COMMERCIAL ANALYSIS OF CARROT GROW CROPS BRASILIA CALIBRATED AVERAGE AND NANTES IN DIFFERENT WATER REPLACEMENTS

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ABSTRACT: The objective of this work was to evaluate the effect of water stress caused by the reduction of soil water availability on root development and the commercial characteristics of carrot grow crops Nantes and Brasília Calibrated Average in protected environment. The study was conducted in a greenhouse at the State University of Goiás, Câmpus Ipameri. Sowing was carried out in July 2016, and the experimental design was a randomized block design, analyzed in a 2 x 5 factorial scheme with four replications. The treatments were composed of the cultivars (Brasília Calibrated Average and Nantes) x percentage of available water in the soil (20, 40, 60, 80 and 100%). The fresh and dried masses of the individual parts of the plants (root, leaf), length, diameter, commercial classification, yield and root defect were determined. The data obtained were treated with statistical analysis through the F test and when significant regression analysis was applied. Regarding the development, the carrot Nantes of carrot in protected environment the blade of 70% obtained the best data. For the cultivar Brasília Calibrada Average the slides between 70% and 80% presented satisfactory performance for the evaluated parameters. The cultivar Brasília Calibrada Meio, showed a higher percentage of increment for regression. For the commercial classification, size and absence of defect, the Nantes cultivar in the 40% blade was the one that presented the best.

KEYWORDS: *Daucus carota*, water available in the soil, commercial classification.

ANÁLISE COMERCIAL DAS CULTIVARES DE CENOURA BRASÍLIA CALIBRADA AMARELA E NANTES EM DIFERENTES REPOSIÇÕES HÍDRICAS

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RESUMO: O objetivo deste trabalho foi avaliar o efeito do estresse hídrico provocado pela redução da disponibilidade de água no solo sobre o desenvolvimento das raizes e as características comerciais das cultivares de cenoura em ambiente protegido. O estudo foi conduzido em casa de vegetação na Universidade Estadual de Goiás, Câmpus Ipameri. A semeadura foi realizada em julho de 2016, sendo adotado o delineamento experimental de blocos casualizados, com quatro repetições. Os tratamentos foram compostos por duas cultivares (Brasília Calibrada Média e Nantes) e o percentual de água disponível no solo (20, 40, 60, 80 e 100%).Determinaram-se as massas frescas e secas das partes individuais das plantas (raiz, folha), comprimento, diâmetro, classificação comercial, produtividade e raiz com defeito. Os dados obtidos foram tratados com análises estatísticas através do teste F e quando significativo aplicou-se a análise de regressão. Quanto ao desenvolvimento, a cultivar Nantes de cenoura em ambiente protegido a lâmina de 70% obteve os melhores dados. Para a cultivar Brasília Calibrada Média as lâminas entre 70% e 80% apresentaram desempenho satisfatório para os parâmetros avaliados. A cultivar Brasília Calibrada Média mostrou maior porcentagem de incremento para regressão. Para a classificação comercial, tamanho e ausência de defeito, a cultivar Nantes na lâmina de 40%, foi a que melhor se apresentou.

PALAVRAS-CHAVE: *Daucus carota*, água disponível no solo, classificação comercial.

INTRODUCTION

Originally from the region assigned to Afghanistan today, the carrot, *Daucus carota*, is a herbaceous plant, with a slightly perceptible stem, located at the point of insertion of the leaves, formed by thinly cut leaflets, with long and sharp petiole. The usable part is characterized by being a pivoting, tuberous, fleshy, smooth, straight and unbranched root, cylindrical or conical in shape and orange colored (FILGUEIRA, 2008).

According to the Food and Agriculture Organization of the United Nations - FAO, (2010) in Brazil approximately 750 to 800 thousand tons of carrot are produced with cultivation covering about 28 thousand hectares year^{-1} in the different regions of the country.

Nutritionally the carrot is a vegetable of high nutritive value, rich in carotene (provitamin A) (SAUNDERS; RAMALHO; LEAL, 2001). Approximately 100 grams of carrot in human food is sufficient to meet the daily needs of vitamin A, (about 5,000 to 15,000 International Units). It is currently the fifth most consumed vegetable in Brazil, and is cultivated worldwide

with the largest producers of China, the United States and Russia (RUBATZKY; SIMON, 1999). According Vieira et al. (2000) in spite of the preference to develop in mild climate the planting of the carrot has been expanding in the states of Bahia and Goiás.

The 21 kg^{-1} box of Class 1 carrot is being traded at the Goiás Food Supply Centers (CEASA - GO, 2017) according to the daily quotation from March 21, 2017 to R $ 1,429 kg with a maximum price of R $ 30.00. On that date, the product is being sold with a maximum price of R $ 20.93 and a minimum of R $ 17.33 according to the Company of Warehouses and General Warehouses of São Paulo (CEAGESP, 2017).

In studies Marouelli & Carrijo (1984) mention that vegetables have their development intensely influenced by soil moisture conditions. Being that water deficiency is one of the most limiting factors to obtaining high productivity and good quality products, but the excess also becomes harmful.

According to Makishima (1993) for most carrot crops, the use of irrigation water occurs indiscriminately, leading to problems of various natures. According to the author, too much water causes erosion and, consequently, the entrainment of nutrients; But its lack decreases the growth of plants, accelerates maturation and impairs the quality of the product. In addition to the low efficiency and excessive use of water in the field, especially in arid and semi-arid regions, where water is a very scarce input.

There are reports in some researches showing the effect of moisture levels on the soil on the productivity of vegetables and the quality of the products. In carrots, the root aspect, which is of fundamental importance at the time of its commercialization, is directly affected by soil moisture and temperature (MAROUELLI & CARRIJO, 1984).

In Piracicaba-SP, the water consumption in the carrot was evaluated and the authors obtained a total consumption of 365 mm in a vegetative cycle of 101 days with an average consumption of 3.61 mm day^{-1} and the culture coefficient was found to be 1.1 (MOURA et al., 1994).

Therefore, this study aimed to evaluate the effect of water stress caused by the reduction of soil water availability on root development and the commercial characteristics of carrot cultivars under protected environment.

MATERIAL AND METHODS

The experiment was conducted in the months of September to November of 2016 in a greenhouse installed at the State University of Goiás - UEG, Câmpus Ipameri. At 17º43 'south

latitude and 48º22' west longitude and 800 m altitude. The climate of the region according to the classification of Köppen is defined as Tropical Humid (AW), consisting of high temperatures with rains in summer and dry in winter.

Polyethylene pots with a capacity of 4 dm^3 were used. The soil used was classified as Red-Yellow Dystrophic Latosol (EMBRAPA, 2006). The soil was destroyed, passed in 2 mm sieve and homogenized. The application of chemical fertilizers to the vessels was carried out according to the methodology proposed by Novais et al. (1991) for controlled environment.

The soil moisture content in the field capacity (CC) at the tension of 0.01 MPa and the soil moisture at the permanent wilting point (PMP) at 1.5 MPa tension, as well as the soil density according to the methodologies of EMBRAPA (1997).

The experiment was installed in a randomized complete block design, analyzed in a 2x5 factorial scheme with four replications. The treatments were composed of the combination of cultivars (Cultivar 1 - Brasilia Calibrada Average) and (Cultivar 2 - Nantes) x percentage of available water in the soil (20, 40, 60, 80 and 100%). The water deficit was started 3 days after sowing to allow the establishment of the plants.

The irrigation slides were based on weighing lysimetry, placing a known volume of water. The irrigations were based on determination of the weight of each experimental unit in the field capacity. Before sowing, the vessels were saturated with water and left in free drainage until they reached the moisture in the field capacity. At the end of each day, the experimental units were weighed in an electronic scale, and the water required for each treatment, that is, in the 100% AD blade, will be returned to the initial weight (weight in the field capacity), A simple three rule was used to obtain the amount of water to be replenished in order to reach the amount of available water in the desired soil (20, 40, 60 and 80% AD).

In the experiment the commercial variables corresponding to the carrot (*Daucus carota*) were evaluated:

Root length: obtained by quantifying the longitudinal length of the root, with the aid of a graduated ruler, in the sampling of all roots per plot, expressed in cm.

• Fresh mass of shoot and root: obtained by quantifying the weight of all roots of each plot, expressed in grams.

• Aerial shoot and root dry mass: obtained after drying in a greenhouse with forced air ventilation in the period of 72 hours at 65ºC, and weighed in a semi-analytical balance.

• Root diameter: obtained by measuring the cross section of the root, with the aid of a digital caliper, with an accuracy of 0.01 mm, in all root samples per plot expressed in mm.

• Classification of commercial roots: According to the Brazilian Program for the Improvement of Commercial Standards and Packaging implemented by the Companhia de Entrepostos e Armazéns Gerais de São Paulo - CEAGESP, the carrot should be classified into Classes: 10 = roots of 10 cm ≤ C10 <14 cm; 14 = 14 cm ≤ C14 <18 cm; 18 = 18 cm ≤ C18 <22 cm; 22 = 22 cm ≤ C22 <26 cm; 26 = C26> 26.5 cm.

• Defective roots: considered serious (impair appearance, compromise quality or conservation such as: soft rot, deformation, dry rot, green / purple shoulder (> 10% of area), woody, wilted, pests or diseases , cracked, mechanical damage (> 10% of area)) and mild (those that do not impair or compromise both appearance, quality or conservation such as: inadequate cutting of the stem, presence of radicella, spots, green / purple shoulder (<10% of the area) and mechanical damage (<10% of the area). The results will be expressed as a percentage (CEAGESP).

• Total productivity: with the use of a precision scale, extrapolating the value to one hectare.

With the data obtained statistical analyzes were performed through the F test and when significant applied to the regression analysis.

RESULTS AND DISCUSSION

According to the analysis of variance (Table 1), it was verified if significant effects at 1 and 5% of probability for the total productivity, yield of commercial roots. It was observed a significant effect for all analyzed parameters, except for root length.

The effect of water stress (Table 1, Figures 1, 2) caused by the reduction of soil water availability on the root development of carrot cultivars under protected environment was more observed for cv. Nantes on the 80% blade. The roots when cultivated in this proportion of water stress, showed good development as the characteristics required for commercialization. In Brazil, roots between 14 and less than 18 cm in length (14 cm ≤ C14 <18 cm) are preferred by the consumer.

It can be observed in the present study that the applied slides were significant in the treatments for each cultivar, assuming a quadratic behavior regarding the water consumption per treatment. In studies about the preference of this root, in the city of Jaboticabal - SP, Oliveira et al. (2002), according to consumer preference and schooling, with regard to root length, 63% of the interviewees prefer carrots of class 14. Regarding the diameter, more than half (53%) of the consumers interviewed preferred carrots of the class 3.

The carrot has a great economic importance in the country, since it is one of the most produced vegetables in Brazil, and also is the flagship of production of many Brazilian states. Also, it is considered a horticultural very beneficial for health possessing a great amount of nutrients and vitamins that help in the well being and functioning of the human body. This time it is important to determine the increment caused by the water deficit in the cultivation of these roots so that the small producer can be offered the option of managing and using the water without damaging the quality and production of *Daucus carota*. It can be observed in Table 2 that the effect of water stress caused by the reduction of water availability in the soil on the commercial characteristics of carrot cultivars in protected environment were diverse in terms of management.

As for the classification, it was verified that the values were between 10, 14 and 18, for the Nantes cultivar in the 100 (10), 80 (14), 60 (18), 40 (14) and 20 (10) slides. For the determination of the defects and classification, it was verified that in the slides of 100 and 40% the roots produced were without defects. Slides of 80, 60 and 20% showed slight defects with the determination of the appearance of green shoulders (80%, 60%) and purple (20% slides).

When evaluating the cultivar Brasília Calibrada, the root classification was also around 10, 14 and 18 according to Table 1. The slides of 100, 80, 60, 40 and 20% presented Class of 18, 18, 14, 14 and 10, respectively. These values correspond to roots with a length of 18 to less than 22 cm in length; (18 cm ≤ C18 <22 cm); 14 to less than 18 cm in length (14 cm ≤ C14 <18 cm); Class 10 = roots with 10 to less than 14 cm in length (10 cm ≤ C10 <14 cm).

The roots obtained in the evaluation of the present study are in line with the demand of the Brazilian consumer market, since this Brazilian market has preference for well developed, cylindrical, smooth carrots, without lateral roots, with a diameter of 3-4 cm, length 15-20 cm, intense orange coloration, no shoulder and green or purple pigmentation on the upper part (Souza et al., 2002; Vieira & Pessoa, 2008). These values between 15 and 20 cm of root length can be observed in classes 10 with roots of at most 14 cm, 14 and 18 evaluated with greater predominance of roots in class 14 and 18, fact verified for both cultivars and blades object of the present study.

CONCLUSION

The cultivar Nantes presented better development in protected environment, the blade of 70% obtained the best performances in the evaluated questions. For the cultivar Brasília

Calibrated Average to lamina between 70% and 80% presented satisfactory performance for the evaluated parameters.

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Table 1. Variables analyzed for carrot cultivars Brasília Calibrada Mean and Nantes: root length (RL), root diameter (RD), fresh shoot mass (FSM), fresh root mass (FRM), dry aerial mass (DAM), root dry mass (RDM) and Productivity (Produt), Total fresh mass (TFM), Total dry mass (TDM), depending on the application of different irrigation strips. Ipameri - GO, 2017.Chemical composition of nutrient stock solution in molar (M), and treatments, in mL L^{-1}, used in this study, Sarruge (1975).

Cultivar	Blade	RL	RD	FSM	FRM	TFM	DAM	RDM	TDM	Produt
	%	cm	mm			g				Kg
Nantes	100	13,00	16,46	7,65	16,32	23,97	1,61	2,58	4,20	7,65
Nantes	80	17,67	20,16	9,97	28,30	38,27	2,04	3,17	5,21	9,98
Nantes	60	13,00	23,28	9,65	21,81	31,46	1,59	2,84	4,42	9,65
Nantes	40	14,67	19,26	8,02	20,02	28,04	1,59	2,20	3,79	8,02
Nantes	20	11,67	11,75	2,48	5,59	8,06	0,75	1,06	1,81	2,48
Test F		1,73^{ns}	8,28**	12,62**	7,93**	13,58**	5,10*	4,12*	6,65*	12.67**
C.V. %		21,67	14,37	19,43	27,99	20,45	23,71	29,28	21,94	19,4
Brasília	100	20,00	23,53	10,99	39,46	50,45	1,72	5,10	6,82	10,99
Brasília	80	19,00	25,29	12,27	36,56	48,83	2,26	4,68	6,94	12,27
Brasília	60	17,00	25,45	8,80	42,92	51,72	1,59	5,61	7,19	8,80
Brasília	40	16,00	22,14	9,59	29,74	39,33	1,65	4,21	5,86	9,59
Brasília	20	11,00	11,03	2,57	7,7	10,28	0,71	1,07	1,78	2,57
Test F		13,18**	10,61**	6,99*	11,05*	15,01*	4,57*	10,01**	16,09*	6,99*
C.V. %		10,08	14,86	27,77	23,39	19,37	28,47	23,66	17,04	27,77

CV: Coefficient of variation. **, * and ns: significant at 1% and 5% and not significant by the F test.

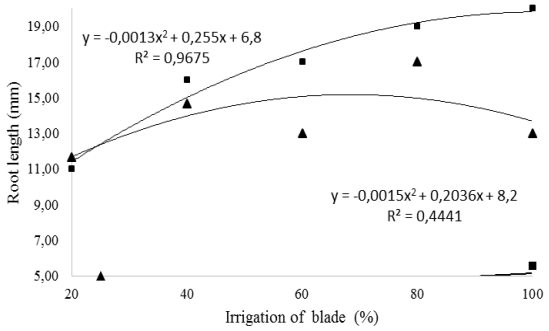

Figure 1 – Root length polynomial function (cm) for carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri -GO, 2017.

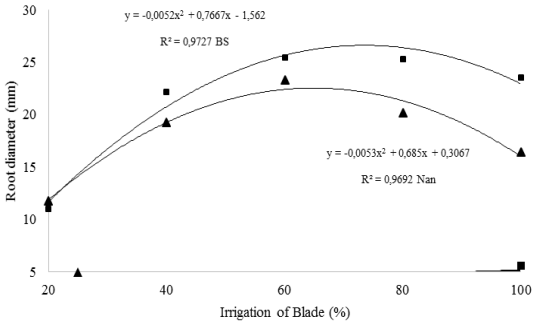

Figure 2 – Polynomial function root diameter (cm) for carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri -GO, 2017.

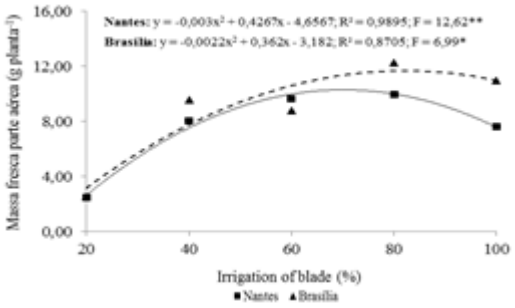

Figure 3 – Polynomial function for fresh shoot mass (g) of carrot cultivars Brasília Calibrada Média and Nantes in different% of irrigation slides. Ipameri -GO, 2017.

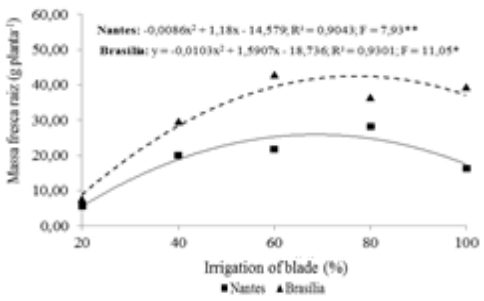

Figure 4 – Polynomial function for the fresh root mass (g) for carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri -GO, 2017.

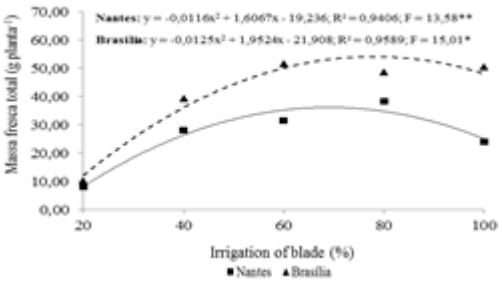

Figure 5 – Polynomial function for the total fresh mass (g) of carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri -GO, 2017.

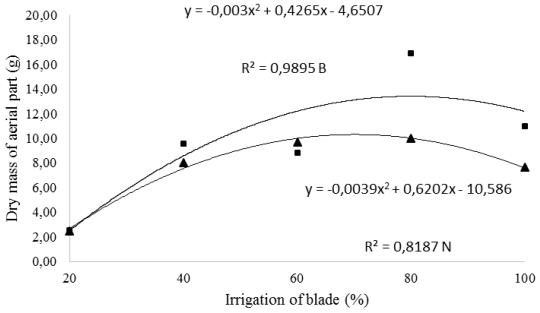

Figure 6 – Polynomial function for aerial shoot dry matter (g) for carrot cultivars Brasília Calibrada Média and Nantes in different irrigation slabs%. Ipameri -GO, 2017.

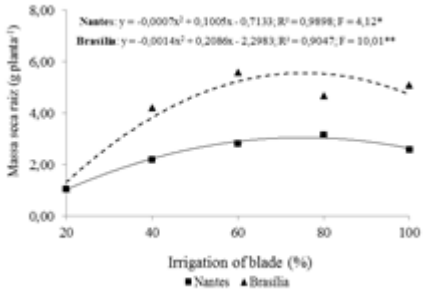

Figure 7 – Polynomial function for root dry mass (g) of carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri - GO, 2017.

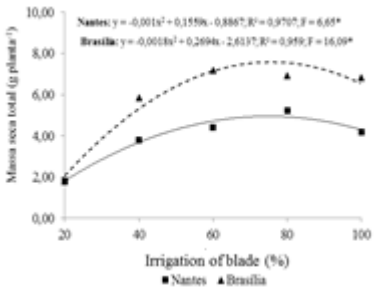

Figure 8 – Polynomial function for aerial shoot dry matter (g) for carrot cultivars Brasília Calibrada Média and Nantes in different irrigation slabs%. Ipameri - GO, 2017.

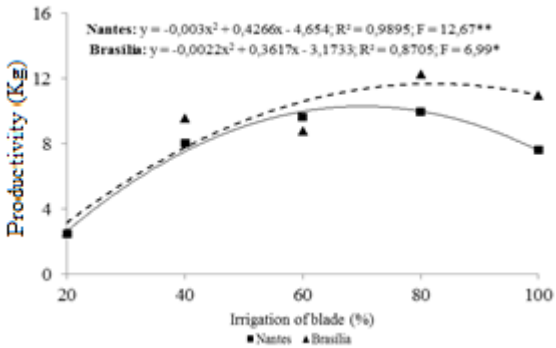

Figure 9. Polynomial function for productivity (g) of carrot cultivars Brasília Calibrada Mean and Nantes in different% of irrigation slides. Ipameri - GO, 2017.