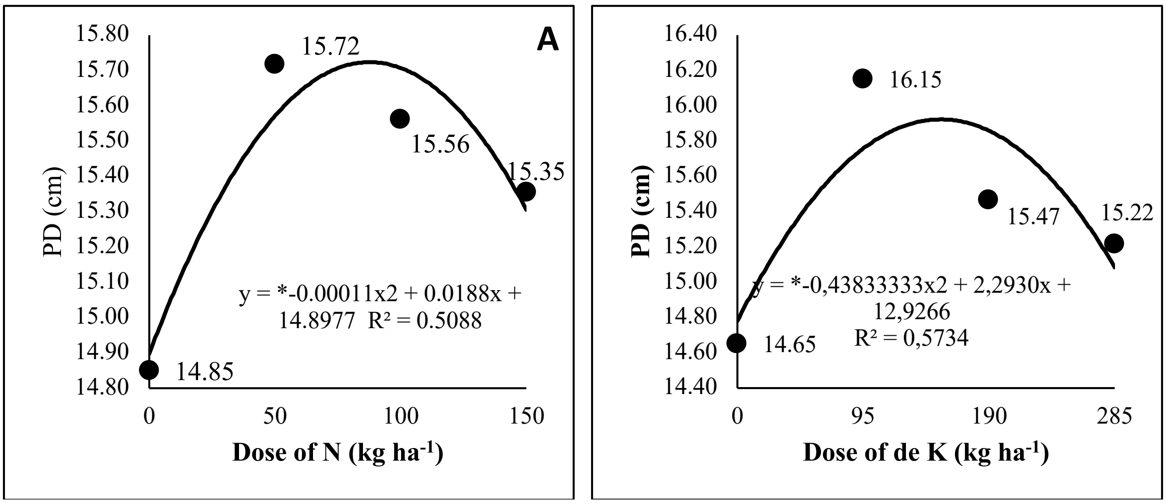


**Figure 3: Polar diameter as a function of nitrogen and potassium doses (NS) not significant; (*) significant at 5 % de probability**

In Figure 3, the analysis of regression carried out for the effect of nitrogen dose on the polar diameter of fruits is shown. A curve fitting quadratic polynomial is observed; a maximum polar diameter value of 15.73 cm was achieved with a nitrogen dose of 87.65 kg ha$^{-1}$; higher doses of the nutrient reduced PD values.

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In the analysis of the effect of potassium dose, it was observed that the polar diameter of fruits fit a polynomial quadratic curve. A maximum value of 15.91 cm was achieved with a dose of 152.04 kg ha$^{-1}$. Higher doses of potassium produced reductions in the polar diameter of fruits (Figure 3B).

**Equatorial diameter of fruits**

Interaction between nitrogen and potassium doses was observed in the evaluation of the equatorial diameter of fruits (ED). The results that were produced individually by the two nutrients evaluated are displayed below.

Figure 4A shows that nitrogen dose (50, 100 and 150 kg ha$^{-1}$) fits a quadratic regression model. Maximum ED levels (14.56, 14.08 and 14.7 cm respectively) were reached with potassium levels of 159.27, 165.63 and 153.16 kg ha$^{-1}$ respectively. The control (no N application) showed no significant differences for analysis of regression in the F-test for different doses of potassium.

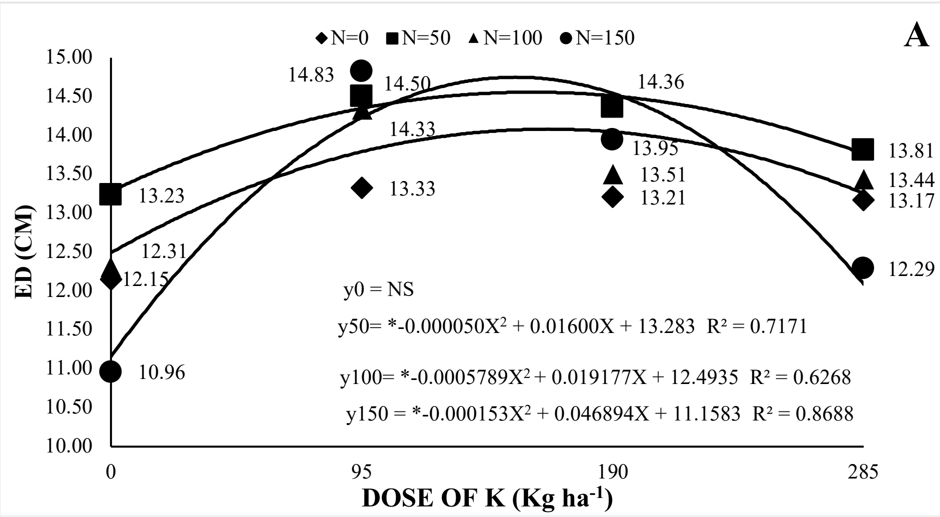


**Figure 4A: Equatorial diameter as a function of potassium levels on nitrogen dose (NS) not significant; (*) significant at 5 % probability**

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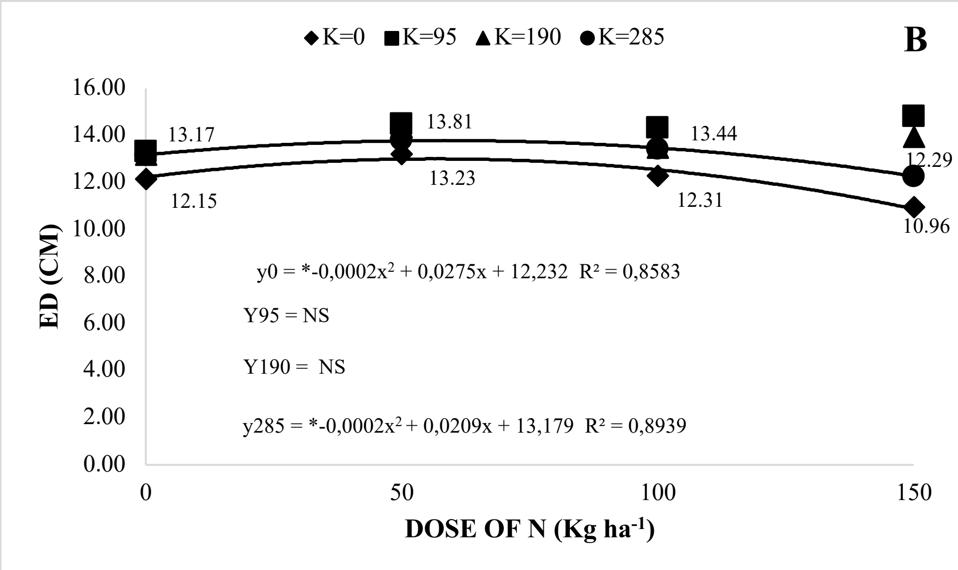


**Figure 4B: Equatorial diameter as a function of nitrogen levels on potassium dose (NS) not significant; (*) significant at 5 % probability**

Figure 4B shows that maximum ED levels of 13.78 cm were obtained using a potassium dose of 285 kg ha$^{-1}$ in interaction with nitrogen levels of 58.21 kg ha$^{-1}$. The analysis of regression shows no statistical response for potassium levels of 95 and 190 kg ha$^{-1}$. In the control, a maximum ED value of 13.00 cm was achieved with nitrogen levels of 56.51 kg ha$^{-1}$.

According to the response surface analysis, the optimal levels of N (71.9495 kg ha$^{-1}$) and K (160.554 kg ha$^{-1}$) for the optimal response value of the equatorial diameter of fruits (14.6322 cm), the adjusted equation for the mentioned characteristic is the following: Y= 12,0396 + 0,0197197*N + 0,023456*P - 0,0001405*N$^2$ + 0,00000310175*N*P - 0,0000737304*P$^2$.

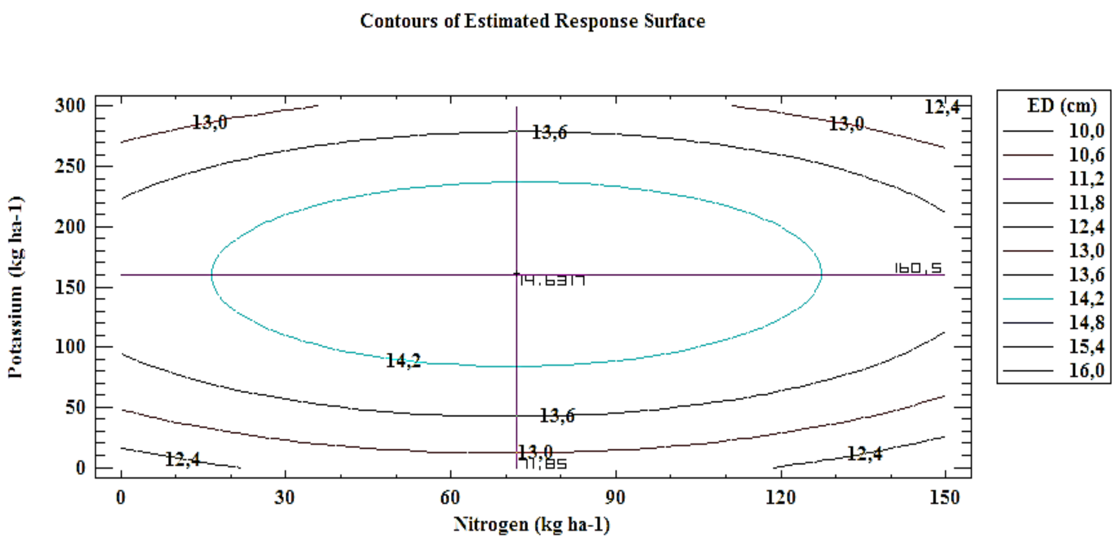


**Figure 4C: Response surface analysis of equatorial Diameter as a function of nitrogen and potassium levels**

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**Fruit weight per plant**

Interaction between different levels of the evaluated nutrients was observed for the variable of fruit weight per plant.

Figure 5A shows that the values recorded fit quadratic models for doses of nitrogen (0, 50, 100 and 150 kg ha$^{-1}$). The control (no N application) produced maximum values of 5.47 kg of fruit/plant with a potassium dose of 146.07 kg ha$^{-1}$. A maximum value of 7.42 kg of fruit/plant was reached with an N dose of 50 kg ha$^{-1}$ in combination with a potassium dose of 139.76 kg ha$^{-1}$. For nitrogen doses of 100 and 150 kg ha$^{-1}$, the maximum weight of fruit per plant were 5.41 and 6.25 kg respectively with respective potassium doses of 189.79 and 150.05 kg ha$^{-1}$.

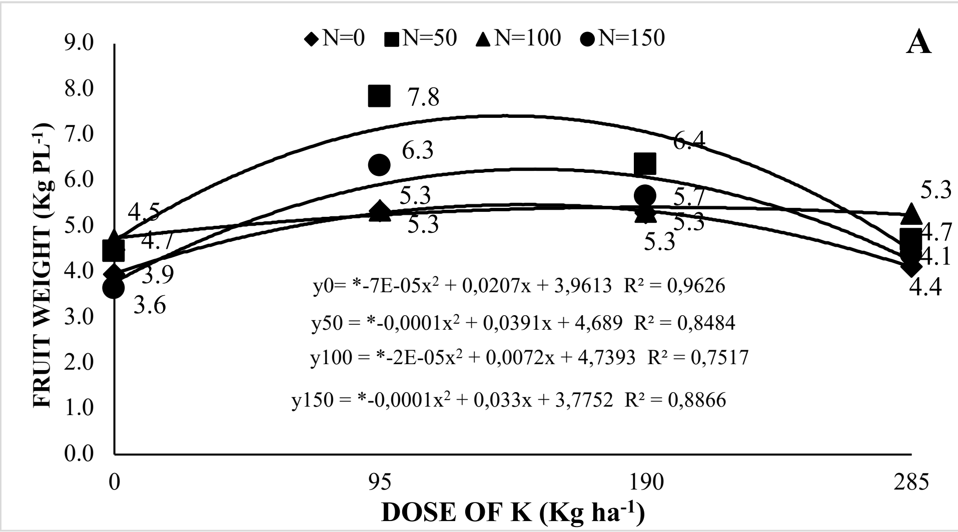


**Figure 5A: Fruit weight as a function of potassium levels on nitrogen dose (NS) not significant; (*) significant at 5 % probability**

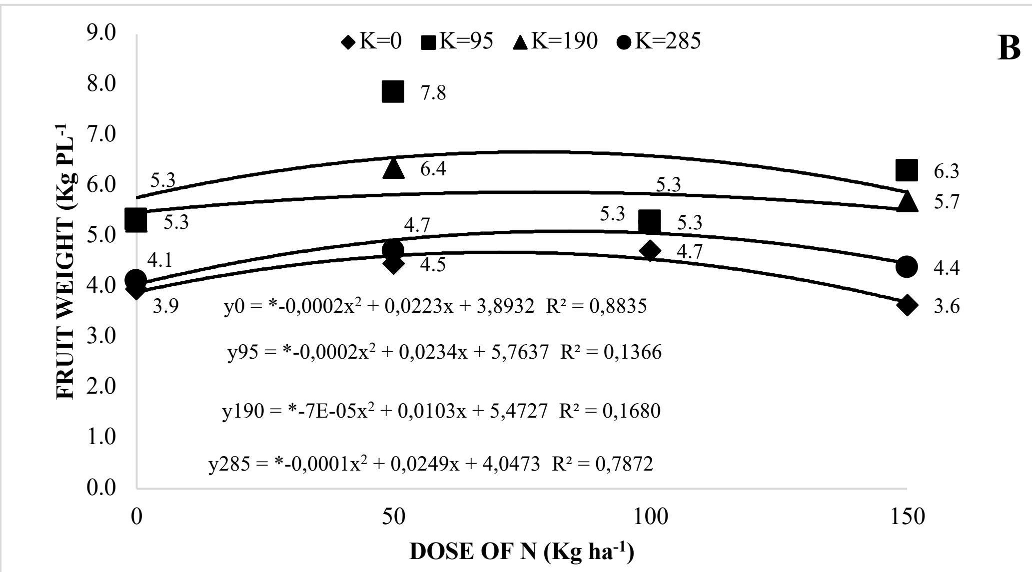


**Figure 5B: Fruit weight as a function of nitrogen levels on potassium dose (NS) not significant; (*) significant at 5 % probability**

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There was an interaction effect between levels of nitrogen and potassium used, fits to a quadratic regression model. The nitrogen doses that produced highest fruit weight were 70.71, 78.27, 75.82 and 84.28 kg ha$^{-1}$, producing respective weights of fruit per plant of 4.68, 6.69, 5.88 and 5.09 kg (Figure 5B). This was achieved in combination with potassium levels of 0, 95, 190 and 285 kg ha$^{-1}$ respectively. Higher doses produced reductions in the weight of fruit/plant.

According to the response surface analysis, the optimal levels of N (77.5921 kg ha$^{-1}$) y K (147.369) for the optimal response value of fruit weight per plant (6.54577 kg pl$^{-1}$), the adjusted equation for the mentioned characteristic is the following: $Y = 4{,}04068 + 0{,}0188278*N + 0{,}0240848*P - 0{,}00013275*N^2 + 0{,}0000120211*N*P - 0{,}00008488*P^2$.

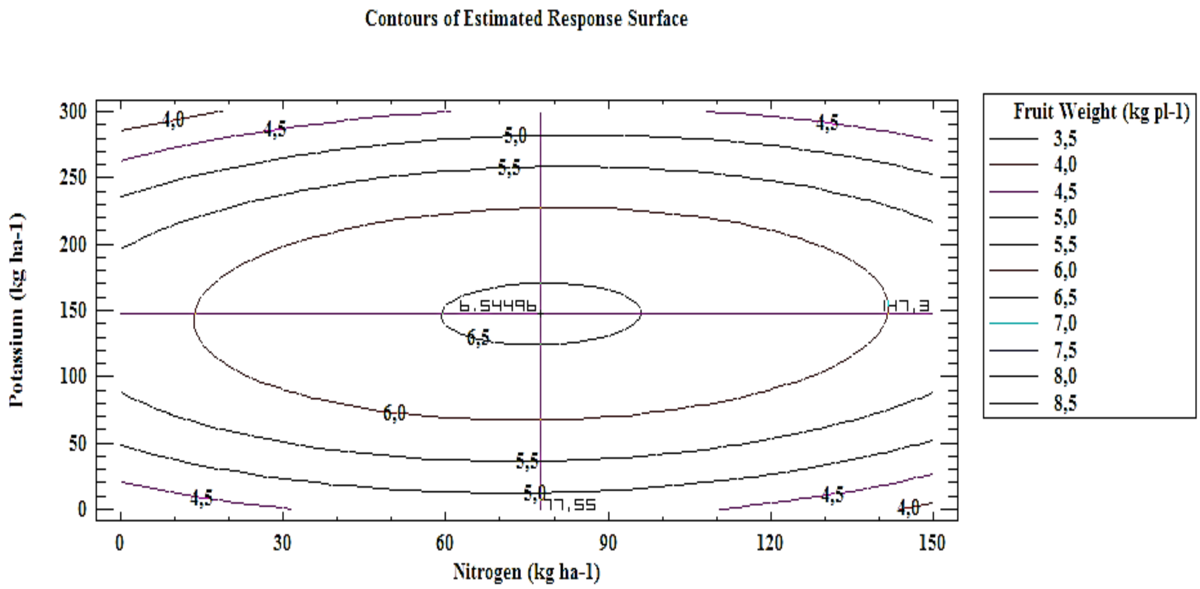


**Figure 5C: Response surface analysis of fruit weight per plant as a function of nitrogen and potassium levels**

The results obtained show the influence of nitrogen and potassium doses on the measurements carried out. Average fruit weight was affected by doses of nitrogen and potassium in correspondence to a quadratic regression model. Fruit weight increased as the dose of N and K was increased. Doses higher than the point of maximum efficiency decreased fruit weight. This could be related to the effect that is produced by an excess of these elements on plants' metabolism. These results correspond with those of Silva [6], in which they observed the effects of doses of nitrogen (100, 160, 220 and 280 kg ha$^{-1}$) and potassium (100, 190, 280 and 370 kg ha$^{-1}$) on the average weights of melon crops. They found there to be direct influence on the productivity of the crop. Elsewhere, positive effects were observed on the average weight of fruits when applying combinations of these nutrients [13, 14].

There were no interaction effects between doses of N and K observed for TSS, although the influence of each individual nutrient can be observed. Ferrante did not find significant effects on total soluble solids when researching the effect of nitrogen

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fertilizers on melon fruit quality [15]. These results are not consistent with those of this investigation. Likewise, other studies have reported that the application of N does not influence TSS [16, 17, 18]. Meanwhile, Nascimento [19] registered a quadratic regression model when evaluating N levels of 0, 60, 120, 180 and 240 kg $ha^{-1}$; the equation coefficient showed significant effects according to the F-test. This conforms with this study. Furthermore, Lin Mahmoud, reported positive effects on TSS with increases of potassium dose [20, 21].

Regarding polar and equatorial diameter of fruits, Queiroga [22] carried out an analysis of regression and obtained a quadratic response for these variables using nitrogen doses. They recorded maximum values for polar and equatorial diameters of 15.24 and 13.132 cm with applications of 365.90 and 384.25 kg $ha^{-1}$ N respectively. These results are similar to those achieved in this experiment. This is not the case for the results achieved by Purquerio [23], who found that increasing levels of nitrogen produces a reduction in the polar and equatorial diameters of fruits. Nascimento [19] did not observe significant differences between fertigation and conventional systems for delivering nitrogen doses.

Reductions in fruit weight per plant have been reported for nitrogen doses of 0 to 60 kg $ha^{-1}$ [24]. On the other hand, Morales [25] recorded an increase in yield, with maximum values reached at 60 kg $ha^{-1}$ of $K_2O$. In turn, Grazia [11], points to the importance of adjusting nitrogen and potassium to obtain high yields. Elsewhere, Coelho [26] did not observe effects of potassium doses on the yield of fruits per plant when evaluating four levels of nitrogen application (0, 60, 120 and 180 kg $ha^{-1}$) and potassium (130, 200, 270 y 340 kg $ha^{-1}$) applied through fertigation. This does not conform with this experiment. Significant effects were observed when using potassium doses.

## CONCLUSION

The nutrients that were evaluated as well as their respective levels of application positively influenced average weight, polar diameter and soluble solids of melon fruits. Best results were found for nitrogen doses of 50 kg $ha^{-1}$ and potassium doses of 95 kg $ha^{-1}$.

The dose combination that produced the best values for equatorial diameter and fruit weight per plant was 71.9495 kg $ha^{-1}$ of N and 160.554 kg $ha^{-1}$ of K, 77.5921 kg $ha^{-1}$ of N and 147.369 kg $ha^{-1}$ of K, respectively.

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**Table 1: Statistical probability (F) of detection of differences between nitrogen and potassium fertilizer in melon**

| | F value 5% | | | | |
|---|---|---|---|---|---|
| | **Average fruit weight (Kg)** | **TSS (ºBrix )** | **PD (cm)** | **ED (cm)** | **Fruit weight** (kg pl$^{-1}$) |
| **Nitrogen (N)** | 9.60* | 4.82* | 6.22* | 7.35* | 71.62* |
| **Potassium (P)** | 19.89* | 9.93* | 26.56* | 46.23* | 398.97* |
| **N x P** | 1.93ns | 0.95ns | 2.19ns | 5.21* | 44.73* |
| **CV (N) %** | 10.14 | 13.58 | 3.41 | 4.50 | 3.89 |
| **CV (P) %** | 8.96 | 14.64 | 2.72 | 3.41 | 3.12 |

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