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Time of transplanting and crop management affects the postharvest quality of melon fruits

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Abstract

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Melon (*Cucumis melo* L. cv Goldex) was cultivated using different ages of seedlings (0, 6, 8, 10 and 12 days after sowing), soil mulching, nonwoven fabric (TNT) barrier against pests, and without mulching and TNT as control, in the Brazilian semiarid. Then, the postharvest quality of fruits was evaluated. Results showed that 8 or 10-day-old seedlings provided fruit with the highest pulp firmness, soluble solids/titratable acidity ratio and lower transverse length. In its turn, the use of soil mulching and nonwoven fabric provided fruits with higher fresh weight and longitudinal length, and lower pulp firmness than control. Such characteristics are desirable for melon exportation. In conclusion, in addition to protecting plants against pest and weeds and to improving soil conditioning and plant growth, the use of mulching, nonwoven barrier, and older seedlings improved the postharvest quality of melon fruits.

Keywords: cucurbit fruits; food quality; soil management; *Cucumis melo* L.; nonwoven fabric; transplanting
Abbreviations: nonwoven fabric (TNT); days after sowing (DAS); fresh weight (FW); hydrogen potential (pH); titratable acidity (TA); soluble solids content (SS); total soluble sugars content (TSS)

Introduction

Melon (*Cucumis melo* L.) is one of the most cultivated vegetables in the world. Almost 32 million tons of melons are produced every year, 53.7% from China (FAOSTAT, 2017). In Brazil, more than 540 thousand tons of melons are produced annually, mainly in the semiarid region (95%; IBGE, 2017). Several techniques are employed to increase yield in this region: high-frequency irrigation, use of hybrid seeds, pest, pathogen and weed control, fertigation, soil mulching, and nonwoven fabric (TNT) for pest control (Câmara et al., 2007; Dantas et al., 2011; Borges et al., 2015).

In melon growing, it is common practices to cover the soil with plastic mulching and plant shoot with TNT. Mulching is used throughout the crop growing aiming to control weed infestation, improve irrigation efficiency (which reduces evaporation losses), and avoid contact of fruits with the soil (Câmara et al., 2007; Dantas et al., 2011; Borges et al., 2015). TNT is used, after the seedling transplanting until full bloom, to protect the plant against pests, such as *Bemisia tabaci* and *Lyriomyza* spp., the main melon pests in Brazil (Medeiros et al., 2007; Medeiros et al., 2008; Santos et al., 2015).

It has been shown how mulching improves the yield and postharvest quality of fruits, like bell pepper (Verma et al., 2019), mango (Das & Dutta, 2018), tomato (Moe et al., 2017), and watermelon (Ajibola & Amujoyegbe, 2019). Benefits of mulching included suppression of weed growth, increased soil moisture and nutrient availability, increased soil microbial population, and moderate soil temperature during growing time compared to uncovered soil (Caruso et al., 2019; Sekara et al., 2019). Such benefits enhance yield components (Caruso et al., 2013) and produce, such as soluble solids content, titratable acidity, and sugars content.

Moreover, the age of seedling at transplanting also influences yield and quality of fruits after harvest, like did in *Cucurbita moschata* Duch and in other species from *Cucurbitaceae* family (Piovesan& Cardoso, 2009; Salata et al., 2011; Conti et al., 2015). Such studies showed fruit quality indicators improved from youngest to oldest transplanted seedlings. However, studies on this practice for melon fruit quality are scarce.

Indeed, pre-harvest factors such as production system, year on year climate variation during growth, and harvest time affect the quality and storability of melon fruits after harvest, like yield, physiological status, retention of aroma, fruit color, and contents of sugar, protein, acid, and antioxidants (Hatami et al., 2019; Spadafora et al., 2019). However, the effects of soil mulching and nonwoven fabric barrier on the postharvest quality of melon fruits are unknown. Therefore, this work aimed to evaluate the effect of seedling age, nonwoven fabric barrier, and soil mulching on the postharvest quality of melon fruits.

Materials and Methods

The experiment was carried out in a commercial melon area located in the Brazilian semiarid region (04º54′9.4″ South and 37º21′59.9″ West). The climate ("BSwh", according to Köppen classification) is characterized by a dry season from June to January, and a rainy season from February to May.

A randomized complete block design with four replicates was used, in a factorial scheme (3x5).The treatments were obtained from the combination of using soil mulching, plant shoot covered with nonwoven fabric (TNT), and uncovered soil and plant shoot as control, and age of seedlings at transplanting time [0, 6, 8, 10 or 12 days after sowing (DAS)]. The experimental unit had 10 m rows, spaced 2.0 m, and 0.4 m between plants, with 25 plants, totaling 25 000 plants per hectare. The area has been explored with melon production for more than 10 years.

Sixty days after transplanting, four fruits of each plot were harvested, when the fruit peel became totally yellow. Then, fruits were transported in boxes (exportation type) to the Physiology and Postharvest Laboratory, Federal Rural University of Semiarid, Brazil. The following variables were evaluated: fresh weight (FW); longitudinal and transverse length; internal cavity; pulp firmness; hydrogen potential (pH); titratable acidity (TA); soluble solids content (SS); SS/TA ratio; and total soluble sugars content (TSS).

The FW (expressed as kg) was obtained using a precise electronic scale and the fruit length (longitudinal and transversal, both expressed as cm) was measured using a measuring tape. Then, fruits were cut lengthwise and pulp thickness (mm) was measured on each fruit side using a digital caliper, for internal cavity estimation. Pulp firmness (expressed in Newton – N) was measured with a manual penetrometer (Fruit Pressure Tester TR, Mc Cormick FT 327, Italy) using a plunger 8 mm in diameter. Two measurements were taken on opposite fruit side, and the mean was taken as the firmness value.

Then, fruit pulp was homogenized using a kitchen blender for chemical evaluation. pH was directly determined by the potentiometer with automatic temperature adjustment, after standardization with pH 7.0 and pH 4.0 buffer solutions (Zenebon et al., 2008). For TA evaluation, a sample (5.0 g) of homogenized pulp was diluted in distilled water (45 ml) and three drops of alcoholic phenolphthalein (1%) were added. Then, the solution was titrated with NaOH (0.1 N) and the results were expressed as a percentage (%) citric acid FW^{-1}(Zenebon et al., 2008). The SS content (% FW) was measured directly in a juice sample using a digital refractometer (model PR – 100, Palette, Atago Co, LTD., Japan) according to AOAC (Latimer, 2012). Then, SS/TA ratio was determined.

TSS was determined by the Antrona reagent method (Yemm & Willis, 1954). A pulp sample (0.5 g) was diluted in distilled water in a volumetric flask (100 ml), and an aliquot of the extract (100 μL) was taken for determination of the absorbance at a 620 nm wavelength by spectrophotometer and results were expressed as % FW.

Data were submitted to one-way analysis of variance by the F test ($p < 0.05$). Mean separations relevant to the first factor were performed by the Tukey's test ($p < 0.05$) and the effect of the different seedling age on fruit characteristics was evaluated by regression analysis ($p < 0.05$). The analysis was performed by SISVAR software version 5.1 Build 72 (Ferreira, 2014).

Results

Both factors affected fruit transverse length ($p < 0.05$) and pulp firmness ($p < 0.01$), and isolated effect for internal cavity ($p < 0.01$). Though, soil mulching and TNT in-

Table 1. Fresh weight, longitudinal length, and internal cavity of yellow melon (*Cucumis melo* L. cv. Goldex) cultivated under different management systems

Treatment	Fresh weight, kg	Longitudinal length, cm	Internal cavity, mm
Mulching	2.44 a	19.46 a	64.96 a
Nonwoven fabric	2.42 a	19.41 a	62.84 ab
Uncovered soil	2.25 b	18.68 b	61.12 b
Mean	2.37	18.85	62.97
CV (%)	8.28	3.79	6.64

Means with different letters in the column are significantly different according to the Tukey's test ($p < 0.05$)

fluenced the fruit fresh weight ($p < 0.01$) and longitudinal length ($p < 0.01$).

Fresh weight, longitudinal diameter, and internal cavity were higher in fruits when soil mulching and TNT were used (Table 1). Fruits with higher transverse length (16.42 cm) were obtained in melon cultivated under mulching system and with use of 8-day-old seedlings, followed by TNT with 5-day-old seedlings (16.04 cm), and uncovered soil (15.84 cm) (Figure 1A). Fruit with a larger internal cavity (67.26 mm) was produced, when 7-day-old seedlings were used, compared to direct sowing (56.44 mm) (Figure 1B). In contrast, pulp firmness was higher in fruits produced in uncovered soil (28.95 N), than under TNT (27.55 N) or mulching (25.61 N) (Figure 1C), while was lower using 8-day-old seedlings.

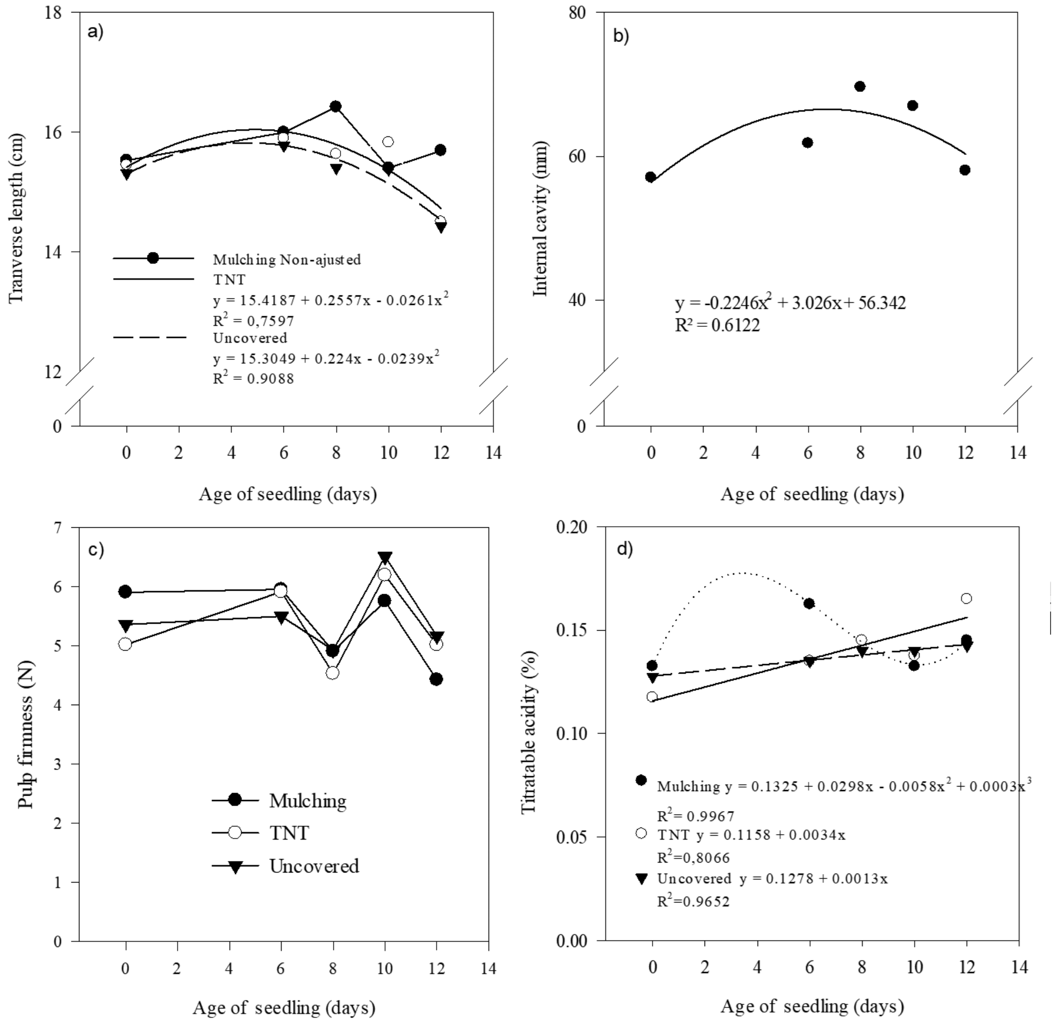

Fig. 1. Transverse length (*a*), internal cavity (*b*), pulp firmness (*c*), and titratable acidity (*d*) of yellow melon (*Cucumis melo* L. cv. Goldex) cultivated using different age of seedlings and management systems

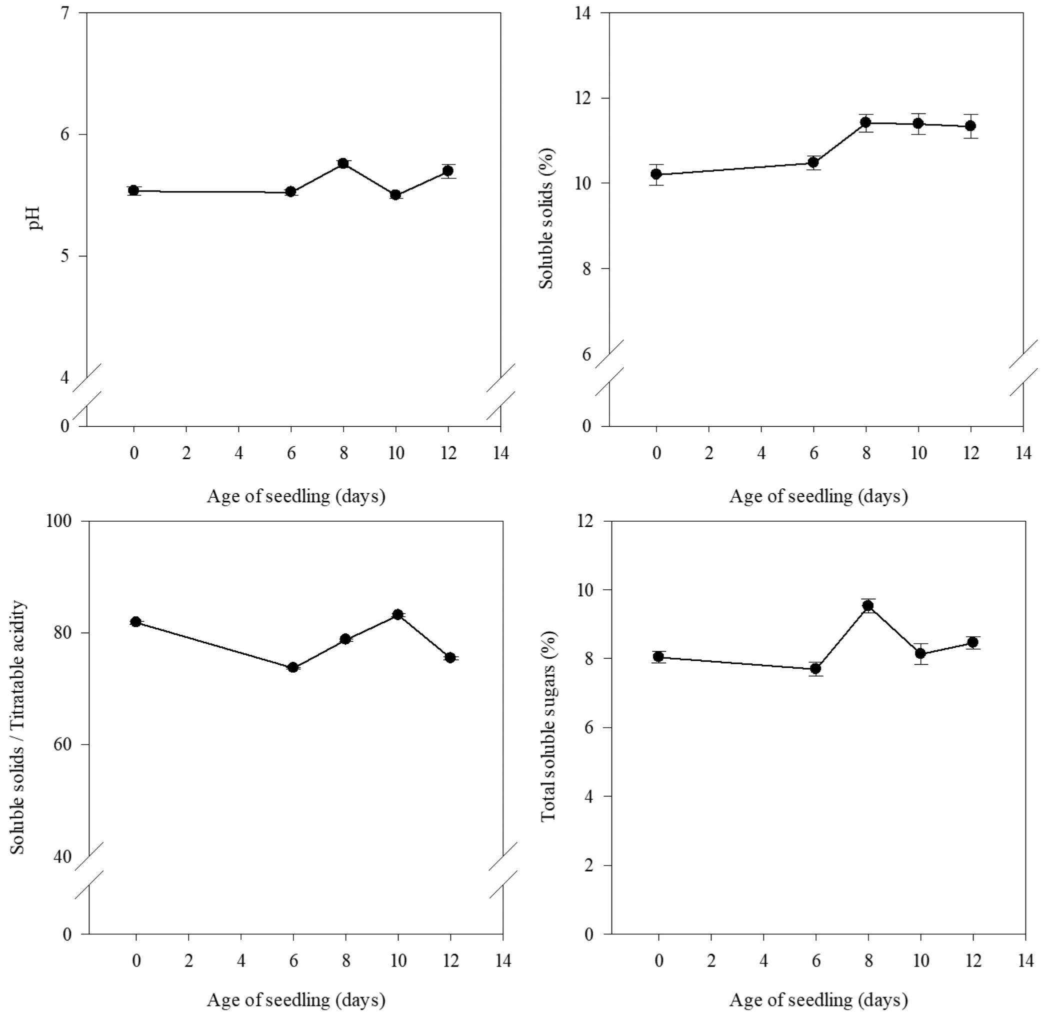

Fig. 2. pH (*a*), soluble solids content (*b*), soluble solids/titratable acidity ratio (*c*), and total soluble sugars (*d*) of yellow melon (*Cucumis melo* L. cv. Goldex) cultivated using different age of seedlings and management systems

TA increased when older seedlings were used, but low variation occurred when TNT and mulching were used. Maximum TA values were obtained using 12-day-old seedlings and TNT (0.165%), followed by control (0.145%) and mulching (0.143%) (Figure 1D). The low variation in TA is according to low variation in pH (5.50 to 5.75; Figure 2A).

Mulching and TNT did not affect the SS content ($p < 0.01$), SS/TA ratio ($p < 0.01$), and TSS ($p < 0.01$). Moreover, SS content did not variate when up to 6-day-old seedlings were used but increased 11.38% with seedlings with more than 8-day-old (Figure 2B), similarly to SS/TA (21.0% increase) (Figure 2C). TSS content was also higher when older seedlings were used (~9.52%), compared to younger (~7.69%) (Figure 2D).

Discussion

The higher fresh weight and fruit length in melons cultivated under soil mulching and TNT may be due to better conditions of humidity, sanity and less weed competition. It has been demonstrated that mulching increases fruit weight (20%) (Dantas et al., 2011) and production of melons (Câmara et al., 2007; Morais et al., 2008). However, fruit length in this work (19.5cm) was higher than those observed in different genotypes of yellow melon (13.62 cm) (Santos et al., 2011).

In this work, smaller fruits were produced when older seedlings were used. This is desired since smaller fruits are required for exportation. Thus, larger fruits obtained with younger seedlings is due to low restriction to root growth of that seedling, which can establish and develop more easily in the field (Salata et al., 2011). Though, these fruits also have more weight and internal cavity. Although it is genetically defined and less influenced by environmental conditions, the internal cavity should be considered due to more resistance to transport (Charlo et al., 2009). Such results have been observed in other cucurbits, such as pumpkin (*Cucurbita moschata*), in which the greater the age of the seedlings transplanted, the smaller the length, diameter and fresh weight of the fruits (Piovesan & Cardoso, 2009).

Mulching and TNT decreased the pulp firmness, compared to control. Such result was similar to those found in melon cultivated under different soil covering systems (Câmara et al., 2007). Mulching maintains moisture content and low temperature in the soil and, consequently, promote good conditions for water absorption for fruit growth. Thus, fruit cells become more turgid, which reduces pulp firmness. As in this work, Filgueiras et al. (2000) found pulp firmness values range from 24 to 40 N in yellow melons, values necessary to withstand handling, transport, and storage.

The low acidity variation was responsible for the lower pH variation. In this way, nopractical difference in consumer sensitivity should occur. Increase in TSS content is accordingly to increase in SS content, since sugars represent the most SS content in melons (76.36%). The SS content (9.52%) in this work is within the melon exportation standards (10 to 12%) (Filgueiras et al., 2000; Dantas et al., 2011). And the TSS was similar to different melons produced in the same region of this study (7.37% to 8.71%) (Tomaz et al., 2009). The higher SS content and the lower TA were responsible for the increase in the SS /TA ratio. Different hybrids yellow melon had a similar ratio (51.00 to 73.33) (Tomaz et al., 2009; Santos et al., 2015). The ratio is widely used for flavor evaluation, being more representative for fruit sweetness than the isolated measurement of SS and TA (Chitarra & Chitarra, 2005).

Older melon seedlings are preferred by producers, due to their compact root system and easier transplanting. However, they should be avoided due to reduction of fruit quality (Piovesan & Cardoso, 2009; Salata et al., 2011). In contrast, younger seedlings may develop in more vigorous plants and photossintetically active until harvest (Salata et al., 2011), providing more quality fruits in SS, TSS, and ratio values (Figure 2). So, this work demonstrated that in addition to protect plants against pest and weeds, improve soil conditioning and plant growth, the use of mulching, nonwoven barrier and older seedlings improve the postharvest quality of melon fruits.

Conclusions

The use of mulching and nonwoven fabric during melon growing provides fruits with higher fresh weight, longitudinal length and lower pulp firmness.

Melon seedlings transplanted at 8 and 10 days after sowing provided fruits with higher firmness and soluble solids / titratable acidity ratio, and lower transverse length.

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