REVISTA CULTURA AGRONÔMICA
AGRONOMIC CROP JOURNAL v.30, n.2, p.166-177, 2021
ISSN 2446-8355 VERSÃO ONLINE, a partir do v. 24, n.1, 2015. ISSN 0104-1010 (IMPRESSO)

http://dx.doi.org/10.32929/2446-8355.2021v30n2p166-177

EFFECTS OF PLANTING DATES ON GROWTH AND NUTRIENT ACCUMULATION OF CARROTS IN THE BRAZILIAN SEMI-ARID

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Recebido: 27/03/2021; Aceito: 01/11/2021

ABSTRACT: Fertilization plays an important role on carrot's yield, root quality, storage, plant growth and on the environment. It was aimed to evaluate the plant growth and macronutrients accumulation of carrot cultivars as a function of two planting dates, under high temperatures in the Brazilian semi-arid. The experiments were carried out in randomized blocks design, with ten treatments and four repetitions. Treatments consisted of ten carrot cultivars sowed in two Planting dates. The characteristics that were evaluated were: plant growth (plant height, number of leaves, plant dry matter accumulation, mean fresh mass of the root) and macronutrient accumulation (N, P, K, Ca and Mg) in plant, leaves and root. Plant's mean height ranged from 42.53 cm (*Melinda*) to 49.25 cm (*Nativa*); the highest plant dry matter was obtained by *BRS Planalto* (12.36 g) and *Kuronan* (12.18 g); the mean number of leaves was the lowest in *Melinda* and *Nativa*: 8.64 and 7.64 leaves plant^{-1}. The root's fresh weight had a significant decrease among the planting dates for the Brasília, Francine and Suprema cultivars. The nutrient accumulation varied accordingly to the planting date and cultivar.

Key words: *Daucus carota L.* Genotypes. Macronutrients. Adaptability. Efficiency.

EFEITOS DA ÉPOCA DE PLANTIO NO CRESCIMENTO E ACÚMULO DE NUTRIENTES EM CENOURAS NO SEMIÁRIDO BRASILEIRO

RESUMO: A fertilização desempenha um papel importante no rendimento, qualidade da raiz, armazenamento, crescimento de plantas de cenoura e no meio ambiente. Objetivou-se avaliar o crescimento das plantas e o acúmulo de macronutrientes de cultivares de cenoura em função de duas épocas de plantio, sob altas temperaturas no semi-árido brasileiro. Os experimentos foram realizados em delineamento de blocos casualizados, com dez tratamentos e quatro repetições. Os tratamentos consistiram em dez cultivares de cenoura semeadas em duas épocas de plantio. As características avaliadas foram: crescimento da planta (altura da planta,

número de folhas, acúmulo de matéria seca da planta, massa fresca média da raiz) e acúmulo de macronutrientes (N, P, K, Ca e Mg) na planta, folhas e raiz. A altura média da planta variou de 42,53 cm (Melinda) a 49,25 cm (Nativa); a maior matéria seca da planta foi obtida por BRS Planalto (12,36 g) e Kuronan (12,18 g); o número médio de folhas foi o menor em Melinda e Nativa: 8,64 e 7,64 folhas planta^{-1}. O peso fresco da raiz diminuiu significativamente entre as épocas de plantio para as cultivares Brasília, Francine e Suprema . O acúmulo de nutrientes variou de acordo com a época de plantio e a cultivar.

Palavras-chave: *Daucus carota* L. Genótipos. Macronutrientes. Adaptabilidade. Eficiência.

INTRODUCTION

In 2015, 780.7 thousand tons of carrots were harvested in Brazil, and the cultivated area with this vegetable in that year was 23.1 thousand hectares. The average yield of the carrot crop in Brazil is about 33.8 tons ha^{-1}, which is below the crop's full potential, estimated between 100 and 120 t ha^{-1}. Amongst the reasons for this subpar performance are the lack of climatic zoning and the inadequate choice of genotypes, population density, fertilization, irrigation and pest control (ANUÁRIO BRASILEIRO DE HORTALIÇAS - ABH, 2016).

In regions with high temperatures, the carrot cultivation is negatively affected, since this climatic trait tends to reduce root's size and pigmentation and, consequently, yield and quality. In some of the Brazilian States, the carrot production does not even supply the domestic demand, as per example in Rio Grande do Norte State, in which virtually all of the carrots that are commercialized come from Bahia State, which increases the costs of this product in the local market (TEÓFILO *et al*., 2009).

Regarding the mineral nutrition of this crop, fertilizers represent about 45% of the total production costs of carrots (CENTRO DE ESTUDOS AVANÇADOS EM ECONOMIA APLICADA - CEPEA, 2010). Besides the economic importance, fertilization plays an important role on yield (MENEGAZZO, 2010), on root quality (Luz *et al*., 2009), on storage (MÜLLER, 1982), on environment and on the profits from the cultivation.

Research that evaluate how the planting date affects plant growth and nutrient accumulation in regions with high temperatures and the semi-arid, however, are scarce.

It is presumed that the different cultivars, due to their genetic traits, and the planting date, due to variations in environmental factors, might interact, exerting influence on nutrient accumulation and transportation in carrot plants and, consequently, on plant's growth.

The aim of this work is to evaluate plant growth and accumulation of macronutrients in ten carrot cultivars as a function of two different planting dates in Mossoró, Rio Grande do Norte.

MATERIAL AND METHODS

Location and Description of the Study Area

The experiments were carried out at the Rafael Fernandes farm, belonging to the Federal Rural University of the Semi-Arid (Ufersa) (Latitude 5º03', Longitude 37º23'W; mean altitude 72m), in a Latosol Yellow Red Argisolic sandy loam soil (EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA, 2013) from June to November 2017. Soil chemical characteristics are displayed in Table 1.

Table 1. Chemical characterization of the soil at 0-20cm depth. Mossoró – RN. Ufersa 2017

pH	CE	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

Note: [1]Mehlich extractor.
Source: Own authorship.

The climate in the region, according to Köppen's classification, is BSwh', dry and very hot (CARMO FILHO *et al*. 1991). Climate data for the experiments period are displayed in Table 2.

Table 2. Climate data from the study area. Mossoró – RN. Ufersa 2017

Month	Air temperature (°C)			Thermal amplitude (°C)	Air relative humidity (%)			Rainfall (mm)	Solar radiation (W/m²)
	Mean	Maximum	Minimum		Mean	Maximum	Minimum		
June	27.72	36.31	20.65	15.66	70.79	97.30	31.50	14.20	211.31
July	26.99	35.64	19.10	16.04	66.86	98.20	29.30	58.60	198.87
August	27.45	37.92	19.37	18.55	64.94	93.50	29.00	0.20	254.67
September	27.96	38.45	19.56	18.84	60.42	90.80	24.50	2.40	263.64
October	28.32	38.64	21.03	17.61	64.19	91.40	29.30	0.80	267.05
November	28.04	37.15	20.96	16.19	67.75	91.50	32.90	0.60	277.66

Source: Meteorological Station from Rafael Fernandes Experimental Farm 2018.

Treatments and Experimental Design

The experimental design was complete randomized blocks, with ten treatments and four repetitions. Treatments consisted of ten carrot cultivars four of which were open-pollinated varieties: *Brasília* (TopSeed®), *BRS Planalto* (ISLA®), *Suprema* (ISLA®) and *Kuronan* (ISLA®); and six were hybrid cultivars: *Nativa* (Sakata®), *Mariana* (Feltrin®), *Melinda* (Feltrin®), *Amanda*, (Agristar®), *Francine* (Agristar®) and *Érica* (Agristar®). The ten cultivars were sown in two dates: June and July. Each experimental unity was composed of a plot with 30 x 1.0m, with six rows of plants, spaced 0.15 x 0.06m, making a total area of 30m² and a population of approximately 780,000 plants per hectare, in which the useful area was the four central rows, dismissing one row of plants in each extremity.

Experiment Implementation

Soil tillage consisted of ploughing, harrowing and lifting of the plant beds to 0,20m height, approximately.

Planting fertilization was performed based on soil analysis. Previously to sowing, 120 kg ha^{-1} of N, 460 kg ha^{-1} of P_2O_5 and 110 kg ha^{-1} of S were applied to the seed beds.

Further fertilizations were performed via fertirrigation, from the 15th through the 90th days after germination apllying 135 kg ha^{-1} of nitrogen and 172 kg ha^{-1} of potassium. Micronutrients were applied using Rexolin® as source (1.6% K_2O 1.28% S, 0.86% Mg 2.1% B, 0.36% Cu 2.66% Fe 2.48% Mn, 0.036% Mo and 3.38% Zn).

Sowing was performed manually in the transverse direction of the seed beds in pits of approximately 2.0cm deep, spaced 6.0cm from each other, putting from three to four seeds per pit.

The irrigation system applied was, during the first 15 days after sowing, micro sprinkler and, after the first 15 days until the end of the crop cycle, via drip irrigation. The drip irrigation system consisted of three hoses per seed bed, spaced 15.0cm between hoses and drippers spaced at each 20.0cm. Irrigation was done daily based on the carrot crop evapotranspiration (ALLEN *et al*., 2006)

Whenever it was necessary, manual weeding was performed.

Harvest was carried out when the oldest leaves yellowed and dried and the younger leaves bended, which happened at around 120 days after sowing.

Characteristics Evaluated

- Plant height and number of leaves (cm): Fifteen plants per plot were measured from soil level to the top of the highest leaf. Measurement was done, approximately, 80 days after the sowing of each experiment.

- Root fresh and dry weight (g): At harvest 10 roots classified as commercial from each experimental plot were washed, split into tops and root and then weighed. After that, they were stored in paper bags and put into a forced circulation oven at 65ºC, until it reached constant weight. After that it was weighted in a precision balance.

- Nutrients accumulation (g plant^{-1}): After dry matter was determined, the plants were milled and the macronutrients content (N, P, Ca, K, Mg) was determined according to Tedesco *et al*. (1995) methodology.

Statistical Analysis

Variance analysis of the evaluated characteristics was performed for each experiment separately. Following, joint analysis of the experiments was performed for those characteristics that passed the homogeneity test (PIMENTEL-GOMES, 2009).

Statistical analysis was performed using the statistical software SISVAR v 5.3 (FERREIRA, 2011). The Scott-Knott test at 5% probability was used for means comparison.

RESULTS AND DISCUSSION

Plant Growth

There was no significant interaction between Cultivars and Planting dates for the characteristics related to plant growth (Table 3). Root and plant dry matter content did not vary significantly at a 5% level, while the dry matter content on the tops did. Open-pollinated

cultivars obtained the highest dry matter content on the leaves, with emphasis on the cultivars *BRS Planalto* and *Kuronan*. During planting date two it was observed the highest dry matter content in the leaves.

Table 3. Number of leaves, plant height (cm) and dry matter content in the leaves (g). Mossoró – RN. Ufersa 2017.

Cultivars	N. of leaves	Plant height (cm)	LDMC (g)
Amanda (H)	9.65 a	43.92 b	10.01 b
Brasília (OP)	10.40 a	45.54 b	11.94 a
BRS Planalto (OP)	9.42 a	48.23 a	12.36 a
Érica (H)	9.40 a	44.54 b	10.49 b
Francine (H)	9.02 a	46.03 b	8.99 b
Kuronan (OP)	9.87 a	45.70 b	12.18 a
Mariana (H)	9.29 a	47.69 a	10.17 b
Melinda (H)	8.65 b	42.53 b	8.68 b
Nativa (H)	7.94 b	49.25 a	8.63 b
Suprema (OP)	9.42 a	43.55 b	11.69 a
Planting dates	N. of leaves	Plant height (cm)	LDMC (g)
June (Planting date one)	9.14 a	50.58 a	9.58 b
July (Planting date two)	9.47 a	40.81 b	11.44 a

Note: H= Hybrid; OP= Open pollinated cultivar. * Means followed by the same letter do not differ statistically from one another by the Scott-Knott test at 5% probability level. LDMC: Dry matter content in the leaves.
Source: Own authorship.

Concerning the number of leaves, the mean number of leaves of the cultivars *Melinda* and *Nativa* differed from the others and were those with the lowest number of leaves. Despite being a cultivar with great plant height, the *Nativa* cultivar was the one with the lowest number of leaves.

Table 4. Root fresh weight (g). Mossoró – RN. Ufersa 2017

Cultivars	Planting dates	
	June	July
	Planting date one	Planting date two
Amanda (H)	133.7 aA	120.1 aA
Brasília (OP)	101.4 bA	77.2 bB
BRS Planalto (OP)	86.8 bA	100.5 aA
Érica (H)	117.6 aA	111.6 aA
Francine (H)	125.2 aA	85.4 bB
Kuronan (OP)	100.5 bA	75.7 bB
Mariana (H)	74.9 bA	81.6 bA
Melinda (H)	87.1 bB	117.5 aA
Nativa (H)	117.1 aA	119.4 aA
Suprema (OP)	109.7 aA	88.4 bB

Note: H= Hybrid; OP= Open pollinated cultivar. * Means followed by the same letter do not differ statistically from one another by the Scott-Knott test at 5% probability level.
Source: Own authorship.

Regarding the root fresh weight (Table 4), it was observed a general decrease between cultivars from planting date one to planting date two. However, only the open pollinated cultivars showed a statistically significant decrease. Overall, the hybrid cultivars showed a non-significant decrease in fresh weight between planting dates, except for the *Melinda* cv., which had an increase in fresh weight.

Nutrient Accumulation

Nitrogen accumulation in the roots was affected by the interaction between cultivars and planting dates and the accumulation of this nutrient in the roots did not differ amongst cultivars in the second Planting date (Table 5). For the plants sown in June (planting date one) the cultivars *BRS Planalto* and *Mariana* differed from the others and were those with the lowest accumulation of N in the roots.

Table 5. Nitrogen accumulation in the roots (mg plant^{-1}). Mossoró – RN. Ufersa 2017

Cultivars	Planting dates	
	June	July
	Planting date one	Planting date two
Amanda (H)	140.62aA	137.63aA
Brasília (OP)	128.27aA	71.92aB
BRS Planalto (OP)	91.02bA	110.77aA
Érica (H)	169.40aA	127.22aA
Francine (H)	136.52aA	120.57aA
Kuronan (OP)	112.52aA	137.77aA
Mariana (H)	67.90bB	114.80aA
Melinda (H)	126.27aA	95.37aA
Nativa (H)	151.35aA	101.59aB
Suprema (OP)	119.45aA	127.57aA

Note: H= Hybrid; OP= Open pollinated cultivar. *Means followed by the same letter do not differ statistically from one another, upper case in the rows and lower case in the columns by the Scott-Knott at 5% probability.
Source: Own authorship.

The accumulation of phosphorus in the leaf, root and total varied accordingly to the interaction between cultivars and planting dates (Table 6).

Regarding the accumulation of potassium, in the leaves it varied only according to the cultivar, while the accumulation in the root and total varied according to the interaction between cultivars and Planting dates (Table 7).

For the accumulation of K in the leaves, two distinct groups were formed. The first group was composed, exclusively, by open pollinated cultivars, with the highest means, and the second group was composed by the hybrid cultivars, with a lower K accumulation in the leaves.

Therefore, the difference between the cultivar that presented the lowest (*Amanda*) and highest accumulation of potassium in the leaves (*Kuronan*) was almost 150mg pl^{-1}.

Table 6. Phosphorus accumulation in the leaves, root and total (mg plant^{-1}). Mossoró – RN. Ufersa 2017

Cultivars	Leaf		Root		Total	
	June Planting date one	July Planting date two	June Planting date one	July Planting date two	June Planting date one	July Planting date two
Amanda (H)	17.90aA	27.39aA	61.27aA	44.28aA	79.17aA	71.67aA
Brasília (OP)	16.66aA	21.30bA	58.20aA	42.84aA	74.87aA	64.15aA
BRS Planalto (OP)	34.21aA	24.24bA	32.43bA	53.10aA	66.64aA	77.35aA
Érica (H)	13.50aA	21.84bA	73.56aA	43.04aB	87.06aA	64.89aA
Francine (H)	12.20aA	17.78bA	77.74aA	26.25aB	89.94aA	44.04bB
Kuronan (OP)	20.57aB	36.10aA	40.72bA	31.67aA	61.29aA	67.78aA
Mariana (H)	13.88aB	37.45aA	30.83bA	33.30aA	44.71aA	70.75aA
Melinda (H)	26.11aA	14.03bA	42.73bA	26.16aA	68.84aA	40.20bB
Nativa (H)	13.98aA	15.58bA	55.54aA	22.08aB	69.53aA	37.67bB
Suprema (OP)	17.52aA	30.32aA	63.47aA	39.45aB	80.99aA	69.77aA

Note: H= Hybrid; OP= Open pollinated cultivar. *Means followed by the same letter do not differ statistically from one another, upper case in the rows and lower case in the columns by the Scott-Knott at 5% probability.
Source: Own authorship.

Table 7. Potassium accumulation in the leaves, root and total (mg plant^{-1}). Mossoró – RN. Ufersa 2017

Cultivars	Leaf	Root		Total	
		June Planting date one	July Planting date two	June Planting date one	July Planting date two
Amanda (H)	306.93 b	565.44 aA	358.57 bB	926.37 aA	611.50 bB
Brasília (OP)	429.96 a	483.63 aA	475.57 aA	966.92 aB	852.22 aB
BRS Planalto (OP)	425.05 a	382.80 aB	674.28 aA	717.29 bB	1189.91 aA
Érica (H)	348.24 b	519.08 aA	428.11 bA	878.57 aB	765.10 bB
Francine (H)	284.41 b	517.78 aA	314.01 bB	813.89 aB	586.72 bB
Kuronan (OP)	448.89 a	459.00 aA	538.26 aA	912.50 aB	982.54 aB
Mariana (H)	357.68 b	318.42 aB	483.58 aA	606.08 bB	911.30 aA
Melinda (H)	244.67 b	408.52 aA	387.81 bA	657.60 bB	628.07 bB
Nativa (H)	353.86 b	518.65 aA	365.08 bA	882.89 aB	708.56 bB
Suprema (OP)	432.80 a	466.66 aA	537.75 aA	881.78 aB	988.25 aB

Note: H= Hybrid; OP= Open pollinated cultivar. *Means followed by the same letter do not differ statistically from one another, upper case in the rows and lower case in the columns by the Scott-Knott at 5% probability.
Source: Own authorship.

For the accumulation of K in the roots, it was also observed the formation of two groups of cultivars. However, in addition to the open pollinated varieties, the *Mariana* hybrid also integrated the group of carrots with the largest accumulations of K. The second group was formed by the hybrid cultivars, except *Mariana*.

Regarding the total accumulation of potassium in the plant, for the cultivation carried out in June, the cultivars *Mariana* and *Melinda* did not differ between themselves and were those with the lowest accumulations of potassium. The other cultivars did not differ between themselves.

Concerning the total accumulation of K in the plants sown in July, it was noticed a greater variation in the means between the cultivars. *Amanda*, *Erica*, *Francine*, *Melinda* and *Nativa* presented the lowest accumulations of K. The remaining cultivars did not differ statistically and presented means varying between 852.22 (*Brasília*) and 1,189.92 mg plant^{-1} (*BRS Planalto*).

Regarding the accumulation of calcium in the leaves, root and total, it did not vary significantly for any of the sources of variation evaluated.

The accumulation of magnesium in the leaves, root and total varied as a function of the interaction between cultivars and planting dates (Table 8).

Table 8. Accumulation of Magnesium in the leaves, root and total (mg plant^{-1}). Mossoró – RN. Ufersa 2017

Cultivars	Leaf		Root		Total	
	June Planting date one	July Planting date two	June Planting date one	July Planting date two	June Planting date one	July Planting date two
Amanda (H)	11.56 bA	8.49 bA	6.33 bA	5.52 aA	17.90 bA	14.01 bA
Brasília (OP)	15.01 aA	13.93 aA	15.55 aA	5.07 aB	30.56 aA	19.01 aB
BRS Planalto (OP)	12.14 bB	19.42 aA	8.05 bA	7.82 aA	20.19 bA	27.24 aA
Érica (H)	18.10 aA	8.32 bB	5.83 bA	3.60 aA	23.93 aA	11.92 bB
Francine (H)	18.21 aA	7.99 bB	4.88 bA	3.89 aA	23.10 aA	11.89 bB
Kuronan (OP)	9.73 bA	14.46 aA	6.77 bA	5.53 aA	16.50 bA	19.99 aA
Mariana (H)	8.55 bA	9.40 bA	4.62 bA	5.68 aA	13.18 bA	15.09 bA
Melinda (H)	9.73 bA	8.91 bA	4.79 bA	5.46 aA	14.52 bA	14.38 bA
Nativa (H)	10.41 bA	7.58 bA	8.72 bA	3.16 aB	19.14 bA	10.75 bB
Suprema (OP)	14.22 aA	14.83 aA	7.14 bA	6.06 aA	21.36 aA	20.90 aA

Note: H= Hybrid; OP= Open pollinated cultivar. *Means followed by the same letter do not differ statistically from one another, upper case in the rows and lower case in the columns by the Scott-Knott at 5% probability.
Source: Own authorship.

There were two distinct groups of cultivars for the accumulation of Mg in the leaves in both planting dates. In season 1, the *BRS Planalto* and *Kuronan* varieties and the *Amanda*, *Mariana*, *Melinda* and *Nativa* hybrids did not differ statistically and composed the group of cultivars with lower Mg accumulation in the plant, whereas in season 2, this group consisted exclusively of the hybrid cultivars.

The accumulation of Mg in the root did not vary significantly between cultivars during the second planting date. In Season 1, only the cultivar *Brasília* differed significantly from the others, being the cultivar that accumulated the most magnesium in this planting date.

Alongside the hybrid cultivar *Nativa*, *Brasilia* presented a negative variation in the accumulation of Mg in the roots during season 2.

The total accumulation of magnesium in the plants also had the formation of two groups of cultivars. Only the *BRS Planalto* cultivar showed an increase in Mg accumulation between planting dates. The *Érica* and *Francine* cultivars presented a decrease in nutrient accumulation in the leaves between seasons one and two. The other cultivars did not present significant variation in the accumulation of Mg in the leaves between the planting dates.

The cultivars *Brasília, Érica, Francine, Mariana* and *Nativa* showed a decrease in the accumulation of total magnesium between the planting dates.

Aquino *et al*. (2015) also found that there was no effect of the cultivars on the dry matter contents in the roots. The values found by Resende *et al*. (2016) regarding leaves dry matter content (15.5 g plant^{-1} in the tops and 31.1 g plant $^{-1}$ in the roots) was slightly higher than the one found in this experiment, probably due to climatic and soil conditions found in the different study areas.

Plant's mean height ranged from 49.25 cm (*Nativa*) to 42.53 cm (*Melinda*). This behavior shows a higher accumulation of dry matter in the leaves won't necessarily result in higher plants.

Amongst planting dates it was observed that greater heights were obtained by those plants sown in June, with a difference of about 10 cm between planting dates. It probably happened because of the climatic factors. In July it was observed a total rainfall of 59 mm, which is above the mean for this month in the study area. The rainfall volume associated with the increase in the minimum temperatures and solar radiation during the cycle of the plants sown in July, might have interfered in their growth in the early stages of plant development, causing the diminishment in plant height.

It was observed that the different Planting dates did not affect the number of leaves and therefore this characteristic is rather related to genetic traits of the different cultivars than to climate. This result is similar to the one found by Teófilo *et al*. (2009).

The decrease in root fresh weight from planting date one to 2 is, once again, probably related with the climatic conditions to which the plants sown in July were submitted during their cycle (i.e. rainfall in July and high solar radiation from August to November, as well as the increase in the minimum temperatures during the same period).

Between Planting dates it was observed a variation in the accumulation of N on the cultivars *Brasília, Mariana* and *Nativa*, in which *Brasília* and *Nativa* presented a decrease and *Mariana* presented an increase in N in the root. Therefore, we observe that the accumulation of nitrogen in carrot roots is related both with genetic characteristics and climatic conditions, as has been previously observed by Aquino *et al*. (2015).

Aquino *et al*. (2015) observed a mean of 21.7 g kg^{-1} of N in the roots and 15.0 g kg^{-1} of N in the leaves.

In general, the accumulation of nitrogen in the roots observed in this work was inferior to the one found by Cecílio Filho and Peixoto (2005). This difference might have occurred

due to differences in the fertilization management and climatic characteristics of the study area.

The cultivars *Amanda*, *Kuronan*, *Mariana* and *Suprema* were those with the highest accumulations of P in the leaves. The nutrient accumulation in the roots, in Planting date two, did not vary significantly between cultivars, while in Planting date one it was observed the formation of two distinct groups: the first one formed by the cultivars *Amanda*, *Brasília*, *Érica*, *Francine*, *Nativa* and *Suprema*, with the highest accumulations of this nutrient; the second one was formed by *BRS Planalto*, *Kuronan* and *Mariana*, with lower accumulations of P in the root.

Concerning the accumulation of P in the whole plant, in planting date one there was no significant difference between the cultivars. In planting date two, the cultivars *Francine*, *Melinda* and *Nativa* were those with the lowest accumulations of P in the plant. Taking into consideration that these two cultivars were also the ones which presented the highest plants (Table 3), it implies that these cultivars are the most efficient in the phosphorus usage.

Regarding the planting dates, the accumulation of phosphorus in the whole plant decreased for the cultivars *Francine, Melinda* and *Nativa*.

Concerning the accumulation of potassium, the results found in this study are consistent with the means obtained by Cecílio Filho and Peixoto (2013) who reported that an accumulation of 381.2mg plant^{-1} K in the leaves and 525.2mg plant^{-1} in the roots. Aquino *et al*., (2015) observed a mean of 375.0 g kg^{-1} of K in the roots and 230.5 g kg^{-1} of K in the leaves. The difference in the results could be related both to edaphoclimatic conditions, fertilization management and the chosen cultivars.

Overall, the results obtained in this study for the accumulation of magnesium diverged from those obtained by Cecílio Filho and Peixoto (2013), who report that the accumulation of Mg in the leaves of *Brasília* was of 16.71mg plant^{-1} and in the roots 20.9mg plant^{-1}. In this study, instead, it was observed a greater accumulation of Mg in the leaves. These results also diverge from those obtained by Souza *et al*. (2003).

However, the results obtained in this study are in agreement with Oliveira *et al*. (2006), who reported a bigger accumulation of Mg in the roots for the Brasilia carrot in Mossoró. This shows that the accumulation of Mg and its distribution in the carrot plant are conditioned by the environment and the agricultural management conditions, since Oliveira *et al*. (2006) and Souza and Resende (2003) tested the same cultivar, but in different study areas: the first in Mossoró and the second in the Federal District.

Overall, it has been seen that in July the nutrient accumulation was lower than in June and it influenced directly the decrease in root fresh weight in this period. As previously observed, the plants sown in July were submitted to climatic conditions that are known to be limiting to carrot's growth. This might have interfered in the physiology of the plant itself, since carrot is classified as a C3 plant and, therefore, is subject to photorespiration as well as photo-inhibition and the rise in solar radiation and the increase of minimum temperatures tend to provoke these physiological processes. Both of these processes directly affect the

photosynthetic efficiency of C3 plants, reducing the efficiency of photosynthesis, thus impacting in its growth.

Finally, the results found in this study match the conclusions made by Aquino *et al*. (2015) which found that both the planting date and the cultivars exert influence in the nutrient contents in the leaves and roots of the carrot crop, and the extraction and exportation of nutrients by the carrot crop.

CONCLUSION

The different planting dates influenced the accumulation of nutrients in the different parts of the plant of the different cultivars, and also affected the growth characteristics of the plants.

The cultivation in June implied in a bigger accumulation of all nutrients, except potassium.

The hybrid cultivars presented nutritional demand similar or lower than that of the open pollinated cultivars, despite their lower dry matter content in the leaves.

In decreasing order, the nutrients that were accumulated the most in the plant were: K>N>P>Ca>Mg.

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