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Effect of main stem pruning and fruit thinning on the postharvest conservation of melon

Rafaella M. de A. Ferreira[1], Edna M. M. Aroucha[1], José F. de Medeiros[1], Iarajane B. do Nascimento[1] & Cristiane A. de Paiva[1]

[1] Universidade Federal Rural do Semiárido. Mossoró, RN. E-mail: rafaellamarafe@gmail.com - ORCID: 0000-0002-4408-765X; aroucha@ufersa.edu.br - ORCID: 000-0003-1530-4114; jfmedeir@ufersa.edu.br - ORCID: 0000-0003-1202-8783; iarajane@hotmail.com - ORCID: 0000-0002-7077-834X; cristiane_uzl@hotmail.com - ORCID: 0000-0003-1588-2125 (Corresponding author)

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ABSTRACT

Main stem pruning and fruit thinning are cultivation practices that can influence the yield and quality of the fruit. This study aimed to evaluate the effects of main stem pruning and fruit thinning on the postharvest conservation of Charentais Banzai melons. In the field, the plants were subjected to main stem pruning and fruit thinning, with harvesting done 74 days after sowing (DAS). The fruits were transported to the laboratory where they were cleaned, characterized, and stored in a cold chamber (5 °C and 90 ± 2% RH). In the field, the experiment was designed as a split-plot using a 2 × 4 + 1 factorial design, with two levels of main stem pruning (pruned and unpruned), four levels of thinning times (42, 45, 48, and 51 DAS), and a control (unpruned and unthinned). The sub-plot consisted of storage times (0, 7, 14, 21, and 28 days), with four blocks. The preharvest treatments did not significantly influence the production characteristics of the Banzai hybrid. The treatment without pruning increased the titratable acidity of fruit, and the thinning at 51 days after sowing (DAS) reduced soluble sugars. There was a decline in pulp firmness, titratable acidity, reducing sugars, and an increase in soluble solids, total soluble sugar, and non-reducing sugars during storage. Pruning the main melon stem reduced the weight loss of the fruit after 28 days of storage.

Palavras-chave:
Cucumis melo L.
relação fonte:dreno
armazenamento

Efeito de poda da haste principal e raleio de fruto na conservação pós-colheita de melão

RESUMO

A poda da haste principal e o raleio de frutos são práticas culturais que podem influenciar a produtividade e a qualidade dos frutos produzidos. Este estudo teve por objetivo avaliar a influência da poda da haste principal e do raleio dos frutos na qualidade e conservação pós-colheita de melão Charentais 'Banzai'. Em campo, as plantas foram submetidas à poda da haste principal e ao raleio dos frutos, com a colheita ocorrendo aos 74 dias após a semeadura (DAS). Os frutos foram levados para o laboratório, onde foram higienizados, caracterizados e armazenados em câmara fria (5 °C e 90 ± 2% UR). Na fase de campo, o experimento foi realizado em parcelas subdivididas utilizando um esquema fatorial 2 × 4 + 1, com dois níveis de poda da haste principal (podada e não podada), quatro níveis de tempo de desbaste (42, 45, 48, e 51 DAS) e um controle (sem poda e sem raleio); enquanto a sub-parcela consistiu de tempos de armazenamento (0, 7, 14, 21, e 28 dias), com quatro blocos. Os tratamentos pré-colheita não influenciaram significativamente as características de produção do híbrido Banzai. O tratamento sem poda elevou a acidez titulável dos frutos e o raleio aos 51 DAS reduziu os sólidos solúveis. Houve redução na firmeza de polpa, acidez titulável e açúcares redutores; e um incremento nos sólidos solúveis, açúcares solúveis totais e açúcares não redutores durante o armazenamento. A poda da haste principal do meloeiro propiciou redução na perda de massa dos frutos aos 28 dias de armazenamento.

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Introduction

Melon is a significant crop in the world economy, generating more than 28 billion dollars annually (FAOSTAT, 2015). In 2015, Brazil exported more than 223,000 MT of melon. Brazilian melons are produced primarily in Northeastern Brazil owing to the climatic conditions of the region (SECEX, 2016).

For melons to achieve the standard of quality required by the international market, the plant must have a strong source-sink relationship (Barzegar et al., 2013); in this respect, pruning has been used in some gardens to increase production and enhance the quality of fruits (Lins et al., 2013). In melons, pruning the main stem promotes a rapid growth of lateral stems. A subsequent increase in the photosynthetic area of the plant allows for the production of larger fruits with a high soluble solids content (Pereira et al., 2017).

On the other hand, fruit thinning is done to reduce competition between fruits (sinks) and/or to fix them in specific positions to ensure they achieve maximum quality (Queiroga et al., 2009). Studies on melon indicate that fruits fixed in the intermediate position on the plant are more efficient sinks (Queiroga et al., 2009; Barzegar et al., 2013).

In the literature, there is evidence that main stem pruning and fruit thinning time influence melon (Long et al., 2004) and watermelon quality (Lins et al., 2013). These results indicate that early pruning/thinning increases fresh fruit weight, but doing so near harvest time raises the soluble solids content.

Given the lack of studies that show the effect of changes in source-sink relationships on the postharvest yield and conservation of melons, this study aimed to assess the influence of pruning and thinning on the production, quality, and postharvest conservation of the Charentais melon.

Material and Methods

The experiment was conducted during the second half of 2012 on the Norfruit farm, located in the community of Pau Branco, municipality of Mossoró, Rio Grande do Norte state (4° 39’ 39.24” S, 37° 23’ 13.309” W and altitude 51 m). The climate in the region, according to the Köppen classification system, is BSwh, i.e., hot and dry with irregular annual rainfall (average of 673.9 mm), an average annual temperature of 27 °C, and average annual relative humidity of 68.9% (Carmo Filho & Oliveira, 1995). During the experimental period, the global mean and photosynthetically active radiation was 22.64 and 14.26 MJ m^{-2} d^{-1}, respectively.

The soil in the area was classified as eutrophic red-yellow Latosolic Argisol (Ultisol) (EMBRAPA, 1999). Fertilizing (broadcast incorporated and fertigation) was done in accordance with the product used by local producers, which contained the following formulation (6-24-12): 360 kg ha^{-1} of Fertilize®, corresponding to 22 kg ha^{-1} of N, 86 kg ha^{-1} of P_2O_5, 43 kg ha^{-1} of K_2O, 22 kg ha^{-1} of Ca, and 22 kg ha^{-1} of SO_4.

The Banzai hybrid of the Charentais melon, produced by Seminis, was used. It has a reticulated epicarp with light green longitudinal sutures and salmon-colored pulp. Seeding was carried out in early September in 128-cell polystyrene trays filled with agricultural substrate; seeds were irrigated daily. Seedlings were transplanted when the second leaf was completely expanded. The spacing used was 2.0 × 0.3 m, with one plant per hole. Each plot consisted of two 8.0 m long lines of plants, totaling 54 plants. The field experiment consisted of 36 plots (nine treatments, each with four repetitions), totaling 1944 plants.

Drip irrigation was used daily, and emitters were placed 0.3 m apart with a flow rate of 2.30 L h^{-1}. Irrigation was applied as a function of the irrigation water need (IN). The IN was calculated daily by estimating crop evapotranspiration (ETc), using the method proposed by FAO 56 (Allen et al., 2006), data from the INMET meteorological station located in Pau Branco, Rio Grande do Norte (RN) state, and Kc values recommended by FAO 56. The duration of each phenological phase was adjusted for the region and the cultivar, applying a leaching fraction of around 15%. The water used for irrigation had an electrical conductivity (EC) of 3.2 dS m^{-1}.

The experiment used a random 2 × 4 + 1 factorial block design, with two levels of the main stem pruning factor (pruned and unpruned), four levels of the fruit thinning factor (42, 45, 48, and 51 days after seeding—DAS), and a control (unpruned and unthinned), with four repetitions. Main stem pruning (decapitation) was done immediately after the agrotextile mat was removed, which occurred 39 DAS. Fruit thinning consisted of removing female flowers and fruitlets in the first three internodes of the plant at four different times.

The melons were harvested at commercial maturity (74 DAS). The analysis of fruit production consisted of counting the number of fruits per plant (obtained from the total number of fruits per plot divided by the number of plants harvested in the plot), average fruit weight (calculated based on the total weight of fruit from the plot divided by the number of fruits from the plants harvested in the plot, with results expressed in kg per fruit), yield (obtained from the ratio between the sum of fruit weights and the number of plants harvested, multiplied by the number of plants in a ha, with results expressed in MT ha^{-1}).

To analyze fruit quality, the harvested fruits were transported to the Laboratory of Food Technology of UFERSA (Federal Rural University of the Semi-arid), where they were divided into five groups, in accordance with the design of the field experiment. The first group was analyzed on harvest day, whereas the other groups were packed in Amcor commercial film and stored in a cold chamber (5 ± 1 °C and 90 ± 2% UR) and analyzed on days 7, 14, 21, and 28.

Both the field and laboratory stages followed a random block design with subdivided plots, where the plot consisted of a 2 × 4 + 1 factorial scheme (field treatments) and the sub-plot of the five storage periods (0, 7, 14, 21, and 28 days).

The following quality analyses were utilized: weight loss (obtained from the difference between final and initial fruit weight, with results expressed as percentages), pulp firmness (obtained using an analog penetrometer, results expressed in Newton), titratable acidity (determined by neutralization titration, with results expressed as percentages), soluble solids (determined with a digital refractometer, with results expressed as percentages), total soluble sugars (calculated using the Antrona method, with results expressed as percentages), reducing sugars (determined by the Somogy-Nelson method, with results expressed as percentages), and non-reducing sugars (obtained by the difference between total soluble and reducing sugars, with results expressed as percentages). The data were submitted to analysis of variance (ANOVA) using SISVAR statistical analysis software (Ferreira, 2014). The means of the pruning and thinning factors were compared using Tukey's test at a 5% probability level. The control was compared to the other treatments by applying Dunnett's test at a 5% probability level. Regression analysis was conducted for the storage factor, with the choice of model based on the biological response, at a significance level of the equation parameters and the value of the coefficient of determination (R^2).

Results and Discussion

The results of ANOVA showed no significant differences between pruning and thinning for the production parameter (Table 1). The average number of fruits per plant, fruit weight, and yield were 1.66, 0.84 kg fruit^{-1}, and 18.63 MT ha^{-1}, respectively (Table 1). The values obtained in this experiment corroborate those observed in the Cantaloupe melon by Queiroga et al. (2009). These authors found an average weight of 0.71–0.98 kg fruit^{-1} and yield of 19.6–31.6 MT ha^{-1}.

On the other hand, the results demonstrated that pruning and thinning had an effect on the physical-chemical characteristics of Charentais melon during the postharvest period.

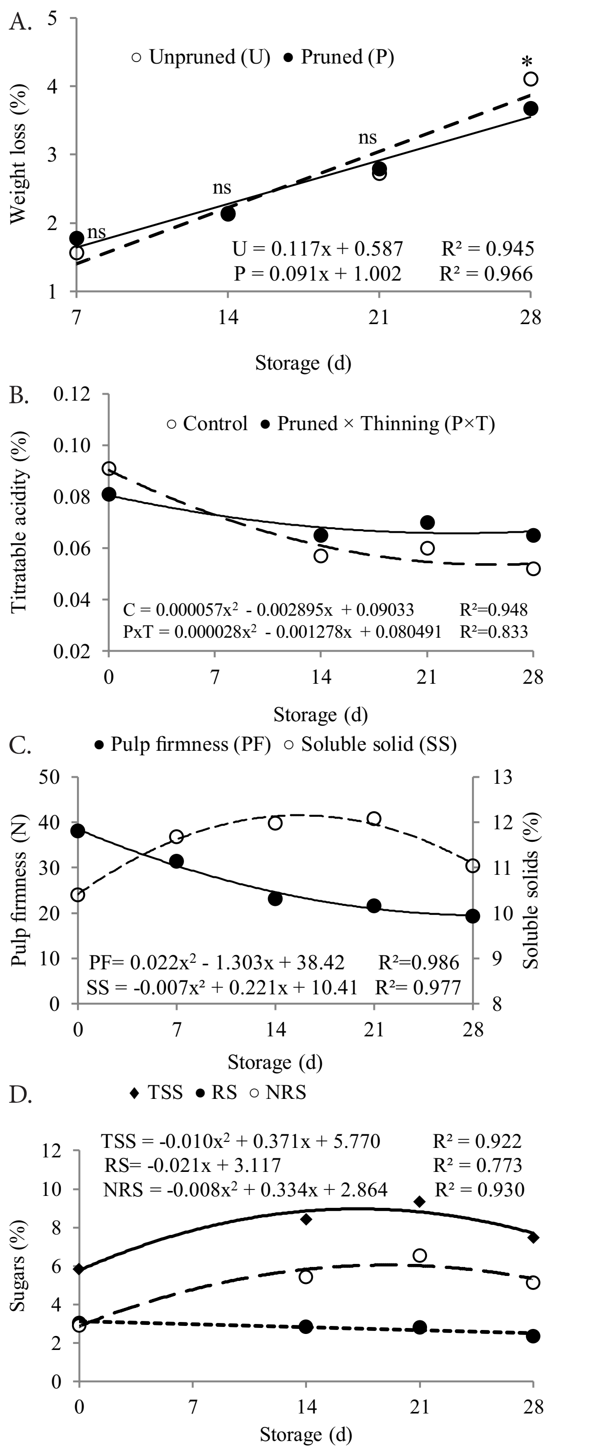
There were significant differences between pruning and storage (Figure 1A) for the parameter weight loss. This result indicates that at the storage period, that characteristic was strongly influenced by the pruning procedure. It was found that at 7 days of storage, the weight loss of fruits resulting from treatments without pruning was statistically equal to that of fruits from pruned plants. Nevertheless, at 21 and 28 days of storage, fruits from pruning treatments had a lower weight loss, respectively of 12.4 and 22%, compared to fruits from unpruned treatments (Figure 1A).

However, weight loss is an important quality parameter for the same storage condition. Treatments presenting less weight loss positively affect the acceptance of the product and provide still more profit because the fruits are marketed by weight (Chitarra & Chitarra, 2005). Weight loss during postharvest storage is primarily caused by transpiration and respiration, which cause water and substrate loss.

A 1.2-fold increase in weight loss was observed from 7 to 28 days for fruits from pruned plants, whereas in unpruned plants, the increase was 1.8-fold (Figure 1A). This means that pruning the main stem has a positive function in the cell membrane and cell wall of the melon. According to Nelgen (1982), pruning can influence the number and size of cells, raise the levels of Ca, K, and Mg in fruits, and increase Ca redistribution from the nucleus to the external parts of the fruit (Perring, 1985).

Table 1. Production characteristics of the Charentais 'Banzai' melon subjected to preharvest main stem pruning and fruit thinning

Production characteristics	Average	CV (%)
Number of fruits per plant	1.66	18.18
Fruit weight (kg)	0.84	19.48
Yield (MT ha^{-1})	18.63	23.17



TSS - Total soluble sugars; RS - Reducing sugars; NRS - Non-reducing sugars; * Statistically significant according to Tukey's test at a 0.05 probability level

Figure 1. Physical and physicochemical characteristics of the Charentais 'Banzai' melon subjected to preharvest main stem pruning and fruit thinning and stored at 5 ± 1 °C and 90 ± 2% RH

A significant effect of pruning on titratable acidity was observed. Fruits produced from pruned plants exhibited lower titratable acidity compared to unpruned plants (Table 2). This difference in organic acid content occurs due to changes in the source-sink relationships induced by this cultivation practice. According to Pereira et al. (2003), pruning the main stem breaks the apical dominance of melon, inducing it to invest in the production of new lateral stems. In pruned plants, some of the assimilates that would form organic acids in fruits were

Table 2. Titratable acidity (%) of Charentais 'Banzai' melon subjected to pruning of the main stem

Treatment	Titratable acidity (%)
Control	0.065 [I]
Unpruned	0.072 a
Pruned	0.070 b
CV (%)	9.12

*Means followed by the same letter do not differ according to Tukey's test ($p < 0.05$); **Minimum significant difference according to Dunnett's test ($p < 0.05$) between the control and the other treatments

possibly redirected to the formation of lateral stems, explaining their lower content relative to fruits from unpruned plants.

On the other hand, the titratable acidity of the control fruits (unpruned and unthinned) was lower than that of the unpruned treatment and did not differ significantly from that obtained with pruning (Table 2). However, this result was not consistent with previous studies on peach (Kumar et al., 2010) and mango (Asrey et al., 2013), which demonstrated that the fruits produced by pruned plants presented a higher organic acid content than those from unpruned plants.

During the 28-day storage period, titratable acidity decreased in the control fruits (40%) and in those produced by pruned and thinned plants (16.3%) (Figure 1B). These results suggest that the fruits of pruned and thinned plants have a slower metabolism than the controls. Additionally, in yellow melon, there was decrease in titratable acidity during 70 days of refrigerated storage (Tomaz et al., 2009). This decline occurs owing to the use of organic acids as carbon skeleton in fruit respiration (Chitarra & Chitarra, 2005).

There was a significant effect of thinning on the soluble solids of fruits (Table 2). The fruits of plants thinned 42 DAS exhibited a higher soluble solids content than fruits from plants thinned 51 DAS. However, fruits from thinned plants showed no statistical difference in soluble solids compared to control fruits (Table 2).

It is known that fixing fruits in higher positions on the plant delays fruiting (Queiroga et al., 2009; Bhering et al., 2013). Thus, the later this crop management is carried out, the greater is the delay in fruiting. For this reason, on harvest day (74 DAS), fruits from plants thinned at 51 DAS had been attached to the plant for fewer days; these fruits consequently received fewer assimilates compared to fruits produced by plants thinned at 42 DAS. Nevertheless, the soluble solids content was 10.9%, which is above the minimum (9.0%) required for export.

During storage, there was an increase of 14.9% in soluble solids content up to 21 DAS, with a subsequent decline of 7.1% until 28 days, when the value was 11.1% (Figure 1C). Melon did not accumulate a significant amount of starch. Nevertheless, at the onset of its development in the Cantaloupe melon, there was an accumulation of 3 mg g^{-1}, which is degraded during ripening to soluble sugar (Menon & Rao, 2012). It is also known that pectin and other monosaccharides in the cell wall, such as xylose, glucose, rhamnose, and mannose, are solubilized during melon ripening (Supapvanich & Tucker, 2013). This sugar solubilization contributes to the increased soluble solids content of fruits.

Table 3. Soluble solid (%) of Charentais 'Banzai' melon subjected to fruit thinning

Treatment	Soluble solids (%)
Control (unthinned)	11.2 [II]
Thinned at 42 DAS	11.9 a
Thinned at 45 DAS	11.5 ab
Thinned at 48 DAS	11.4 ab
Thinned at 51 DAS	10.9 b
CV (%)	15.24

*Means followed by the same letter do not differ according to Tukey's test ($p > 0.05$); **Minimum significant difference according to Dunnett's test ($p < 0.05$) between the control and the other treatments

A reduction in the soluble solids content is commonly observed in fruits during storage (Souza et al., 2008), because soluble sugars - the primary components of soluble solids - are used as a substrate in aerobic respiration (Chitarra & Chitarra, 2005).

Melon pulp firmness was not influenced by preharvest management (main stem pruning and fruit thinning). However, there was a 50.1% decline in pulp firmness from harvest day (38.42 N) to 28 days (19.18 N) of storage (Figure 1B). The reduced fruit firmness reported in several studies (Souza et al., 2008; Aroucha et al., 2012) is due to a break in pectin chains, which provide plant tissues with cohesion. This leads to pectin solubilization, culminating in an increase in tissue softness (Chitarra & Chitarra, 2005). A longer shelf life is established by high pulp firmness, an important quality parameter during fruit handling.

The sugar content of the fruits was not significantly influenced by preharvest treatments. At harvest time, the reducing sugar content (composed of glucose and fructose) is nearly equal to that of non-reducing sugars (composed primarily of sucrose), with values of approximately 3%. During storage, there was an increase in total soluble sugars (Figure 1D), corroborating the results obtained for soluble solids content (Figure 1B). While non-reducing sugars increased by 3.8% during the 28 days of storage, reducing sugars decreased by 0.53% in the same period (Figure 1D). Tomaz et al. (2009) assessed the quality of yellow melon during refrigerated storage, observing that the total soluble sugar content increased only slightly with storage time.

Conclusions

1. Main stem pruning and fruit thinning did not influence the production characteristics (number of fruits per plant, average fruit weight, and yield), but it did influence some physical-chemical parameters during storage.

2. Pruning caused a reduction in weight loss after 28 days of storage, as well as a decrease in organic acid content compared to melons from unpruned plants.

3. Early fruit thinning (42 DAS) led to a rise in the soluble solids content compared to thinning at 51 DAS.

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