

# Original Research Article

## Effects of fruit thinning and main stem pruning in melon crops

### ABSTRACT

**Objective:** This study aimed to assess the productivity and quality of a melon crop treated with fruit thinning and main stem pruning under field conditions.

**Experimental design:** The treatments comprised the amount of fruit thinning in the plant (one, two and without thinning) and the period of main stem pruning (35, 40, 45 and 50 days after transplanting - DAT). The crop was set up in a randomized block design factorial of type 3x4, with five replications.

**Location and Duration of the Study:** The experiment carried out at the Center for Agrifood Science and Technology (CCTA) of the Federal University of Campina Grande (UFCG), Campus Pombal - PB, Brazil, from December 2016 to February 2017.

**Methodology:** The Hopey King hybrid of the Cantaloupe group was cultivated at a spacing of 2.0 x 0.4 m.

**Results:** The plants without thinning of fruits provided lower values of leaf area and fruits of lower mass. However, due to their higher quantity per hectare, the crop total productivity was high. On the other hand, plants with fewer fruits had the highest values of soluble solids, total and non-reducing soluble sugars. The leaf area, fruit mass, total productivity, and the concentration of reducing and non-reducing soluble sugars were higher when the plants were pruned at 35 DAT.

**Conclusion:** The fruit thinning and main stem pruning affected the production and quality of melon fruits significantly. For more demanding markets, we recommend to treat the plants with one or two fruits and prune at 35 days after transplantation, aiming to enhance the quality variables.

**Keywords:** *Cucumis melo* L.; Competition; Physiology. Yield.

### 1. INTRODUCTION

The vegetables contain carbohydrates, proteins, and an excellent supply of vitamins and minerals, which makes them essential nutritional sources in the human diet [1].

In the Northeast of Brazil, the cultivation of Cucurbitaceae has been outstanding due to the high productivity and quality of fruits, which is provided by the edaphoclimatic conditions of the region [2]. In this context, the state of Paraíba presents conditions favorable to the cultivation of these vegetables, such as high temperature and lightness, and low rainfall and relative humidity. However, the production of the fruits is still unexpressive due to problems in the management of the plants.

The study of carbon assimilation dynamics is essential to improve crop performance, which is functionally controlled by a source-sink relationship [3]. The sources are the tissues where the net CO<sub>2</sub> assimilation takes place, whereas the sinks are tissues where the photoassimilates are destined for growth or storage [4].

28 The use of new cultivation practices requires the knowledge of the crops and  
29 choose of the most appropriate management for production. Besides, the production  
30 and quality of fruits harvested can be influenced by the relationship between the  
31 source and the drain by controlling the number of fruits and stems in the plant [5].

32 Studies on carbohydrate economics are relevant for agricultural production due to  
33 its potential for modification in carbon allocation in the plant, which reflects on the  
34 increase or decrease in commercial fruit production. These changes are directly  
35 influenced by cultural practices, affecting translocation and carbon allocation fixed  
36 during the photosynthetic process [6]. Therefore, a balanced source-sink  
37 relationship allows carbon allocation to be primarily directed to the fruit, favoring its  
38 growth [7].

39 In melons, fruit thinning can improve the distribution of photoassimilates in the plant,  
40 allowing the production of larger or smaller fruits, depending on the demand of  
41 consumers [8]. Therefore, crop management through the thinning of flowers or fruits  
42 may result in increased fruit production and size, as well as, raise the quality of  
43 these fruits.

44 In a study evaluating the effect of the period of fruit thinning on the post-harvest  
45 quality of melon, in the municipality of Mossoró-RN, the fruits had the greatest  
46 length (134 mm) and pulp firmness (40 N) when the thinning was performed at six  
47 days after the removal of the row cover. Also, the soluble solids, soluble  
48 solids/acidity ratio, and pH decreased as thinning was retarded [9].

49 On the other hand, pruning of the main stem promotes rapid growth of lateral  
50 branches and subsequent increase in the photosynthetic area of the plant, which  
51 allows the production of larger fruits with high soluble solids content [10].

52 In pumpkin crop without pruning, and with pruning in the sixth, eighth and tenth  
53 node of the main stem, it was verified that there was a significant difference only for  
54 the number of secondary branches per plant and mass of thousand seeds. Thus,  
55 apical pruning does not influence fruit and pumpkin seed production nor the  
56 physiological quality of seeds [11].

57 With the fruit thinning and the pruning of the main stem, one expects to stimulate the  
58 emission of more lateral shoots, with larger leaf area per fruit and higher contribution  
59 of photoassimilates used in growth and sweetening of fruits in the harvest period.

60 Thus, this work aimed to evaluate the productivity and quality of melon fruits as a  
61 function of fruit thinning and pruning of the main stem under field conditions in the  
62 semiarid region of Paraíba.

Comment [J1]: Research?

## 63 2. MATERIAL AND METHODS

64 The experiment was carried out at the Center for Agrifood Sciences and  
65 Technology, Campus Pombal - PB, from December 2015 to February 2016. The soil  
66 of the experimental area was classified as Fluvisol.

Comment [J2]: Add coordinates and climate information of the study region

67 The experimental crop was cultivated in a randomized block design with a 3 x 4  
68 factorial scheme in five replications. The first factor comprised the number of fruits  
69 set per plant (one fruit, two fruits, and plants without fruit thinning) and the second  
70 factor consisted of different periods of main stem pruning (35, 40, 45, and 50 days  
71 after transplanting - DAT).  
72  
73

74 In the preparation of the soil, we perform plowing, harrowing, and turning over the  
75 upper layer of the land. Fertilization with N and K was done as follows: 10% of both

76 nutrients were applied in planting, and the remaining (90%) in cover, via fertigation.  
77 The P fertilization with  $P_2O_5$  at the rate of  $40 \text{ kg ha}^{-1}$  was 100% applied fifteen days  
78 before planting.

79 The sowing occurred in polystyrene trays of 128 cells filled with a commercial  
80 agricultural substrate on December 9, 2015. Thirteen days after planting, we  
81 transplanted the seedlings, when the second leaf was expanded entirely on  
82 December 22, 2015. The Hopey King melon hybrid of the Cantaloupe group have a  
83 yellow to greenish netted peel and a salmon-colored pulp, their aroma is intense,  
84 and the average cycle is 65 to 70 days. The spacing for cultivation was  $2.0 \times 0.4 \text{ m}$ .

85 After transplanting, the plants were covered with a white polypropylene row cover,  
86  $1.38 \text{ m}$  wide and  $15 \text{ g cm}^{-2}$  in weight. After twenty-five days after transplanting, the  
87 row cover was removed and performed the manual removal of weeds.

88 In the top side dressing fertilization, we used an amount of  $126 \text{ kg ha}^{-1}$  of N and  $135$   
89  $\text{kg ha}^{-1}$  of  $K_2O$ , which were applied in seven subsequent weeks after transplanting.  
90 In each week, the following percentages of each nutrient were applied: 1st week =  
91 5.0% N and 7.0%  $K_2O$ ; 2nd week = 8.0% N and 8.0%  $K_2O$ ; 3rd week = 10.0% N  
92 and 15.0%  $K_2O$ ; 4th week 15.0% N and 18.0%  $K_2O$ ; 5th week 20.0% N and 18.0%  
93  $K_2O$ ; 6th week = 20.0% N and 18.0%  $K_2O$ ; 7th week = 12.0% N and 6.0%  $K_2O$ .

94 Drip irrigation was performed daily, using  $0.4 \text{ m}$  spaced drippers with a flow rate of  
95  $2.7 \text{ L h}^{-1}$ .

96 Two applications with registered crop protection products were carried out, one at  
97 the time of the row cover removal and the other 15 days after the first application, on  
98 January 29, 2016.

99 The harvest was carried out on February 23-28, 2016. The fruits were harvested  
100 when the peduncle was cracked and peel with a uniform netting, which are reliable  
101 indications for harvest moment of this cultivar. The crop cycle lasted 82 days, from  
102 sowing until the end of harvest.

103 One week before the fruit harvest, the leaf area of plants ( $\text{cm}^2 \text{ plant}^{-1}$ ) was estimated  
104 using leave samples with more than  $3.0 \text{ cm}$  in length. The measurement was  
105 performed with the aid of a Li-3000 apparatus.

106 During the harvest, the following variables were evaluated: number of fruits per  
107 plant, counted only in the treatment without fruit thinning; average fruit mass ( $\text{g fruit}^{-1}$ ),  
108 calculated by the ratio of total fruit weight to number of plants in the useful area;  
109 the total productivity ( $\text{mg ha}^{-1}$ ), estimated at  $1.0 \text{ ha}$  at the experimental level. Twenty  
110 fruits per treatment were analyzed for soluble solids (%) and titratable acidity (%  
111 citric acid) according to the methodology of the Adolfo Lutz Institute [12].  
112 Subsequently, the total soluble sugars were evaluated by the reaction with Antrona  
113 according to Yemn and Willis [13], the reducing sugars by DNS method [14], and  
114 non-reducing sugars by the difference between total and reducing sugars.

115 The significance of the effect of fruit thinning and main stem pruning on the  
116 response variables was investigated using an analysis of variance at the SAEG 9.0  
117 software. As post-hoc tests, we used the Tukey test at 5% probability for fruit  
118 thinning, and regression analyses for the pruning period of the main stem at the  
119 Table Curve 2D software.

120

**Comment [J3]:** Inform the normality pre-test of the variables used to define the ANOVA as a comparison test

### 3. RESULTS AND DISCUSSION

Fruit thinning had a significant effect on leaf area, fruit mass, and yield of melon ( $P < 0.05$ ). The period of main stem pruning affected only the fruit mass ( $P < 0.05$ ). There was no significant effect of the interaction between the fruit thinning and the pruning season of the main stem on the leaf area and the production characteristics of the melon.

Plants with one and two fruits, because of the control exerted by the treatment, kept the number of fruits constant. However, plants without fruit thinning produced an average of 3.5 fruits per plant (data not shown).

The leaf area of the melon is an important measure to estimate the photosynthetic potential and, consequently, the final production and quality of the fruits at harvest [15]. Regarding fruit thinning, plants with only one fruit had higher values of leaf area than plants without fruit thinning (Table 1). According to Shi et al. [7], the allocation of carbon in the vegetative part of plants is favored by the reduction of sinks (fruits), which increase leaf production, raising the leaf area.

Regarding the mass of the fruits, the highest values occurred in plants submitted to thinning, leaving one and two fruits, which provided a greater mass compared to plants without fruit thinning. However, these conditions resulted in lower productivity due to the smaller number of fruits per hectare (Table 1).

**Table 1** - Average values of leaf area (LA), fruit mass (FM), and total productivity (TP) of melon fruits as a function of the number of fruits in the plant. CCTA/UFCG. Pombal - PB, 2016.

Number of fruits	LA (cm <sup>2</sup> plant <sup>-1</sup> )	FM (g fruit <sup>-1</sup> )	TP (t ha <sup>-1</sup> )
Plants with one fruit	47820.3 a	2578.68 a	25.78 c
Plants with two fruits	40480.3 ab	2430.59 a	48.61 b
Plants without fruit thinning	37006.2 b	2081.53 b	72.26 a
CV (%)	26.73	11.32	21.56

\*Averages in the same column and followed by the same letters did not differ significantly according to the Tukey Test at 5% of probability level.

The number of fruits in the plant directly influences the fruit mass, because the sinks also compete with each other for photoassimilates, which leads to the development of fruits with lower mass [15]. Thus, the largest leaf area available per fruit, when only one fruit set per plant, provide more assimilates from the source (leaf) to the sink (fruit), contributing to the increase of fruit mass.

Pathirana et al. [16], studying the tomato crop to determine the appropriate management of shoot and fruit thinning, verified that fruit thinning between 2 and 5 fruits per bunch per plant increased the fruit masses. Thus, the higher the number, the lower the mass of fruits, demonstrating that the plant has production capacity limited by the source. These results also corroborate the findings of Valantin-Morinson et al. [17] in melon, which verified that the competition by assimilates affects the final size of the fruit.

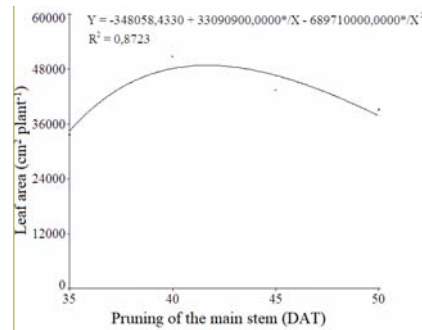
Plants cultivated without fruit thinning showed higher total productivity (Table 1). In these plants, the fruits had lower mass but, due to the higher number of fruits per

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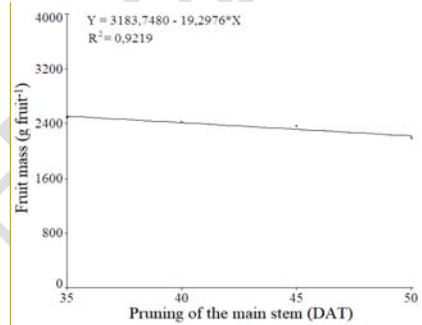
162 plant and area, there was a compensation of the loss of its mass concerning the  
163 plants with one and two fruits.

164 In melon, the number of fruits per plant and the mass of the fruits are determinant  
165 characteristics in crop productivity. These factors may change due to the partitioning  
166 of assimilates in the plant. Thus, the high number of fruits per hectare contributed  
167 significantly to increase productivity in plants without thinning. According to Dalastra  
168 et al. [8], in the cultivation of melon with different cultivars ('Amarelo', 'Rendilhado,  
169 and 'Pele de Sapó') and number of fruits per plant (one and two), the system with  
170 two fruits per plant is the most productive and shows high quality for  
171 commercialization regardless cultivars.

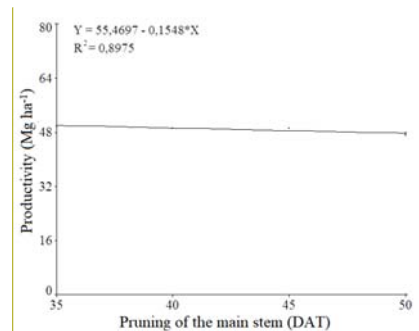
172 As for the period of main stem pruning, we found a quadratic response of the leaf  
173 area over time and a linear response decreasing of the fruit mass and total  
174 productivity of crop (Figure 1).



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Comment [J7]: Idem

175 **Figure 1** - Response functions adjusted for leaf area, fruit mass, and total productivity of  
 176 melon fruits as a function of pruning period of the main stem. CCTA/UFCG, Pombal - PB,  
 177 2016.

178

179 During the pruning of the main stem at 35 DAT, the plant leaf area value was  
 180 estimated in 34,335.5 cm<sup>2</sup> plant<sup>-1</sup>. After this period the leaf area increased, reaching  
 181 its maximum value of 48,848.86 cm<sup>2</sup> plant<sup>-1</sup> at 41.6 DAT (an increase of 42.2%).  
 182 With the pruning at 50 DAT, the leaf area decreased to 37,875.6 cm<sup>2</sup> plant<sup>-1</sup> (-  
 183 22.5%) was observed (Figure 1).

184 When pruning of the main stem is carried out earlier, at 35 DAT, occurs the  
 185 emission of a higher number of secondary and tertiary lateral branches, which  
 186 contributed to increase the leaf area until approximately 41.6 DAT, when the plant  
 187 was already in full fruiting phase. Thus, as the fruit is the preferential sink after  
 188 anthesis, from 41.6 DAT, the plant invests photoassimilates from the photosynthesis  
 189 process preferably in fruit growth to the detriment of vegetative growth, so the leaf  
 190 area values decreased when the plants were pruned later, that is, at 50 DAT.

191 Campagnolo et al. [18] verified that plants with only one stem have lower leaf area  
 192 than plants with two stems (3485.5 cm<sup>2</sup> plant<sup>-1</sup> and 4263.7 cm<sup>2</sup> plant<sup>-1</sup>, respectively),  
 193 suggesting that the more branches, the larger the leaf and the higher the leaf area  
 194 of the plant.

195 The fruit mass of the melon had maximum and minimum values of 2508.3 and  
 196 2218.9 g fruit<sup>-1</sup> with the pruning of main stem at 35 and 50 DAT, respectively (Figure  
 197 1). In this sense, the delay of main stem pruning until 50 DAT reduces at 11.5% in  
 198 the mass of fruits.

199 Therefore, when pruning of main stem of melon is performed up to 41.6 DAT, the  
 200 plant increases the leaf area, contributing to the production and subsequent  
 201 translocation of photoassimilates to the fruits. Besides, plants with no fruit thinning  
 202 had a lower number of fruits (data not shown) when pruning was performed at 35  
 203 DAT, proving that the presence of fewer fruits per plant provides an increase in the  
 204 average mass of these fruits.

205 Similar results were found in the watermelon cultivation, in which a reduction of fruit  
 206 mass was observed with pruning delay from 25 to 40 DAT [2]. The pruning  
 207 performed earlier, at 25 DAT, probably favored the investment in lateral branches  
 208 due to the loss of apical dominance and, consequently, the formation of a larger leaf  
 209 area per fruit set. With this, there was an increase in transport of photoassimilates  
 210 for the growth of fruits in detriment of their higher set.

211 When pruning of main stem was performed at 35 and 50 DAT, we estimated  
 212 maximum and minimum values in total melon productivity of 50.05 and 47.72 mg ha<sup>-1</sup>,  
 213 respectively. Thus, with the pruning delay, there was a 4.7% reduction in crop  
 214 yield (Figure 1). This higher total productivity of the melon found in plants pruned at  
 215 35 DAT is a result of the higher mass of fruits regardless of the number of fruits per  
 216 plant.

217 Freitas et al. [11] suggested that apical pruning in pumpkins could stimulate the  
 218 emission of lateral shoots, leading to the development of more flowers and fruits  
 219 and, consequently, increase the production per plant. However, these same  
 220 authors, in their experiments, concluded that apical pruning did not influence fruit  
 221 production in the pumpkins.

222 Regarding the quality of melon fruit, there was no interaction between fruit thinning  
 223 and the period main stem pruning ( $P_p > 0.05$ ) (Table 2). These results were similar  
 224 to those obtained by Ferreira et al. [9]. However, when analyzed individually, fruit  
 225 thinning affected soluble solids, non-reducing sugars, and total soluble sugars,  
 226 whereas main stem pruning influenced only soluble solids ( $P \leq 0.05$ ). The factors  
 227 studied did not affect total acidity and reducing sugars ( $P_p > 0.05$ ).

Comment [J8]: Add the value of test

Comment [J9]: idem

228 **Table 2** - Mean values of soluble solids (SS), total acidity (TA), reducing sugars (RS), non-  
 229 reducing sugars (NRS) and total soluble sugars (TSS) of melon fruits as a function of the  
 230 number of fruits in the plant. CCTA/UFCG. Pombal - PB, 2016.

Number of fruits	SS (°Brix)	TA (% citric acid)	SR (%)	NRS (%)	TSS (%)
Plants with one fruit	9.00 a	0.169 a	2.02 a	5.56 a	7.58 a
Plants with two fruits	8.85 a	0.179 a	2.22 a	4.97 a	7.19 a
Plants without fruit thinning	8.13 b	0.183 a	2.34 a	4.21 b	6.55 b
CV (%)	15.51	13.53	21.40	16.75	16.99

231 \*Averages in the same column and followed by the same letters did not differ significantly  
 232 according to the Tukey Test at 5% of probability level.

233

234 The plant cultivated with one and two fruits increased the values of soluble solids,  
 235 non-reducing sugars, and total soluble sugars compared to melons without thinning.  
 236 This result was favored by the larger leaf area per fruit that increased the production  
 237 and transport of photoassimilates, initially for the fruit growth and, after the  
 238 beginning of the maturation phase, for the accumulation of sugars in the fruit pulp.

239 Barzegar et al. [19] observed that the removal of some melon fruits induces the  
 240 plant to direct photoassimilates to the fruits setting or to the vegetative growth, being  
 241 more efficient when the thinning is carried out in the early stages of development.

242 The melon requires an increase in the availability of carbohydrates near the harvest,  
 243 after the fruit has gone through the phases of cell division and expansion, resulting  
 244 in the increment of stored sugars. Valantin-Morinson et al. [17] found that the  
 245 competition for assimilates caused by sinks (fruits) reduces the content of soluble  
 246 solids in melon, which are directly related to the sugar content, being a good  
 247 indicator of the sweetness due to the amount of sucrose.

248 The main sugars present in melons are glucose and fructose (reducers) and  
 249 sucrose (non-reducing). Reducing sugars comprise almost 100% of the total sugar  
 250 content in the initial stage of fruit development. However, sucrose can reach up to



251 50% of total sugars in the final stage of maturation and approximately 25% of  
252 glucose and 25% of fructose [20].

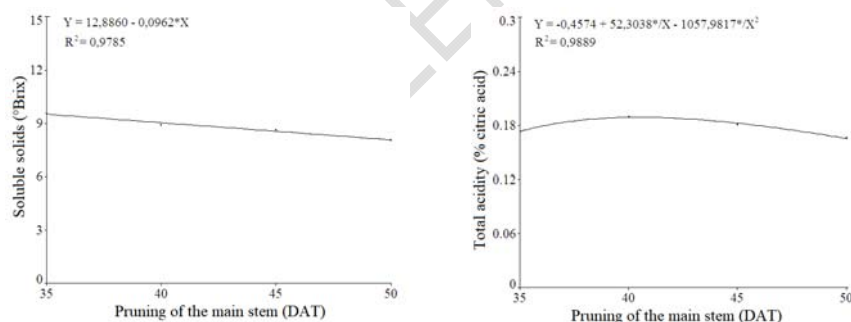
253 Although there was no significant effect on total acidity, there was a tendency of  
254 increase of acidity values with the increase in number of fruits per plant. This  
255 increase in fruit pulp acidity may be related to the higher concentration of non-  
256 reducing sugars (sucrose) in plants cultivated with only one fruit that had a higher  
257 proportion of sugars compared to organic acids.

258 The number of fruits per plant potentially affect the quality of melons since it can  
259 change the leaf area per fruit ratio and modify the relation between the source and  
260 sink and the assimilated partition in the plant. Queiroga et al. [15], working with  
261 melon 'Rendilhado' verified that the number of fruits in the plant did not interfere in  
262 the total acidity, which corroborates with our results.

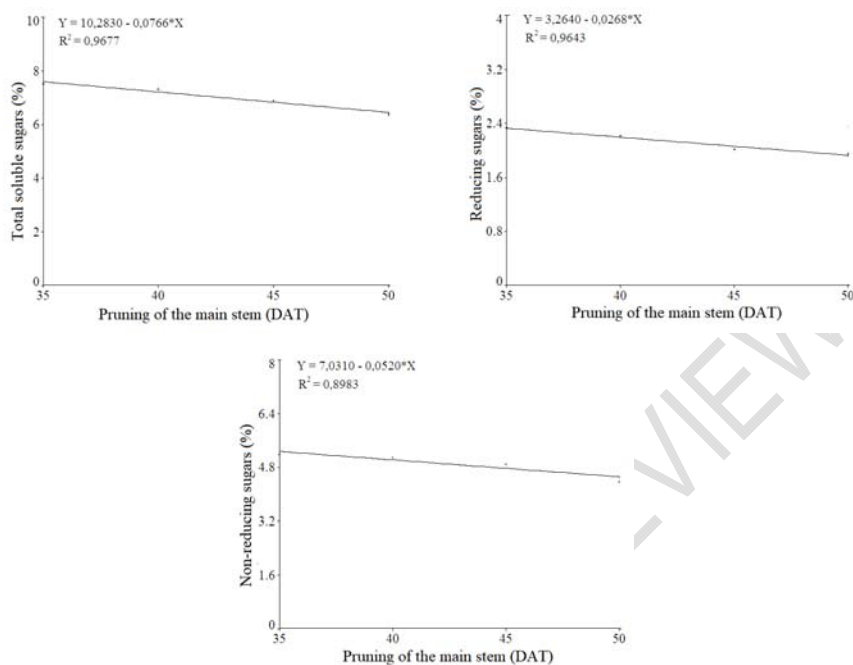
263 The soluble solids contents varied from 9.0 to 8.1 in plants with one fruit and plants  
264 without thinning, respectively (Table 2). The low values of soluble solids found in  
265 this research can be related to two factors: the incidence of melonworm moth that  
266 defoliated the plants and leaf senescence that is common in the final phase of the  
267 cycle, both of which led to a reduction in leaf area. In this sense, the decline of leaf  
268 area of the plant one week before the harvest may have affected the accumulation  
269 of sugars in the fruit due to the low production and transport of photoassimilates in  
270 the stage of maturation and sweetening.

271 The total acidity varied in a quadratic way as a function of the period of main stem  
272 pruning, with a maximum value of 0.18% of citric acid reached at 40.4 DAT. From  
273 this period, a minimum value of 0.16% was recorded, that is, occurred a decrease of  
274 11.1% with the delay of pruning for 50 DAT (Figure 2).

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275 **Figure 2** - Response functions adjusted for soluble solids, total acidity, total soluble  
 276 sugars, reducing and non-reducing sugars in melon fruits as a function of pruning  
 277 period of the main stem. CCTA/UFCG, Pombal - PB, 2016.

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278  
 279 On the other hand, the soluble solids showed a linear decrease with the delay of the  
 280 pruning period from 35 to 50 DAT, decreasing from 9.5 to 8.0°Brix, which led to a  
 281 15.8% reduction in soluble solids content (Figure 2).

282 Higher value of soluble solids observed when pruning of the main stem at 35  
 283 compared to 50 DAT was probably influenced by the highest leaf area recorded  
 284 when pruning was done earlier.

285 A study evaluating the influence of main stem pruning and the period of fruit thinning  
 286 on post-harvest quality of melon 'Amaregal' and 'Banzai' showed that the titratable  
 287 acidity (0.077%) were low while soluble solids were high in treatments with early  
 288 pruning [9].

289 Total soluble sugars, reducing sugars, and non-reducing sugars had similar  
 290 behaviors, presenting linear decreasing responses with estimated values of 7.6%,  
 291 2.3%, and 5.2%, and minimum values of 6.4%, 1.9%, and 4.5% at 35 and 50 DAT,  
 292 respectively (Figure 2). These decreases corresponded to a reduction of 15.8% in  
 293 total soluble sugars, 17.4% in reducing sugars and 15.6% in non-reducing sugars  
 294 with delay up to 50 DAT of the pruning.

295 It is possible that the higher concentration of sugars in the fruits of the plants pruned  
 296 earlier occurred due to these fruits grew under suitable conditions, that is, when the

297 plants had no signs of foliar senescence and no attacks of pests and diseases that  
298 arise at the end of the cycle.

299 In this way, under favorable conditions of growth at 35 DAT, the melon fruit  
300 accumulates monosaccharides in the cell wall, such as xylose, glucose, rhamnose,  
301 and mannose, which are solubilized during fruit ripening, which contributes to the  
302 increase of the content of sugars in fruits [21].

303 Besides, the early break of apical dominance increases the number of secondary  
304 and tertiary branches, raising the available leaf area with the successful production  
305 and translocation of photoassimilates in the final phase of fruit maturation. On the  
306 other hand, in plants pruned later, the photoassimilates that would be destined to  
307 fruits (preferential sinks) were redirected to new branches (source), reducing the  
308 accumulation of sugars in the fruit pulp [9].

309 A study evaluating the influence of main stem pruning and fruit thinning on quality  
310 and post-harvest conservation of Charentais 'Banzai' melon showed that the  
311 treatment without pruning increased the titratable acidity of the fruits, while the  
312 thinning at 51 days after sowing reduced soluble solids, pulp firmness, titratable  
313 acidity, and reducing sugars [22].

314

#### 315 4. CONCLUSION

316

317 Melons submitted to fruit thinning produced fruits with high values of soluble solids,  
318 total soluble sugars, and non-reducing sugars. On the other hand, the cultivation  
319 without the thinning resulted in small leaf areas and fruits of low mass, however, due  
320 to their high number per hectare, there was an increase in total productivity. Plants  
321 pruned at 35 DAT had high values of leaf area, fruit mass, total productivity, total  
322 soluble sugars, reducing and non-reducing sugars.

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#### 325 COMPETING INTERESTS

326

327 The authors state that there are no competing interests.

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Comment [J12]: Update references. Less than  
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