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# Effect of different soil water tensions and potassium fertilization on the production and quality of netted melon (*cucumis melo* l.) in the Amazon area

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**Abstract**

The objective of this study was to evaluate the production and qualitative behavior of netted melon in a protected environment subjected to different soil water tensions and potassium doses, applied via fertigation. The experimental design was randomized blocks (RBD) in a 4 x 5 factorial scheme with 20 treatments and three replicates, consisting of five percentage doses of potassium (0, 50, 100, 150 and 200%) and four soil water tensions (15, 30, 45 and 60 kPa). The variables analyzed were average yield (t $ha^{-1}$), transverse and longitudinal diameter of fruits (mm), pulp thickness (mm), °Brix (%) and pH. Yield and fruit longitudinal diameter were decreased linearly with the increase in soil water tension. The best result for yield and fruit longitudinal diameter of 51.24 t $ha^{-1}$ and 127.7 mm were achieved, respectively, when irrigation performed at 15 kPa tension. The lowest value was found at the maximum tension (60 kPa). Regarding potassium doses, a quadratic model fitted to the data, with maximum values of yield and longitudinal diameter at the $K_2O$ doses of 235.30 and 232.82 kg $ha^{-1}$, respectively. The interaction of T x K led to higher values of °Brix under 247.68 and 371.52 kg $ha^{-1}$ of $K_2O$ with tension of 24.67 kPa, with no difference between both. The best result of fruit transverse diameter was observed under combination of 371.52 kg $ha^{-1}$ of $K_2O$ and 15 kPa tension. Irrigation at tension of 15 kPa and $K_2O$ dose of 247.68 kg $ha^{-1}$ can be indicated for the study conditions.

**Keywords:** *Cucumis melo* L.; tensiometry; fertigation; irrigation; fruit production.

## Introduction

The melon tree (*Cucumis melo* L.) is a species belong to Cucurbitaceae family. It grows in tropical climate and is of great importance for the Brazilian market (Filgueira, 2008). Brazil occupies twelfth place in the world production scale, being the largest melon producer in South America (IBGE, 2012). The largest production of melon is concentrated in the Brazilian semiarid region, as it presents adequate soil and climatic conditions for cultivation and corresponds to about 95% of annual exports (Barros et al., 2019; Pinto et al., 2019).
There are several varieties of melon on the market, but the exploration of noble melon hybrids has been showing a growing trend in Brazil, as it is a very appreciated melon by the domestic and foreign consumer market. It has a greater added value, better aroma, texture, firmness, greater sweetness, and productive potential, compared to the yellow type, especially when irrigated (Santos et al., 2011; Cavalcante Neto et al., 2020). Despite the growing domestic consumption of noble melons, Europe still has the biggest consumers.
In view of the high productive demand for lace melon in the country, cultivation in a greenhouse with fertigation has been a technique capable of ensuring greater safety in the quality and production of the fruits, since vertical staking facilitates cultural treatments, control plant health and harvesting, enabling an increase in plant density. Protected cultivation also provides a reduction in pest attacks, greater efficiency in fertigation and protection against heavy rains in the Amazon (Melo, 2009).
Despite the melon tree being a water demanding plant, studies have shown that irrigation must be carried out properly, as the excess and water deficit cause losses in production and fruit quality. However, many producers apply irrigation without a correct management of the necessary depth for the development of the crop. Monitoring soil moisture using tensiometers has been one of the most used strategies to define the ideal time for irrigation (Cabello et al., 2009; Carvalho et al., 2011; Marouelli et al., 2011; Oliveira et al., 2011).
Irrigation is a fundamental technique for melon cultivation, as in its absence, production is directly affected by the lack of water availability. Irrigation of melon should be mainly promoted by the drip system, avoiding wetting the aerial part of the plant, as it is a crop sensitive to pest attack. This system holds greater control in chemigation and water use efficiency, which should be provided with emitters spaced between plants and rows (Pereira et al., 2017; Guimarães et al., 2020; Pereira et al., 2021).
Potassium (K) is one of the most used nutrients in fertigation, as it is efficient due to its high mobility in the soil and its high solubility in water (Guerra et al., 2004). K, being as a nutrient most required by melon, regulates the stomatal opening during photosynthesis, balances the entry of CO2, enzyme activator and its deficiency can reduce the

photosynthetically active leaf area of plants and losses in fruit production and quality. However, for the better use by the culture the environment must present a good humidity condition (Hasanuzzaman et al., 2018; Bagagim, 2019).

Therefore, this work aimed to evaluate the productive and qualitative behavior of lace melon, in a protected environment, submitted to different soil water tensions and potassium doses applied via fertigation.

***Results***

***Behavior of water depths, soil water tensions and potassium doses***

The initial water depth applied before the differentiation of treatments (Init), total water depth applied in each treatment (Irrig), number of irrigation events (NI), irrigation interval for each treatment (INT), as well as water demand (WD, total irrigated after differentiation of treatments/ irrigated days) are shown in Table 1.

It is observed that the total irrigation depth showed a decreasing behavior as a function of soil water tension, being higher in treatments with lower tensions, with irrigation system being activated more often (NI), and with higher frequency of irrigation system activation, i.e., shorter irrigation interval (INT). Sensoy et al. (2007) and Morais (2008) indicated that irrigation management in melon crop with more frequent water applications conditions the soil to remain with an optimal water content, favoring better crop development. The variables fruit weight (FW), pulp thickness (PT), longitudinal diameter (LD), transverse diameter (TD) and ºBrix (%) were influenced by soil water tension and potassium doses. On the other hand, the pH did not differ significantly (at 5% probability level) between the treatments used (Table 2)

***Yield and fruit longitudinal diameter***

The water tension treatments significantly affected the yield (Y) and fruit longitudinal diameter, causing linearly reduction as water tensions increased, whereas the best results achieved when irrigation was performed at 15 kPa tension, with 51.24 t ha-1 and 127.7 mm, respectively. The lowest value obtained at maximum tension (60 kPa) (Figure 1A and 1B). Several studies have shown that melon is a sensitive culture when subjected to water deficit condition (Sensoy et al., 2007; Oliveira et al., 2008; Sousa et al., 2010).

The netted melon hybrid 'Pingo de mel' showed high water requirement for fruit development, since the treatment maintained with soil moisture closer to field capacity (15 kPa) had higher yield and fruit longitudinal diameter, while the lowest values were observed under water stress condition (60 kPa). Likewise, similar responses were reported by Lima (2015), who evaluated the response of melon to different soil water tensions and verified that the best fruit diameters were obtained with soil water tension of 15 kPa, the closest to the field capacity.

Yield and longitudinal diameter showed a quadratic polynomial variation as a function of the applied potassium dose, with maximum points of 55.28 t ha$^{-1}$ and 127.50 mm for K2O doses of 235.30 and 232.82 kg ha$^{-1}$, respectively (Figure 1C and 1D). This yield value was above the national average (around 25 t ha-1; Crisóstomo et al., 2003) and those obtained in experimental work (Rocha, 2015 obtained 13.250 kg hectare-1, with the lowest dose 50% of K2O; Queiroz, 2016 obtained 30341.494 kg ha$^{-1}$ corresponding to a dose of 86.72 K and Guimarães et. al, 2020; 48.13 t ha$^{-1}$ was obtained with the application of 370 kg ha$^{-1}$ of $K_2O$). It was reported that the dose below the recommendation can impair the fruit development. This is probably due to the function of potassium in translocation of carbohydrates by phloem and defect storage in fruits (Medeiros et al., 2008). Excessive doses also affected the size and weight of the fruits, which may have been caused by antagonism with other nutrients such as $Ca^{2+}$ and $Mg^{2+}$, which can sometimes lead to a deficiency of these two nutrients, and consequent drop in production (Meurer, 2006).

***Interaction (T x K)***

There was significant interaction between tension and potassium dose ($p<0.05$) for the variables pulp thickness (PT), °Brix and fruit transverse diameter (TD).

The interaction tension of 38.5 kPa and potassium dose of 123.84 kg of K2O ha$^{-1}$ (K50%) provided greater pulp thickness with economical dose (42.52mm). The best result of transversal diameter of the fruits (128.67 mm) was obtained in the combination of 371.52 kg ha$^{-1}$ of $K_2O$ (K150%) and tension 15 kPa and the smallest values of pulp thickness, as well as diameter In the treatments with high doses of potassium, 495.36 kg ha$^{-1}$ of $K_2O$ (K200%) and in the treatment without addition of potassium (K0%) were observed in the treatments with high doses of potassium (60 kPa) (Figure 2A and 2B).

Similar results were obtained by Silva et al. (2014) in Rafael hybrid red arrowing melon cultivation, under different potassium doses. They observed a maximum pulp thickness of 30.70 mm was obtained under 240 mg dm$^{-3}$ dose of potassium while high- and low-dose reduced this characteristic. The greater thickness of the pulp is desirable, while it increases the weight and the edible part, improving the quality of the fruit (Coelho et al., 2003).

The treatments with high potassium doses did not show satisfactory response, probably because the low amount of water affected the absorption and translocation of the nutrient. Likewise, the treatment without potassium fertilization led to lower values, demonstrating the importance of this nutrient for melon crop. According to Raij (1991), potassium availability is greatly influenced by soil water content, especially due to the cation ratios.

It was observed that the interaction of soil water tension and potassium dose presented higher values of ° Brix (9.5%) under 247.68 kg ha$^{-1}$ of $K_2O$ and 371.52 kg ha$^{-1}$ of $K_2O$ with tension of 24.67 kPa, respectively, showing no difference between them (Figure 2C). The minimum established by international standards is 9% (Silva et al., 2008). In the treatment with the highest tension of water in the soil (60 kPa; 6.67%) and the one with the lowest tension (15 kPa; 6%) in interaction with K0%, the lowest values of °Brix of the fruits were observed. The °Brix of the fruits showed different behavior compared to that found in other studies. It should have been higher in fruits of plants subjected to the lowest irrigation depths, due to the increase in the concentration of sugars in fruit tissues (Andrade júnior et al., 2001; Fabeiro et al., 2002). Figueiredo (2014) studied the influence of irrigation depth and frequency on the melon crop grown on stakes in the lower São Francisco valley and found similar results that obtained in the present study, where the treatments that received lower irrigation depth had fruits with lower °Brix, a significant difference when compared to treatments that received greater amount of water.

**Table 1.** Soil water tensions at 0.30 m depth.

| Tension (kPa) | Init (mm) | Irrig (mm) | NI (un) | Tot (mm) | INT (day) | WD (mm/day) |
|---|---|---|---|---|---|---|
| T15 | 52.22 | 4.55 | 34 | 206.92 | 1.5 | 2.97 |
| T30 | 52.22 | 13.75 | 10 | 192.14 | 5.11 | 2.64 |
| T45 | 52.22 | 19.44 | 7 | 188.30 | 7.6 | 2.61 |
| T60 | 52.22 | 23.42 | 4 | 145.90 | 11.5 | 1.80 |

Irrigation depths applied before the differentiation of treatments (Init), irrigation depths applied after differentiation of treatments (Irrig), total water depths (Tot), irrigation shift after treatment differentiation (TR), number of irrigations (NI) and water demand (WD).

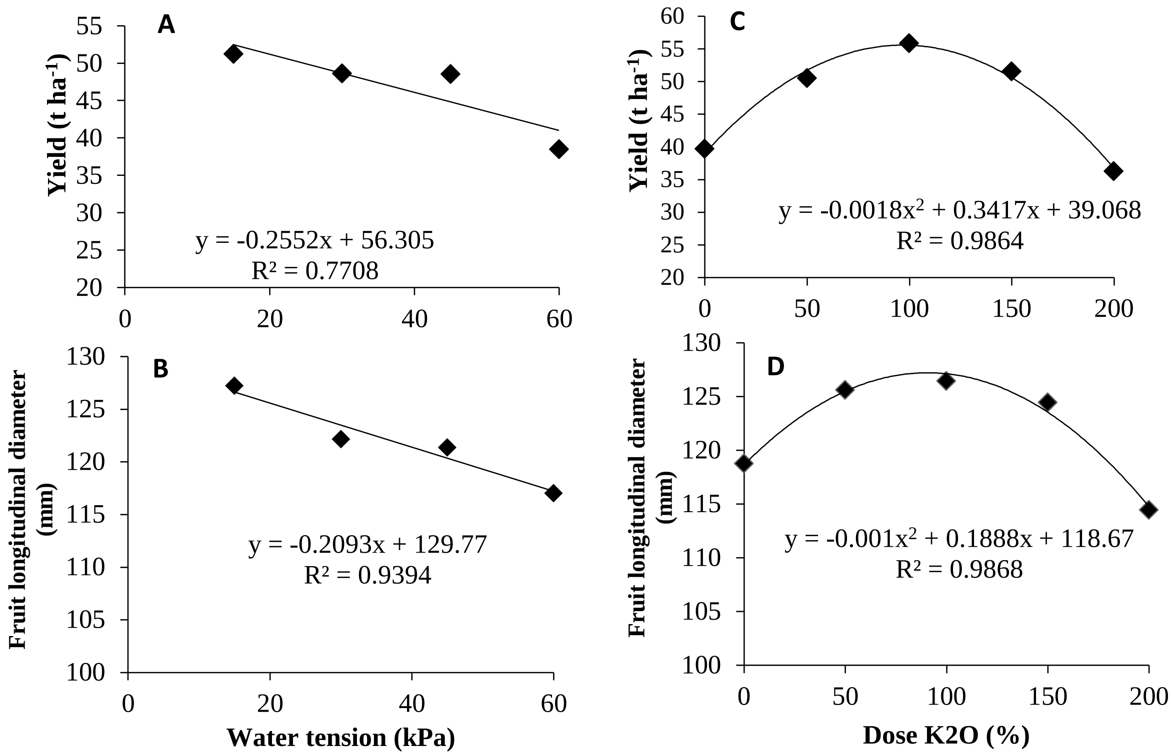


**Figure 1.** Yield (A); Fruit longitudinal diameter (B), as a function of different water tensions in the soil, in kPa; Yield (C); Fruit longitudinal diameter (D) as a function of different potassium doses in netted melon hybrid 'Pingo de mel'.

**Table 2.** Analysis of variance (F values) for average fruit yield (Y, t ha$^{-1}$), pulp thickness (PT, mm), longitudinal diameter (LD, mm), transverse diameter (TD, mm), ºBrix (%) and pH (in water) in melon plants grown at different water tensions (T) and potassium doses (K) in the soil.

| | F values | | | | | |
|---|---|---|---|---|---|---|
| Source of variation | Y (t ha$^{-1}$) | PT (mm) | LD (mm) | TD (mm) | ºBRIX (%) | pH |
| Block | 1.20* | 0.46$^{ns}$ | 3.07$^{ns}$ | 0.52$^{ns}$ | 0.78ns | 0.49$^{ns}$ |
| Tension (T) | 7.81* | 9.27* | 6.57* | 68.88* | 11.42* | 1.60$^{ns}$ |
| Potassium (K) | 13.82* | 11.25* | 7.98* | 129.66* | 73.80* | 1.11$^{ns}$ |
| Interaction T x K | 0.88$^{ns}$ | 3.83* | 1.87$^{ns}$ | 42.09* | 7.63$^{*}$ | 0.92$^{ns}$ |
| CV (%) | 16.68 | 10.24 | 5.18 | 1.59 | 5.41 | 3.32 |

$^{ns}$ – not significant by F test, * – significant at 5% probability level by F test.

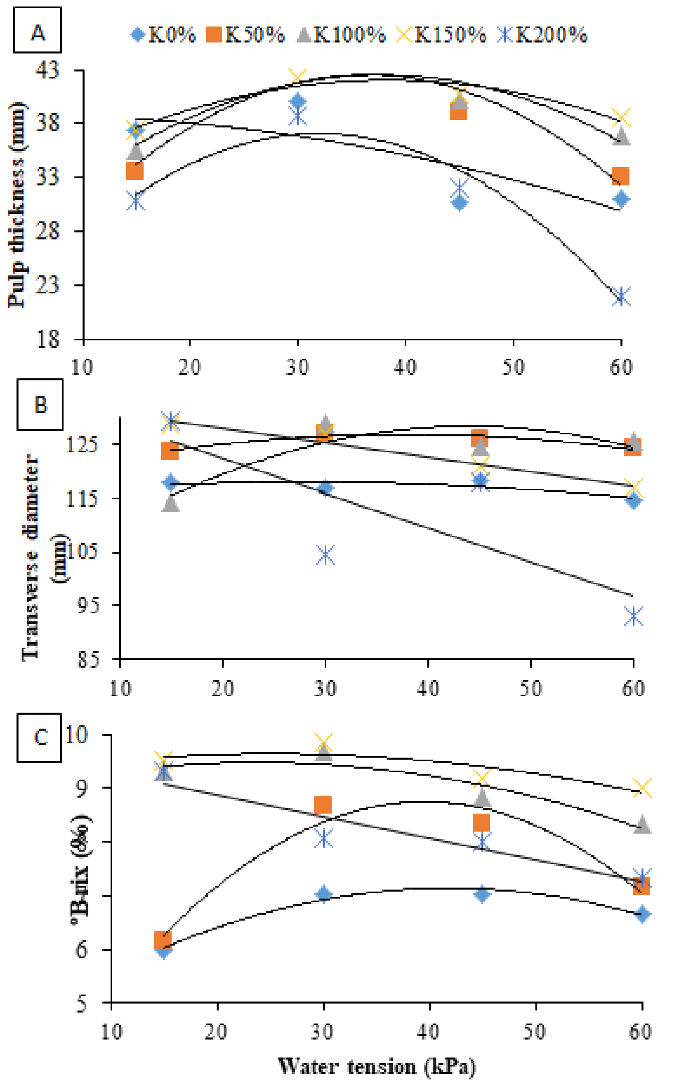


**Figure 2.** Interaction (T x K) effect on pulp thickness (mm) (A), ºBrix (B) and fruit transverse diameter (mm) (C).

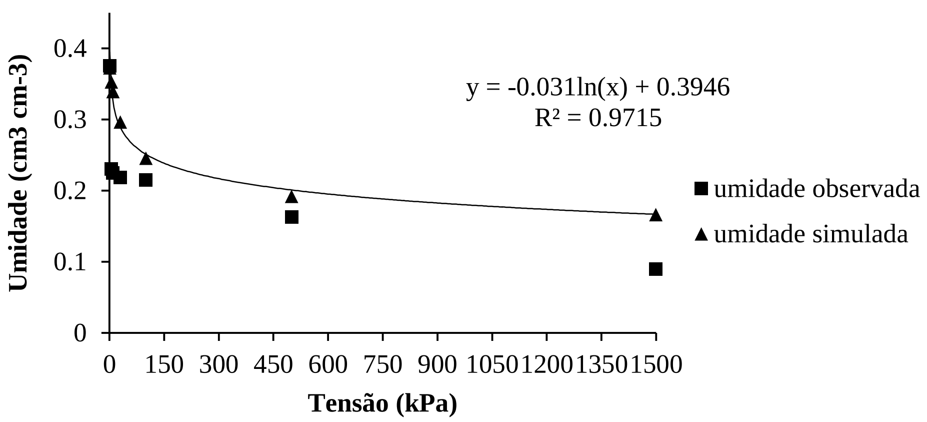


**Figure 3.** Soil water retention curve in the 0-30 cm layer.

Potassium is responsible for transporting photoassimilates to the fruits, hence promoting higher contents of soluble solids and sugar (Prado, 2008). Probably, the translocation of photoassimilates in the plants was negatively influenced by water stress due to the difficulty in absorbing potassium under the low moisture condition, which led to lower values of °Brix at higher soil water tension (Faria, 1990; Katayama, 1993).

### *Materials and methods*

### *Experiment location*

The experiment was conducted in a greenhouse, covered by plastic film, from May to August 2019, installed in the experimental area of Federal Rural University of the Amazon (UFRA), located in the municipality of Igarapé-açu - PA, Brazil, at 39 m altitude and with geographic coordinates of 01º 07' 33" South and 47º 37' 27" West.

### *Plant material*

The hybrid melon cultivar 'Pingo de mel' was sown in polyethylene trays with 128 cells, containing substrate based on açaí fiber and black earth. At 20 days after sowing (DAS), the seedlings were transplanted to the definitive location. The experimental plots were 0.25 m wide by 2.5 m long (0.625 m2), and 0.15 m high. The spacing used was 1.20 m between beds and 0.50 m between plants. Each plot had five plants, and only the three central plants of each plot were considered for evaluations. In order to ensure good development of the seedlings, the differentiation of treatments was occurred only 20 days after transplantation (DAT). Plants were staked immediately after the production of the first tendrils, using bamboo and three rows of smooth wire no. 14, arranged parallel to each other at a distance of 50 cm. Nylon wire was used to attach the plants to the wire. Plants were grown on a single stake, vertically fixed using ribbons. Two secondary stems were left in each, at 50 cm height from the soil, and each stem formed one fruit, while the other fruits were thinned. Apical bud was removed when the main branch reached the third wire, with 2 m height. 20 days after flowering, the daily manual pollination began from 7 am to 9 am. When the fruits reached the size of an orange, they were supported with nylon nets. Fruit harvest was performed at 72 DAT, considering the harvest point as the formation of the abscission layer next to the peduncle and yellow rind color, characteristic of the cultivar.

### *Climate aspects*

According to Köppen's classification, the climate of the study region is Ami, with an average annual rainfall of 2,500 mm and an average annual temperature of 25 °C. During the experimental period, the temperatures ranged from 26 to 30 °C and the average relative humidity ranged between 76 and 89%. The behavior of average temperatures was mostly within the optimal range for better growth and production of melon (between 20 and 30 °C) (Alvarenga and Resende, 2002).

### *Soil type and characteristics*

The soil at the site was classified as Argissolo Amarelo Distrófico (Ultisol) with sandy loam texture. A composite soil sample was collected in the 0-20 cm layer. The following characteristics were found: pH (in H2O) = 5.59; H + Al= 1.91 cmolc dm-3; V (%) = 70.6; m (%) = 0.43; CECtotal = 6.50 cmol dm-3; CECeffective = 4.61 cmol dm-3; OM = 13.85 g kg-1; N = 0.70 g kg-1; Ca (cmolc dm-3) = 2.78; P = 26 mg dm-3; Na = 9 mg dm-3; K = 21.8 mg dm-3, Mg = 1.76 cmolc dm-3; Cu = 0.96 cmolc dm-3; Fe = 260.73 cmolc dm-3; Mn = 9.06 mg dm-3; Zn = 3.13 mg dm-3. Clay, silt and sand contents were 120, 96 and 484 g kg-1, respectively.

### *Preparation of the area and fertilization*

There was no need for liming in the area. Fertilizations were performed according to soil analysis and to the recommendation of Sousa et al. (2011) for melon. The following doses were required: N = 140 kg ha$^{-1}$, P2O5 = 180 kg ha$^{-1}$ and $K_2O$ = 247.68 kg ha$^{-1}$. At 10 days prior to transplanting, basal fertilization was performed in the planting furrow, consisting of 60% P (108 kg of $P_2O_5$ ha$^{-1}$), 20% N (28 kg N ha$^{-1}$) and 10% $K_2O$, applied according to the quantity recommended for each treatment (0, 50, 100, 150 and 200% of the recommended dose), applying along the furrow and subsequently covered with soil.

Three top-dressing fertilizations were performed, applied through the irrigation water, adding all the rest of N and P and applying the different potassium treatments. First fertilization was 50% N (70 kg ha$^{-1}$), 20% P (36 kg ha$^{-1}$) and 40% K; second fertilization was 20% N (28 kg ha$^{-1}$), 20% P (36 kg ha$^{-1}$) and 40% K; and third fertilization was 10% N (14 kg ha$^{-1}$) and 10% K.

### *Treatments and experimental design*

The experimental design adopted was the Randomized Block Design (RBD), in a 4 x 5 factorial scheme, with three replicates. The treatments consisted of five percentage doses of potassium (0, 50, 100, 150 and 200%) considering the recommended dose for the crop, which corresponded to 0, 123.84, 247.68, 371.52 and 495.36 kg ha$^{-1}$ of $K_2O$, respectively, and four soil water tensions (15, 30, 45 and 60 kPa).

The plants were irrigated by a drip system through polyethylene drip hoses, with nominal diameter of 16 mm, operating pressure of 7.5 mwc at the end of the hose, flow rate of 1.20 L h$^{-1}$, and emitters spaced apart by 15 cm. The drip hoses were positioned in the planting row, and each drip hose per plot had 3.5 emitters per plant.

To monitor the energy state of the water in the soil, a set of twelve tensiometers were installed in the central block, three for each tension treatment, two at 0.30 m depth for irrigation monitoring, i.e., tensiometers for decision making, and one at 0.40 m depth to verify the occurrence of percolation, in each treatment, installed in the planting rows at 10 cm distance from the plant stems (Sousa et al., 2014).

Daily readings were performed in the tensiometers at 8 a.m., adopting the criterion of restarting the irrigations when the averages of the two tensiometers for decision making reached the critical tension. Irrigations were performed in order to increase soil moisture, obtained indirectly by the tensiometer, to the condition of field capacity, which corresponded to 10 kPa (0.3339 cm3/cm$^{-3}$). Tensiometer readings were performed using a puncture tensiometer (digital). Irrigation management was based on the soil water characteristic curve obtained in the 0-30 cm layer (Figure 3), which was used to monitor the soil moisture contents in all treatments.

### *Evaluated characteristics and statistical analysis*

The variables analyzed were transverse diameter (TD) and longitudinal diameter (LD) of fruits (mm), yield (Y) in t ha$^{-1}$, pulp thickness (mm), ºBrix (%) and pH. These variables were subjected to analysis of variance by F test and, in case of significance, regression analyses were applied with R 3.5.0 program (R Development Core Team, 2018).

## **Conclusions**

The present study shows that irrigation at tension of 15 kPa, used as a reference to start irrigation, and potassium dose around 100% of the recommended dose (247.68 kg ha$^{-1}$ of

$K_2O$) promoted higher fruit production and quality of the netted melon hybrid ‘Pingo de mel’. Excessive potassium dose (495.36 kg $ha^{-1}$ of $K_2O$) and water stress condition (60 kPa) led to lower fruit production and quality.

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