



Acta Scientiarum. Agronomy

ISSN: 1679-9275

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Universidade Estadual de Maringá
Brasil

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Acta Scientiarum. Agronomy, vol. 36, núm. 3, julio-septiembre, 2014, pp. 317-321

Universidade Estadual de Maringá
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Distribution of the root system of peach palm under drip irrigation

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ABSTRACT. The incorporation of technologies has resulted in increased productivity and the more rational management of peach palm, with irrigation being an important tool for certain regions. Thus, studies leading to proper crop management are extremely important, such as the estimate of the effective depth of the root system, which is indispensable for proper irrigation management. The objective of this study was to evaluate the effects of different irrigation depths, as applied by drip irrigation, on the distribution of the root system of peach palm. This experiment was conducted in Ilha Solteira, São Paulo State, Brazil, with drip irrigation, with the two systems (flow of 0.0023 m³ h⁻¹) consisting of four irrigation treatments corresponding to 0, 50, 100 and 150% of Class 'A' pan evaporation. After five years, an analysis of the *Bactris gasipaes* root system was performed at a distance of 0.0, 0.5 and 1.0 meters from the trunk, collecting sampling at two depths (0.0 to 0.3 m and 0.3 to 0.6 m) via the auger method (volumetric analysis). We concluded that the effective depth of the root system used for irrigation management should be a maximum of 0.3 meters.

Keywords: *Bactris gasipaes*, roots, localized irrigation, irrigation management.

Distribuição do sistema radicular da pupunheira irrigada por gotejamento

RESUMO. A incorporação de tecnologias vem trazendo aumento de produtividade e manejo mais racional da pupunheira, sendo a irrigação uma ferramenta importante para algumas regiões produtoras. Nesse sentido, estudos que levem ao manejo adequado da cultura são de extrema importância, como a estimativa da profundidade efetiva do sistema radicular da cultura, indispensável para o correto manejo de irrigação. O objetivo deste trabalho foi avaliar os efeitos de diferentes lâminas de irrigação, aplicadas por gotejamento, sobre a distribuição do sistema radicular da pupunheira. Este experimento foi conduzido em Ilha Solteira, Estado de São Paulo, com irrigação por gotejamento, com dois gotejadores autocompensantes de 0,0023 m³ h⁻¹ por planta, constando de quatro tratamentos de irrigação que corresponderam a 0, 50, 100 e 150% da evaporação da água do tanque Classe 'A'. Após cinco anos, foi realizada a análise do sistema radicular das pupunheiras, à distância de 0,0; 0,5 e 1,0 metro do estipe, com amostragens em duas profundidades, de 0,0 a 0,3 m e 0,3 a 0,6 m, pelo método do trado (análise volumétrica), concluindo-se que a profundidade efetiva do sistema radicular da pupunheira, utilizada para o manejo da irrigação, deve ser de, no máximo, 0,3 metro.

Palavras-chave: *Bactris gasipaes*, raiz, irrigação localizada, manejo da irrigação.

Introduction

Hernandez et al. (2001) noted that the current methods for the production of peach palm hearts are still predominantly based on irrational exploitation and extraction, a fact that is causing the extinction of the production species, particularly when considering the very long life cycle of these trees.

As indicated by Fernandes et al. (2002), peach palm is cultivated in different regions of Brazil, but predominantly in Southeast Brazil. The expansion of cultivated areas, including the semi-arid region, has been accompanied by an advance in technology,

with the use of liming, fertilization and irrigation, and these techniques have enabled more rapid production.

With the use of irrigation, as shown by Marques and Coelho (2003), peach palm has proved to be an excellent economical choice for both human consumption and for use in animal feed (ALVES JÚNIOR et al., 2004, 2005; LOPES et al., 2004; RODRIGUES NETO et al., 2001).

Earliness is a great stimulus to the cultive peach palm, because the harvest initial is at around 18 months, generating a more rapid financial return. Furthermore, due to the uneven distribution of

rainfall and the very shallow root system of this plant with a high economic value, the practice of irrigation can provide a higher production yield (ROSA et al., 2004).

A knowledge of the quantity, quality and distribution of roots is useful in agricultural production to provide information on the location of fertilizer application, spacing, intercrops, soil management and irrigation (FRACARO; PEREIRA, 2004).

The root systems of palms are generally composed of primary, secondary, tertiary and quaternary roots, all lacking absorbent hairs (JOURDAN; REY, 1997).

According to Fante Júnior et al. (1994) the assessment of such factors as the volume of soil explored, root length and root activity is a difficult task, and great difficulties are encountered in any sampling technique, including the time spent, limited information obtained and great variability of results. According to Vasconcelos et al. (2003), a perfect method for evaluating roots does not exist because the suitability of a method for the evaluation of the root system depends on the in situ conditions.

The objective of the present study was to evaluate the effects of different irrigation levels estimated by the Class 'A' pan method, as applied by drip irrigation, on the distribution of the root system of *Bactris gasipaes* in Ilha Solteira, the northwest region of the State of São Paulo, Brazil.

Material and methods

This work was conducted at the Experimental Area of Irrigated Agriculture, Ilha Solteira, São Paulo State, Brazil, Engineering Faculty of the UNESP - Universidade Estadual Paulista. The geographical coordinates are 20°25'23"S and 51°21'13"W, and the average elevation is 335 m. According to the Köppen classification, the climate is type Aw, defined as tropical humid with a rainy season during the summer and a dry winter; the average annual precipitation is 1,259 mm, the mean annual temperature is 24.7°C, and the mean annual insolation is 7.4h day⁻¹. The soil in the area is classified as Acrisol; the particle size is shown in Table 1.

Table 1. Granulometric analysis of the soil of experimental area (Ilha Solteira, Brazil).

Deep (m)	Sand (%)	Clay (%)	Silt (%)	Classification
0.00 – 0.15	85.5	10.5	4.0	Sandy
0.15 – 0.30	84.5	11.0	4.5	Sandy
0.30 – 0.45	82.0	14.5	3.5	Sandy
0.45 – 0.60	80.5	17.5	2.0	Sandy

Peach palm seedlings were planted in 1993 at a spacing of 2.0 x 1.0 m, and irrigation was performed by two drip irrigation systems with a flow of 0.0023 m³ h⁻¹. The irrigated treatments received fertigation four times a year, according to the soil analysis and recommendations of Bovi and Cantarella (1996).

The experimental design was completely randomized in a 4 x 3 x 2 factorial scheme of four irrigation treatments at three distances from the stem and two depths, with four replications. The treatments were implemented based on the replacement of Class 'A' pan evaporation (CAE) corresponding to no irrigation (NI), 50% CAE, 100% CAE and 150% CAE.

An analysis of the root system of peach palm was performed in November 1999 when the adult plants were five years old and considered to have a stable root system. The sampling occurred at 0.0, 0.5 and 1.0 m from the trunk, between the planting lines, and at two depths, 0.0 to 0.3 m and 0.3 to 0.6 m. For this purpose, an auger was used, and both the soil and roots were collected in a receptacle of known volume (4.03 dm³); the material (root + soil) was washed in the laboratory and dried in an oven at 65°C for 48h.

The results were expressed in grams of roots per cubic decimeter of soil (g dm⁻³); the data were subjected to an analysis of variance, and the means were compared using the Tukey test at a 5% probability. The selection of the equation of best fit was based on the significance of the regression effect, the deviations of the regression tested by the F-test at 5% and the highest coefficient of determination (R²).

Results and discussion

The drip irrigation system used resulted in an elevated soil moisture in the monitored area, which was between the planted rows. An understanding of the wet bulb area, the movement of water in the soil via percolation and the extraction by the plants as functions of the treatment is necessary for studying a root system under drip irrigation.

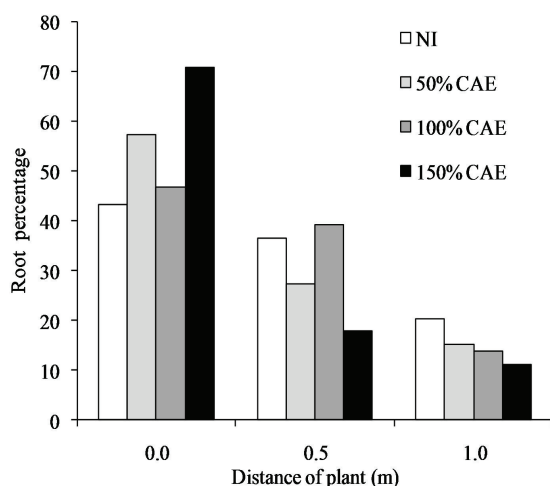
Table 2 shows that there was an increase in the amount of dry root biomass as the irrigation depth increased, results that are consistent with those of Reichardt (1993), reporting that the root system of a plant is proportional to the soil moisture. Reichardt and Tim (2004) also reported that the amount of water absorbed by plants is a function of both the water potential in the soil and also the ability of the roots to absorb water from the soil with which they are in contact, in addition to soil properties for the provision and transmission of water to the roots at a rate that meets the requirements of transpiration.

Table 2. Dry root mass referring to the irrigation treatments, distance from the trunk and depth of the root system of peach palm⁽¹⁾ (Ilha Solteira, Brazil).

Distance (m)	Deep (m)	NI ⁽¹⁾		50%CAE		100%CAE		150%CAE	
		g dm ⁻³	%	g dm ⁻³	%	g dm ⁻³	%	g dm ⁻³	%
0	0.00 – 0.30	1.78	35.79	4.23	52.05	4.11	43.61	8.19	65.62
	0.30 – 0.60	0.37	7.44	0.43	5.35	0.30	3.24	0.64	5.15
0.5	0.00 – 0.30	1.27	25.44	2.00	24.64	3.52	37.38	2.16	17.27
	0.30 – 0.60	0.55	11.04	0.23	2.84	0.19	2.02	0.08	0.68
1.0	0.00 – 0.30	0.86	17.31	1.10	13.55	1.17	12.47	1.23	9.88
	0.30 – 0.60	0.15	2.98	0.13	1.57	0.12	1.29	0.17	1.40
Total	-	4.98	100	8.12	100	9.42	100	12.48	100

⁽¹⁾No irrigation (NI), 50% evaporation of the Class A pan (50%CAE), 100% of the evaporation of the Class A pan (100% CAE) and 150% of the evaporation of the Class A pan (150% CAE).

Although the root system of peach palms is very shallow, a better root distribution was observed (in percentage) without irrigation (NI). In all of the treatments studied (except NI), over 90% of the roots were found at depths from 0 to 0.3 m, which indicates that 0.3 m is the effective depth of the root system for the purpose of irrigation management. This value was higher than that found by Ramos et al. (2009), who reported that 65% of the root system of this palm is concentrated in the top 0.2 m of soil, noting that this depth can be considered for the proper management of water and fertilizer applications. However, in the present study, there was a decrease in the root content when approaching the middle of the row (Figure 1).

**Figure 1.** Percentage of roots in relation to distance from the trunk of the palms and irrigation treatments; No irrigation (NI), 50% of the evaporation of the Class A pan (50% CAE), 100% of the evaporation of the Class A pan (100% CAE) and 150% of the evaporation of the Class A pan (150% CAE) (Ilha Solteira, Brazil).

It can be observed in Table 3 that there was interaction effect between the irrigation treatment and the root depth and for the treatment of root depth and irrigation, resulting in significant differences for the interaction between the treatments of root depth in all of the irrigation levels studied in this work.

Table 3. Interaction of the treatment for irrigation and root system depth of peach palm for the root dry mass⁽¹⁾ (Ilha Solteira, Brazil).

Deep (m)	NI ¹	50% CAE	100% CAE	150% CAE
	g dm ⁻³			
0.00-0.30	1.30aC	2.44aB	2.93aAB	3.86aA
0.30-0.60	0.36bA	0.26bA	0.21bA	0.30bA

¹Averages followed by different lower case letters in the column and upper case letters in the line differ among themselves at the probability level of 5% by the Tukey test. No irrigation (NI), 50% of the evaporation of the Class A pan (50% CAE), 100% of the evaporation of the Class A pan (100% CAE) and 150% of the evaporation of the Class A pan (150% CAE).

The root dry mass at a depth of 0.0 to 0.30 m showed a linear response, increasing with the increase of the systematic provision of water based on the CAE and treatment with application of 150% CAE averaged 3.86 g dm⁻³.

In evaluating the development of the root system of peach palm in the field, Vega et al. (2005) found that the root system in one year-old trees was concentrated mostly in the topsoil (0.0-0.2 m deep) and at distances up to 0.5 m from the plant, as also indicated in the present study. This palm species exhibited a high concentration of roots near the stem and at shallow depths (Figure 2).

Under the conditions of the study area, irrigation management should prevail, with the adoption of a more frequent irrigation frequency such that there is no percolation of water in the soil profile and, therefore, no accumulation of water below the effective depth of the root system.

With the irrigation managements NI, 50% CAE, 100% CAE and 150% CAE, the proportions of the total dry root mass in the 0.0 to 0.3 m layer were 78.3, 90.4, 93.3 and 92.8%, respectively. When evaluating peach palm in sandy and clayey texture soils in the São Francisco valley in the semi-arid region of northeastern Brazil, Bassoi et al. (1999) observed that the root system of peach palm grown at a spacing of 2.0 x 1.0 m and with irrigation performed by farrows presented shallow rooting and that approximately 90% of the roots were concentrated in the top 0.4 m of the soil.

Figure 2 shows the linear regression equations of decreasing root dry mass for each irrigation management as a function of the distance from the

trunk. It can be noted that the dry mass between the treatments of 50% CAE and 100% CAE showed a negligible variation at 0 m from the trunk. In contrast, at one meter away from the trunk of peach palm, all of the irrigation management treatments showed similar root dry weights, such that this was most likely not influenced by the irrigation.

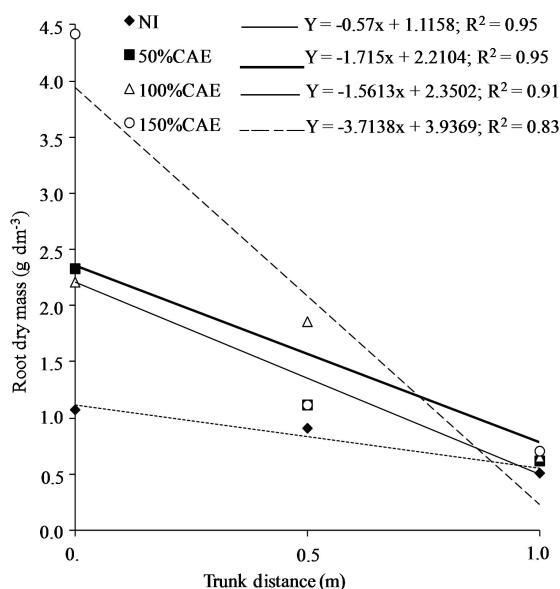


Figure 2. Root dry mass as a function of the distance from the trunk of peach palm in relation to the irrigation treatment. No irrigation (NI), 50% of the evaporation of the Class A pan (50% CAE), 100% of the evaporation of the Class A pan (100% CAE) and 150% of the evaporation of the Class A pan (150% CAE) (Ilha Solteira, Brazil).

Ferreira et al. (1995) observed by regression analysis that the mass of the root system of peach palm decreases dramatically at a distance exceeding 0.50 m from the trunk. Bassoi et al. (2003) observed that a depth maximum rooting of 0.40 m at 6 months and 1.0 m at 12 and 24 months after planting. Furthermore, between rows, these authors reported that the roots reached a distance of 0.6 m from the trunk at 6 months after planting but the presence of the root system was observed at a distance of 1.0 m from the stem after 12 months, indicating entanglement among the roots of neighboring plants. This was also observed in all of the treatments of the present study. However the strategy of irrigation management should be to provide a water supply to the surface layer (up to 0.3 m); in the case of drip irrigation, this should be performed close to the trunk, not exceeding 0.5 m. For a better efficiency of water use, irrigation should be performed frequently, preferably daily for drip irrigation in Acrisol and at least every 5 days for sprinkler irrigation.

It can be observed in Table 3 that the root dry mass was influenced by the interaction between the irrigation treatment and the depth of 0.0 to 0.3 m. The NI treatment showed the lowest value, differing from the other irrigation treatments and showing a difference of 1.14, 1.63 and 2.56 g dm⁻³ in relation to treatments 50% CAE, 100% CAE and 150% CAE, respectively. It may be noted that, at a 5% probability, the irrigation treatments did not influence the root dry mass for the depth of 0.3 to 0.6 m.

Conclusion

It is recommended that the effective depth of the root system used for irrigation management in peach palm, which is at maximum 0.3 meters.

Acknowledgements

To FAPESP for the scholarship and financial support, allowing that this study be carried out.

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Received on March 7, 2012.

Accepted on October 3, 2012.

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