Effect of planting date on postharvest quality of roots of different carrot cultivars grown in the Brazilian semiarid region

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ABSTRACT

In regions with high temperatures, carrot cultivation is difficult because high temperatures tend to reduce the size and pigmentation of the root and, consequently, the yield and quality of the product. However, with the advent of summer cultivars, the cultivation of quality carrots under high temperatures has been viable. The aim of this work was to evaluate the postharvest quality of ten carrot cultivars as a function of different planting dates. The experiments were carried out on the Rafael Fernandes Experimental Farm of the Universidade Federal Rural do Semi-Árido (UFERSA). Four experiments were carried out in May, June, July and August 2017. The experimental design was a randomized block with ten treatments and four replications. The following was evaluated: white halo percentage, soluble solids content, total soluble sugars, total titratable acidity, soluble solids/titratable acidity ratio and beta-carotene content. The interaction between the carrot cultivars and planting date had a significant influence on the postharvest quality of carrot roots. The hybrid cultivars had an overall better post-harvest quality. The carrots sown in July had better quality traits; however, they were more affected by the "white halo" disorder.

Keywords: *Daucus carota* L.; adaptability; consumer preference; limiting environment.

INTRODUCTION

Modern agriculture has increasingly sought to maximize available resources, aimed not only at increasing productivity, as in the past, but also at seeking higher quality food. Nowadays, due to the greater degree of knowledge about the quality of products, consumers are giving preference to fresh produce that is smaller in size and has greater nutritional value (Hoppu *et al*., 2020).

The chemical composition of carrot roots is variable and influenced by genetic factors and cultivation conditions, such as crop system, soil type and physical properties, planting time, rainfall, and temperature during the growing season (Seljåsen *et al*., 2013), as well as phytosanitary aspects, fertilization, and planting density.

Among the climatic and management factors that affect carrot quality, precipitation and irrigation are very important (Soltoft, 2010). Stress from high or low water availability in the soil can induce the production of undesirable compounds (Reid & Gillespie, 2017). Other important factors are temperature and light conditions. Warm and humid climates seem to affect quality by inducing a turpentine-flavored, less sweet-tasting carrot compared to carrots grown in cooler and drier climates. It is known that low cultivation temperatures (9 - 21 ºC) affect the sensory aspect by increasing the sweet taste (+35%) and content of fructose (+49%) and glucose (+28%) and reducing the bitter taste ("30%) and content of sucrose ("33%) and â-carotene ("40%) (Seljåsen *et al*., 2013).

Therefore, understanding the environmental conditions in different regions and climates where a crop is grown is crucial when choosing a cultivar.

In order to overcome the limitations imposed by high temperatures, Brazilian researchers have developed cultivars that perform well in the temperature range of 18 to 25 ºC. The new varieties, in addition to good climate adaptability, have resistance to diseases caused by fungi

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and nematodes. This makes it possible to cultivate carrots in regions and states where the temperatures are higher, such as Bahia and Goiás (Silva *et al*., 2011).

The use of summer cultivars and seeds from primary umbels has been the main strategy to enable carrot cultivation in regions where this vegetable was not cultivated in the past (Resende *et al*., 2016).

Although the summer cultivar Brasilia is still one of the most widely used in warm regions during summer, in recent years the planted area using imported hybrid cultivars has also increased and research using these new materials, mainly in high temperature conditions, is still incipient. Among the advantages of hybrid cultivars over open-pollinated cultivars are the higher degree of hybrid heterosis and vigor, as well as greater uniformity of internal root color and low presence of white halo.

However, in some states, even with the advent of summer and hybrid cultivars, carrot production is insufficient to meet the domestic demand. In the state of Rio Grande do Norte, where virtually all commercialized carrots come from Bahia, the price of this product in local markets is usually well above the average of the Brazilian market (Bezerra Neto *et al*., 2014).

Additional research is needed due to the difficulties of carrot production in warm and lower elevation regions, starting with the selection of cultivars with genetic potential for quality root production under high temperatures.

Thus, it is assumed that the planting date influences the postharvest quality of carrot roots due to climatic and environmental variations, such as precipitation, temperature, and cloudiness.

In order to provide more information about the behavior of new carrot cultivars under limiting environmental conditions, the objective of this study was to evaluate the effects of planting dateson the root quality of ten carrot cultivars under semiarid conditions, in Mossoró, Rio Grande do Norte.

MATERIAL AND METHODS

Location and characterization of the area

The experiments were carried out on the Rafael Fernandes Experimental Farm, 20 km from Mossoró, RN (Latitude 5º03’37"S; Longitude 37º23’50" W; average elevation 72m), in a sandy loam, Argissolic Red Latosol (Embrapa, 2016). Four experiments were conducted, with planting in May (Season 1), June (Season 2), July (Season 3) and August (Season 4) 2017.

The climate of the region according to the Köppen classification is BSwh’, dry and very hot, with two seasons: a dry season, which is usually from June to January; and a rainy season, between February and May (Carmo Filho *et al*., 1991). Table 1 shows the monthly averages for temperature, relative humidity, precipitation and solar radiation during the experiments.

For the chemical characterization of the soil, soil samples were collected from 0 to 20 cm deep. Results are presented in Table 2. Since the experiments were carried out in adjacent areas, only a composite sample was taken from the experimental area for analysis.

Treatments and experimental design

The experimental design was a completely randomized block with 10 treatments and four replications. The treatments consisted of the Brasilia (TopSeed®), BRS Planalto (ISLA®), Supreme (ISLA®), Nativa (Sakata®), Kuronan (ISLA®), Mariana (Feltrin®), Melinda (Feltrin®), Amanda, (Agristar®), Francine (Agristar®) and Erica (Agristar®) cultivars, cultivated in May, June, July and August. Each experimental plot consisted of a 3.0 x 1.0 m seedbed with six rows of plants spaced 0.15 x 0.06 cm apart. The four central rows were considered the harvestable area and one plant at each end was neglected.

Implementing and conducting the experiment

The tillage consisted of plowing, harrowing and raising the beds to a height of approximately 0.20 m. Planting fertilization was performed based on a soil analysis and recommendations by carrot producers in the region, with adaptations made according to the need of the crop. For each planting, we applied 120 kg.ha^{-1} of N, 460 kg.ha^{-1} of P_2O_5 and 110 kg.ha^{-1} of S using mono ammonium phosphate.

Fertilization was performed three times a week, via fertigation, from 15 to 90 days after germination, using 98.4 kg.ha^{-1} N, 300 kg.ha^{-1} P_2O_5, 170 kg.ha^{-1} K_2O, 7.1 kg.ha^{-1} Mg, 1 kg.ha^{-1} Ca, 13.7 kg.ha^{-1} S and 1.7 kg.ha^{-1} B for each experiment. Micronutrients were supplied at a dosage of 2.1% B, 0.36% Cu, 2.66% Fe, 2.48% Mn, 0.036% Mo and 3.38% Zn. The micronutrient source also had a proportion of 1.6% K_2O, 1.28% S and 0.86% Mg. A phytosanitary product was applied to control gall nematodes.

Sowing was performed manually in the transverse direction of the bed in holes approximately 2.0 cm deep, placing 3 to 4 seeds per hole. Thinning was performed 25 days after sowing (DAS), leaving one plant per hole.

The irrigation system used in the first 15 days after sowing was a micro sprinkler. During the remainder of the crop cycle, drip irrigation was used. Dripping was performed with three hoses per seedbed, spaced 0.15 m apart and with drippers every 0.20 m. Irrigation was performed daily, with the irrigation depth based on crop evapotranspiration (Allen *et al*., 2006).

Harvesting was performed when the older leaves yellowed and dried and the younger leaves bent down, which occurred, on average, 120 DAS.

Characteristics evaluated

For the postharvest quality analysis, 10 commercial roots from the experimental plot area were sampled.

- Soluble solids (°Brix): The roots were processed in a Philips Walita® Juicer Centrifuge to extract the juice. Then, the juice was filtered with filter paper and read using a digital refractometer with automatic temperature correction.

- Total soluble sugars (%): This was determined in the juice, using the method of Antrona (Southgate, 1991) and 1 mL of juice diluted in distilled water in a 250 mL volumetric flask. An aliquot of 1 mL was transferred to test tubes and then 2 mL of anthrone was added and homogenized. Subsequently, the absorbance was determined with a spectrophotometer at a wavelength of 620 nm.

- Total titratable acidity (% malic acid): This was determined using the titrometric method. 5 g of root sample was weighed in a 125 mL Erlenmeyer flask, completed to 50 mL with distilled water, and then three to five drops of 1% phenolphthalein were added and titrated with a 0.1N NaOH solution (Instituto Adolfo Lutz, 2008).

- Beta-carotene content (mg $100g^{-1}$): This was determined according to a method adapted from Nagata & Yamashita (1992). After crushing five carrots in a processor, a 0.5 g sample was taken and 5 mL of an acetone-hexane mixture (4:6) was added for the extraction. Then, the samples were left to rest for 30 minutes. The readings were made with a spectrophotometer, at wavelengths of 453, 505, 645 and 663 nm, to quantify the levels of β -carotene according to the equation below:

$$\beta\text{-carotene (mg } 100g^{-1}) = 0.216*A663 - 1.22*A645 - 0.304*A505 + 0.452*A453$$

In which A663, A645, A505 and A453 stand for the absorbance of the sample at each of these wavelengths.

- Percentage of white halo in the roots (%): A sample of ten marketable plants was taken from the useful area of the plot. These plants were cut in half and the presence or absence of the physiological disturbance "white halo" was verified.

Statistical Analysis

A variance analysis of the evaluated characteristics was performed separately for each experiment. Then, based on the recommendation by Pimentel-Gomes (2009), the experiments were jointly analyzed for the characteristics that passed the homogeneity test. The characteristics that did not present homogeneity were corrected according to the methodology recommended by Pimentel-Gomes (2009). The statistical analyses were performed using the software SISVAR v 5.3 (Ferreira, 2003). To compare the means, the Scott-Knott test at a 5% probability level was used.

RESULTS AND DISCUSSION

According to the joint variance analysis, there was an interaction between the cultivar and planting time factors for all of the post-harvest quality related characteristics, except for beta-carotene content (Table 3).

Regarding the white halo percentage, there was a significant difference between cultivars for all planting times. In general, the percentage of carrots with white

Table 1: Meteorological data of the study area during the experiment. Mossoró, RN. Ufersa, 2017

Year	Month	T (°C)			RH (%)			R (mm)	S.R. (W/m²)
		Mean	Max	Min	Mean	Max	Min		
2017	May	28.0	38.6	19.4	75.6	98.0	31.9	15.4	226.4
	June	27.7	36.3	20.7	70.8	97.3	31.5	14.2	211.3
	July	27.0	35.6	19.1	66.9	98.2	29.3	58.6	198.9
	August	27.5	37.9	19.4	64.9	93.5	29.0	0.2	254.7
	September	28.0	38.5	19.6	60.4	90.8	24.5	2.4	263.6
	October	28.3	38.6	21.0	64.2	91.4	29.3	0.8	267.1
	November	28.0	37.2	21.0	67.8	91.5	32.9	0.6	277.7
	December	28.4	37.3	21.8	69.2	93.5	36.7	1.4	250.9
2018	January	28.1	37.5	20.3	71.7	96.6	30.0	64.4	236.1

Note: T = Temperature; RH = Relative humidity; R = Rainfall; S.R. = Solar radiation.

Table 2: Chemical characterization of the soil in the experimental areas. Mossoró, RN. Ufersa, 2017

pH	EC	P[1]	K^+	Na^+	Ca^{2+}	Mg^{+2}
(water)	dS m^{-1}	mg dm^{-3}			cmol$_c$ dm^{-3}	
5.10	0.03	6.70	32.20	4.80	0.80	0.50

[1]Melich Extractor 1

halo increased with each planting date, from 25% in Season 1 to 76.2% in Season 4. The cultivars that showed the highest percentages of the disorder were Brasília, Kuronan and Suprema. The hybrid cultivar Nativa had the lowest percentage (Table 4).

Although the open-pollinated cultivars were more susceptible to this disorder, hybrids were also susceptible. The Amanda cultivar did not exhibit the disorder in Season 1. In seasons 2 and 3, almost half of the roots were affected by white halo. In Season 4, nearly all of the roots of the Amanda cultivar showed the physiological disorder. A similar pattern was observed for the Francine cultivar.

This evolution of the physiological disturbance throughout the planting dates is certainly related to changes in climatic conditions that the plants were subjected to throughout the year, especially temperature, relative humidity and solar radiation. Although high temperatures are determinant for the occurrence of this physiological disorder, some cultivars appeared to be more tolerant (i.e., Melinda and Nativa). It was also observed that the *Meloidogyne* sp. infection tends to aggravate the problem. Therefore, the increased incidence of white halo in seasons 3 and 4 may also be related to a higher incidence of this disease in the study area.

White halo is a physiological disorder that affects the xylem vessels in carrot roots. It begins as a whitish halo around the vascular bundle and progresses to complete discoloration of the vascular bundle (Grangeiro *et al*. 2012). Carrot roots with this disorder have low market acceptance. Pereira *et al*. (2015) point out that in the Brazilian market, for consumption *in natura*, there is a preference for roots with a pronounced orange color and little differentiation between the colors of the xylem and phloem.

Carrot hybrids showed higher levels of soluble solids compared to open-pollinated cultivars, except for the hybrid Nativa, which was not statistically different from open-pollinated cultivars, and the Suprema cultivar, which was the only open-pollinated cultivar with a soluble solids content statistically similar to the one observed for hybrid cultivars during seasons 1, 3 and 4 (Table 5). The means

Table 3: ANOVA table. Mossoró, RN. Ufersa, 2017

S.V.	F. D.	WHP	S S	TA	SS/TA	TSS	βC
Block	12	3.64^{ns}	0.3802^{ns}	0.0015^{ns}	0.3756^{ns}	1.5956^{ns}	0.4577^{ns}
Cultivar(C)	9	66.89**	1.9434**	0.0064**	1.9914**	7.2344**	1.9380**
Planting date (S)	3	214.61**	13.8576**	0.0475**	98.5999**	13.7020**	4.6020**
C x S	27	9.14**	0.6119**	0.0034*	0.8439**	4.6366**	0.6460^{ns}
Residual	105	2.82	0.2216	0.0019	0.3220	1.1969	0.5092
C.V. (%)		28.35	4.64	14.50	13.38	14.67	29.44

Note: WHP= White halo percentage; SS= Soluble solids content; TA= Titratable acidity; SS/TA= Soluble solids/Titratable acidity ratio; TSS= Total soluble sugars; bC= Beta-carotene content.

*= Significant at 5% level; **= Significant at 1% level; ns= not significant.

Table 4: White halo percentage in carrot roots as a function of the planting date. Mossoró, RN. Ufersa, 2017

Cultivars	White halo percentage				
	Planting dates				Mean
	May (Season 1)	June (Season 2)	July (Season 3)	August (Season 4)	
Amanda	0.0cC	47.5bB	47.5cB	97.5aA	48.1
Brasília	55.0bB	95.0aA	100.0bA	75.0bA	81.3
BRS Planalto	0.0cB	62.5bA	60.0cA	70.0bA	48.1
Érica	0.0cC	62.5bB	62.5cB	100.0aA	46.2
Francine	2.5cB	62.5bA	45.0cA	70.0bA	45.0
Kuronan	87.5aA	97.5aA	85.0bA	100.0aA	92.5
Mariana	37.5bB	77.5aA	70.0cA	95.0aA	70.0
Melinda	10.0cB	50.0bA	62.5cA	52.5cA	43.8
Nativa	0.0cC	22.5cB	70.0cA	37.5cB	32.5
Suprema	57.5bB	92.5aA	95.0bA	82.5aA	81.9
Mean	25.0	67.0	69.8	76.2	

Means followed by the same letter do not differ statistically (uppercase in the row and lowercase in the column) using the Scott-Knott test at 5% probability.

of total soluble solids obtained in the present study are above the range of 6.5 to 7.5º Brix, which is recommended for harvest and consumption (Paulus *et al*., 2012).

Soluble solids content is directly related to the taste and sweetness of plant products. Therefore, the high soluble solids content value is a positive result, since sweetness is a desirable attribute that increases the quality of carrots (Schifferstein *et al*., 2018).

Planting in July favored higher levels of soluble solids in the roots in all cultivars (Table 5). The high solar irradiance observed during the cycle of the plants sown in July, especially between September and December 2017, may have caused the greatest accumulation of soluble solids. This is because high luminosity favors an increase in soluble solids content in the plants (by reducing the root weight) and a decrease in acidity, resulting in better-tasting carrots (Mattiuz, 2007).

For the Shin Kuroda cultivar, which belongs to the Kuronan group, the average soluble solids content observed by Paulus *et al*. (2012) was 9.5 ºBrix, with the highest averages observed for carrots grown in the winter. In Mossoró, Grangeiro *et al*. (2012) report an average of 7.62 – 8.90 ºBrix for the Brasília cultivar.

Regarding titratable acidity, the cultivars did not differ statistically from each other for the planting dates of May and August. In June, the cultivars Brasília, Kuronan and Mariana did not differ from each other and were the ones with the greatest acidity (Table 6). In July, in addition to the cultivars mentioned above, the cultivars Amanda and BRS Planalto also formed the group of cultivars with the highest acidity.

The synthesis of organic acids in a plant is directly related to the photosynthetic capacity of the plant (Taiz & Zeiger, 2017). Thus, environmental factors such as temperature and solar radiation, associated with planting density, may have influenced the decrease in the acid content in the roots during the planting dates.

In general, the titratable acidity means found here were similar or approximate to those in the literature. Alves at al. (2010) obtained 0.167% malic acid for the Brasília cultivar. Pereira (2014) reports that the titratable acidity of conventional and organic carrot samples was 0.19 and 0.2% malic acid, respectively, with no significant differences between the two cultivation systems.

For the ratio of soluble solids/titratable acidity, there was no significant difference between cultivars in Season 1. Seasons 3 and 4 had the highest soluble solids/total titratable acid (SS/TA) ratios. The increase in the SS/TA ratio during the planting dates was observed for practically all cultivars, except Érica, Melinda and Nativa that showed an increase in Season 3 and a decrease in Season 4 (Table 7).

The Francine, Mariana and Nativa cultivars had the highest SS/TA averages and were statistically equal. The other cultivars did not statistically differ from each other and had averages ranging from 62.61 to 70.78 (Table 7).

The increase in the SS/TA ratio in seasons 3 and 4 is related to the increase in the content of soluble solids in those seasons and to the decrease in the titratable acidity observed in the same seasons.

The results obtained in the present study were superior to those obtained by Figueiredo Neto *et al*. (2010) (30.8 °Brix/% for Brasília cultivar) and Alves *et al*. (2010) (°Brix/50.15% for Brasília carrot). This difference can be attributed to the difference in soil, spacing, management and local average temperature.

Table 5: Soluble solids content (ºBrix) in carrot roots as a function of the planting date. Mossoró, RN. Ufersa, 2017

Cultivars	Soluble Solids Content (ºBrix)				
	Planting dates				Mean
	May (Season 1)	June (Season 2)	July (Season 3)	August (Season 4)	
Amanda	10.37aB	9.87aB	11.22aA	10.45aB	10.48
Brasília	9.51bB	9.61bB	10.57bA	9.88aB	9.90
BRS Planalto	9.20bB	9.01bB	11.07aA	9.28bB	9.64
Érica	10.27aA	10.20aA	11.03aA	8.60bB	10.36
Francine	10.20aB	10.40aB	11.08aA	10.46aB	10.54
Kuronan	9.56bB	9.15bB	10.26bA	9.72aB	9.68
Mariana	10.02aB	10.20aB	11.42aA	10.52aB	10.54
Melinda	9.06bB	10.83aA	11.13aA	10.40aA	10.36
Nativa	9.38bC	9.10bC	11.12aA	10.06aB	9.92
Suprema	10.10aB	9.45bB	11.20aA	9.86aB	10.15
Mean	9.77	9.78	11.02	10.03	

Means followed by the same letter do not differ statistically (uppercase in the row and lowercase in the column) using the Scott-Knott test at 5% probability.

The total soluble sugar levels ranged from 6.46 to 8.28%. A significant difference was observed between cultivars in seasons 1, 2 and 3. In seasons 1 and 2, the cultivars that stood out were the hybrids Amanda, Érica, Francine, and Mariana (Table 8).

In general, it was observed that the concentration of total soluble sugars tended to decrease throughout the year. This shows that planting carrots at the hottest times of the year will result in root quality loss. The lowest concentration of sugars in the hottest times of the year is related to the metabolism of the carrot plant. The carrot is a C3 metabolism plant and, therefore, it tends to undergo photorespiration with increased temperature and solar irradiance, and can also suffer photoinhibition due to high solar radiation, which can damage the photosynthetic apparatus and, consequently, have a direct impact on the ability to synthesize carbohydrates (Taiz & Zeiger, 2017).

The mean sugar contents found here are in accordance with Umuhoza *et al.* (2014), who reported that in Brasília type cultivars the sugar content varies in the range of 9.9 to 10.27%, values similar to those found in American cultivars.

The means found by Alves *et al*. (2010), for the Mossoró region, ranged between 5.12 and 6.32% and are, therefore, lower than the averages identified in this study, even for the most unfavorable planting times for carrot cultivation in the region.

For the levels of beta-carotene, there was a significant effect of the cultivar factors and planting times alone (Table 9). The cultivars Brasília and Kuronan were similar

Table 6: Titratable acidity (malic acid %) in carrot roots as a function of the planting date. Mossoró, RN. Ufersa, 2017

Cultivars	Titratable Acidity (malic acid %)				
	Planting dates				Mean
	May (Season 1)	June (Season 2)	July (Season 3)	August (Season 4)	
Amanda	0.1854aA	0.1581bB	0.1452aB	0.1504aB	0.1598
Brasília	0.1542aA	0.1743aA	0.1538aA	0.1256aB	0.1520
BRS Planalto	0.1329aB	0.1498bA	0.1563aA	0.1153aB	0.1386
Érica	0.1687aA	0.1615bA	0.1367bA	0.1367aA	0.1542
Francine	0.1653aA	0.1572bA	0.1273bB	0.1136aB	0.1409
Kuronan	0.1662aA	0.1965aA	0.1418aB	0.1359aB	0.1601
Mariana	0.1559aB	0.1854aA	0.1469aB	0.1111aC	0.1498
Melinda	0.1854aA	0.1623bA	0.1273bB	0.1444aB	0.1549
Nativa	0.1551aA	0.1273bA	0.1102bB	0.1239aB	0.1291
Suprema	0.1653aA	0.1606bA	0.1649aA	0.1282aB	0.1547
Means	0.1634	0.1633	0.1411	0.1278	

Means followed by the same letter do not differ statistically (uppercase in the row and lowercase in the column) using the Scott-Knott test at 5% probability.

Table 7: Soluble solids/titratable acidity ratio (ºBrix/%) in carrot roots as a function of the planting date. Mossoró, RN. Ufersa, 2017

Cultivars	SS/TA ratio (ºBrix/%)				
	Planting dates				Mean
	May (Season 1)	June (Season 2)	July (Season 3)	August (Season 4)	
Amanda	56.29aB	63.23aB	77.51bA	69.76bA	66.70
Brasília	61.98aB	55.19aB	72.51bA	79.52bA	67.30
BRS Planalto	70.10aA	60.25aB	74.08bA	81.83bA	71.57
Érica	60.95aA	63.26aA	81.10bA	62.91bA	68.01
Francine	62.77aB	66.25aB	87.27aA	93.75aA	77.51
Kuronan	58.85aB	46.99aB	72.67bA	71.93bA	62.61
Mariana	65.18aC	55.84aC	77.90bB	98.97aA	74.48
Melinda	55.00aC	67.18aC	88.27aA	72.68bB	70.78
Nativa	62.16aC	71.51aC	101.32aA	82.21bB	79.30
Suprema	61.81aA	58.91aA	68.22bA	77.01bA	66.49
Mean	61.51	60.86	80.09	80.37	

Means followed by the same letter do not differ statistically (uppercase in the row and lowercase in the column) using the Scott-Knott test at 5% probability.

Table 8: Total soluble sugars (%) in carrot roots as a function of the planting date. Mossoró, RN. Ufersa, 2017

Cultivars	Total Soluble Sugars (%)				
	Planting dates				Mean
	May (Season 1)	June (Season 2)	July (Season 3)	August (Season 4)	
Amanda	9.33aA	8.89aA	7.15bB	7.25aB	8.16
Brasília	7.55bA	5.37bB	7.86aA	6.81aA	6.91
BRS Planalto	7.09bA	5.51bB	7.84aA	6.35aB	6.70
Érica	9.46aA	9.46aA	6.24bB	5.99aB	8.21
Francine	9.47aA	9.00aA	7.12bA	6.38aB	7.99
Kuronan	7.13bA	6.50bA	7.08bA	7.23aA	6.99
Mariana	8.88aA	8.27aA	6.72bB	6.87aB	7.69
Melinda	7.28bB	10.08aA	8.53aB	7.22aB	8.28
Nativa	7.89bA	6.00bB	8.25aA	7.15aA	7.33
Suprema	7.95bA	5.35bB	6.86bA	5.68aB	6.46
Mean	8.21	7.45	7.37	6.76	

Means followed by the same letter do not differ statistically (uppercase in the row and lowercase in the column) using the Scott-Knott test at 5% probability.

Table 9: Beta-carotene content (mg.100 g^{-1}) in the carrot cultivars and different planting dates. Mossoró, RN. Ufersa, 2017

Cultivars	Beta-carotene (mg.100g^{-1})
Amanda	2.78 a
Brasília	1.68 b
BRS Planalto	2.50 a
Érica	2.47 a
Francine	2.36 a
Kuronan	2.06 b
Mariana	2.59 a
Melinda	2.78 a
Nativa	2.73 a
Suprema	2.30 a
Planting date	**Beta-carotene (mg.100g^{-1})**
May (Season 1)	2.50 b
June (Season 2)	2.41 b
July (Season 3)	2.80 a
August (Season 4)	1.96 c

* Averages followed by the same letter do not differ statistically from each other by the Scott-Knott test at 5% probability.

to each other. The Brasília cultivar, which has been the most recommended cultivar for summer cultivation, once again exhibited the worst performance among the ten cultivars studied.

Regarding the planting dates, carrots planted in July showed, on average, the highest content of beta-carotene in the roots, while carrots planted in August (Season 4) had the lowest content.

One of the main climatic factors that influences the content of carotenoids in carrots is air temperature. Air temperatures ranging from 16 to 25 ºC are considered ideal for the synthesis of beta-carotene (Vieira & Pessoa, 1997). The average temperatures in the study area, during the entire period of the experiment, were above the ideal range for the synthesis of beta-carotene, which would justify the low levels of this pigment found here.

CONCLUSIONS

The interaction between the carrot cultivars and the planting dates had a significant influence on postharvest quality of carrot roots.

For the study area, the cultivation of carrots in May and June is most recommended, since the July and August plantings resulted in a decrease in marketability, mainly due to a higher occurrence of white halo in the roots.

Finally, further studies should be conducted to find ways to attenuate the occurrence of white halo and cultivate carrots throughout the year in regions with hot climates.

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