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RESEARCH ARTICLE

COWPEA GROWTH AND PRODUCTION UNDER DIFFERENT LEVELS OF AVAILABLE WATER AND SOIL COVER

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ABSTRACT

This study aimed to evaluate the productive performance of cowpea, cv. 'BRS Pujante', under the influence of different levels of available water in the soil with and without mulch. The experiment was conducted under plastic tunnel conditions at the Federal University of Campina Grande, Campus of Pombal, from December 2014 to mid-March 2015. The experimental design was completely randomized in a 5 x 2 factorial scheme, which corresponded to levels of available water (AW) of 20, 40, 60, 80 and 100%, maintained after irrigations of the soil, with (WM) and without (WOM) mulch, with 10 treatments and 4 replicates, totaling 40 experimental units. Plants were analyzed for: leaf area, number of pods, number of grains per pod, 100-grain weight and production per plant. The growth and production components of 'BRS Pujante' cowpea are influenced by the levels of available water and soil cover. The highest growth and production of 'BRS Pujante' cowpea plants were observed at the mean levels of 80 and 100% of available water in the soil with and without mulch, respectively. Mulching reduces water consumption of 'BRS Pujante' cowpea plants, promoting satisfactory production at lower levels of available water in relation to the soil without mulch.

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INTRODUCTION

Cowpea(*Vigna unguiculata*(L.) Walp), also known as 'macassar', 'feijão-de-corda', 'feijão-fradinho', 'feijão-de-praia', 'feijão gerutuba', 'feijão-trepa-pau' and 'feijão miúdo', is a leguminous species cultivated by small, medium and large producers (Guedes, 2008). In the last years in Brazil, there have been expansion in the area and increase in the consumption of cowpea, which became an excellent alternative of commercialization for the farmers of the North, Northeast and Midwest regions of Brazil (Nascimento, 2009). In general, the Brazilian bean production in the 2014/15 season was 3,112.2 million tons, which maintained the country as the largest global producer of this grain and, regarding the Northeast region, this shows that, despite the largest planted area of the country (1,565.3 ha), it has only the second highest production (709.2 thousand tons), a fact that is explained by the low yield, compared with those of other regions;the mean yield of the Midwest region is 1,863 kg ha^{-1}, against 453 kg $ha^{-1}$of the Northeast (Conab, 2015).Cowpea yield can vary from 300 to 900 kg ha^{-1}, which is considered low, especially due to factors such as climatic conditions and use of cultivars with low yield, associated with the lack of information of the farmer (Rodrigues *et al*., 2013). This low yield may be related to its cultivation, predominantly performed under rainfed conditions, which causes the irregularity of rains and high temperatures to promote a considerable water deficit, because the increasing level of water deficit drastically affects its performance, causing alterations in the properties of the membranes, increase in respiration, inhibition of photosynthesis, lower dry matter production, premature senescence and, as a consequence, reduction in production and its components (Tagliaferre *et al*., 2013; Duarte *et al*., 2013; Pereira Junior *et al*., 2015).Currently, this plant has emerged as a new option for irrigated cultivation in the Northeast (Teles *et al*., 2013). Thus, for an adequate water management, aiming at high yields, it becomes necessary to know the capacity of response to water deficit levels, as well as the relationship between water consumption and yield (Cattivelli *et al*., 2008; Anjum *et al*., 2011).

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Besides the irrigation management, cultivation practices such as soil mulching bring gains in the water use efficiency of the plants (Bizari *et al*., 2009; Simidu *et al*., 2010), since the use of mulch on soil surface in adequate amount creates a physical barrier that prevents the direct incidence of solar radiation on the soil, reducing the evapotranspiration rate of the crops, for not allowing the soil to heat and increase energy availability, especially in stages in which the canopy does not cover the soil completely, which results in reduction of irrigation frequency and saving in the operation costs of the system (Stone *et al*., 2006; Locatelli *et al*., 2014), besides favoring biological activity. Given the above, this study aimed to evaluate the productive performance of cowpea, cv. 'BRS Pujante', under the influence of different levels of available water in the soil with and without mulching.

MATERIALS AND METHODS

The experiment was carried out under conditions of plastic tunnel at the Federal University of Campina Grande, Campus of Pombal, from December 2014 to mid-March 2015. The municipality is geographically located at longitude 37º 48'06''W and latitude - 06°46'13''S, with mean altitude of 184 meters. The climate in Pombal, based on the international classification of Köppen, was included in the Bsh type (semi-arid), hot and dry, with rains of summer and autumn and mean annual rainfall of 800 mm, with interannual variability. The months of February, March and April are the rainiest ones, in which 60 to 80% of the total annual rainfall concentrates. It has mean monthly temperatures varying from 23.40 to 27.90 °C, with maximum monthly values of 35.70 °C in December and minimum of 19.30 °C, in July and August.The treatments were arranged in a 5 x 2 factorial scheme, corresponding to levels of available water (AW) of 20, 40, 60, 80 and 100%, maintained after irrigations of the soil, with (WM) and without (WOM) mulch, with 10 treatments and four replicates, totaling 40 experimental units. The experiment was performed in experimental units, which consisted of pots with capacity for 12 dm^3, manually sown with four seeds each.

The soil was classified according to the Brazilian Soil Classification System (Embrapa 2013) as Fluvic Neosol, with mean granulometric composition of 795 g kg^{-1} of sand, 117 g kg^{-1} of silt and 88 g kg^{-1} of clay, and the following chemical attributes in the layer of 0-20 cm: pHH_2O = 8.2; OM = 0 g dm^3; P = 1494 mg dm^{-3}; H+Al = 0.0 $cmol_c.dm^{-3}$; K = 0.51 cmolc dm^{-3}; Ca = 7.8 cmolc dm^{-3}; Mg = 2.7 cmolc dm^{-3}; SB = 11.2 cmolc dm^{-3}; CEC = 11.2 cmolc dm^{-3}; and base saturation of 100%. Basal fertilization was performed according to the soil analysis and the technical bulletin of fertilization recommendation for the state of Pernambuco (CAVALCANTI *et al*., 2008) and consisted in the application of 60 kg ha^{-1} of P_2O_5 and 40 kg ha�1 of K_2O, in the forms of single superphosphate and potassium chloride, respectively. Twenty days after sowing, 20 kg ha�1 of N were applied as top-dressing in the form of urea.Four seeds of cowpea, cv. 'BRS Pujante', were planted in each pot at a depth of 2 cm and the emergence of the seedlings stabilized on the fifth day after sowing. Thinning was performed 15 days after sowing (DAS), leaving the most vigorous plant. After sowing, the soil was covered with leaves of 'Pau Ferro' (*Caesalpinia leiostachya* (Benth.) Ducke) as mulch on soil surface, using 40 g of dry leaves per pot, which resulted in a layer of 3 to 5 cm. Cultivation practices were performed to maintain the crop free from weeds, diseases and pests during the experiment. Irrigations were daily performed with a uniform volume of water (EC_w = 0.3 dS m^{-1}), according to the mean evapotranspiration in the control treatment, obtained through weighing. The volume applied (Va) per pot was obtained by the difference between the mean weight of the pots at maximum water retention (W_{fc}) – determined by saturating the pots with water and subjecting them to drainage; when the drained volume stabilized, the containers were weighed, thus determining the W_{fc}, i.e., the weight of the containers at maximum water retention – and the mean weight of the containers at the actual condition (W_a), divided by the number of containers (n), as indicated in equation 1:

$$Va = \frac{Wfc - Wa}{n} \text{Eq.} \quad 1$$

At 60 DAS, cowpea plants were evaluated for growth through the determination of leaf area, using a portable leaf area (m^2) meter (LICOR - 3100C).At 80 DAS, plants were evaluated for production, through the determination of the number of pods per plant (NP/P), number of grains per pod (NG/P), 100-grain weight (100GW) (g) and production per plant (P/P) (g). The number of pods was determined through manual count of the number of pods produced in each plant and the number of grains through the mean number of grains of five pods collected in each plant. The weight of 100 grains was calculated based on the five randomly collected pods, according to the following equation:

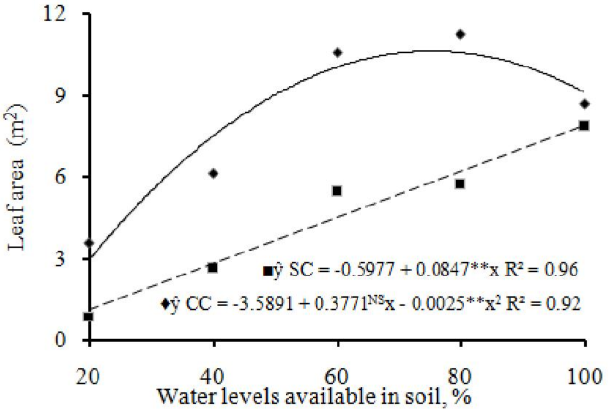
$$100GW = \frac{GW5P}{NG5P} x\ 100 \ \text{Eq.} \quad 2$$

Where: GW5P = grain weight of 5 pods and NG5P = number of grains of the 5 pods.

Number of grains per pod (NG/P): Number of grains of five pods randomly collected.The effects of levels of available water (AW) and mulch (M)and the interaction AW versus M were statistically evaluated through analysis of variance. Regression analysis was applied for variables for which the levels of AW, M or the interaction of AW x M were significant, according to the F test. This analysis tested linear and quadratic models, selecting the model that was significant at 0.05 probability level and with highest correlation coefficients for the obtained data, to express the behavior of each variable. The program SISVAR was used for the statistical analysis.

RESULTS AND DISCUSSION

There was significant influence ($p<0.05$) of the interaction between the levels of available water in the soil and the soil cover for all evaluated components, except for 100-grain weight, which was influenced only by the applied levels of water deficit, indicating that the water stress significantly influenced the production of 'BRS Pujante' cowpea (Figures 1, 2 and 3). There was an increment in leaf area (LA) due to the increase in irrigation depth, with an increasing linear behavior for plants cultivated in soil without mulch, on the order of 1.69 $m^2$for every20%increase inavailable water (AW) (Figure 1). For Correia & Nogueira (2004), the reduction in total leaf area of plants under water stress can be attributed to a survival strategy, decreasing the area available for the process of transpiration. In general, leaf area presents itself as an important parameter in the determination of the photosynthetic capacity of the crops (NASCIMENTO, 2009). According to Larcher (2000), the reduction in water loss due to the decrease in the transpiration surface of the plant is one of the behavioral measures of resistance to water deficit. In the present study, this was also observed for the cv. 'BRS Pujante', especially in the treatments with levels of 20 and 40% of available water in the soil.

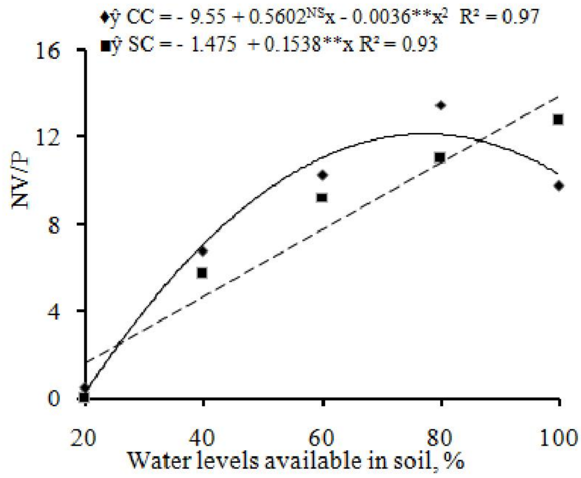


NSand ** = not significant and significant at 0.01 probability level (p<0.01), respectively.

Figure 1. Leaf area (cm^2) of cowpea, cv. 'BRS Pujante', at 60 DAS, cultivated under different levels of available water in soil with (WM) and without (WOM) mulch

The leaf area of plants cultivated in soil with mulch showed a quadratic response as a function of the availability of water in the soil, and the highest value (10.63 m^2) was observed for the estimated availability of 75% AW (Figure 1). The reduction of leaf area in plants cultivated in soil with mulch at water availability levels above 75% is possibly related to the lower aeration of the soil, since the use of mulch on soil surface creates a physical barrier that prevents the direct incidence of solar radiation on the soil, reducing the evapotranspiration rate of the crops and maintaining soil moisture higher for a longer time (Stone *et al*., 2006, Locatelli *et al*., 2014).There was an increment in NP/P as water availability increased, with maximum production of 12.9 and 13.9 pods per plant, on average, at the levels of 78.9 and 100% AW in the soil with and without mulch, respectively (Figure 2A). In the comparison of the results, 'BRS Pujante' cowpea plants cultivated in the soil with mulch maintained with 78.9% AW obtained production similar to that of plants cultivated in soil without mulch with 100% AW. This response can also be attributed to the reduction in soil temperature, which does not occur in conventional systems without mulch, because they have large oscillations, with high peaks of temperature (Simidu *et al*., 2010). These results corroborate those observed by Locatelli *et al*. (2014), who reported means of 12 pods per plant with the increment of irrigation depths in the cultivars 'BRS Guariba', 'BRS Novaera' and 'BRS Pajeú'. However, when the cowpea plants were subjected to water deficit at the conditions of 20 and 40% AW, there were drastic reductions in the production of viable pods. This fact was expected, since the main component affected by water deficiency is the number of pods (Nascimento *et al*., 2004).

There was a quadratic response of the number of grains per pod (NG/P) as a function of the increase in AW in the soil, with maximum production of 11.9 and 9.7 grains per pod, on average, at levels of 92.1 and 75.4% AW, in the soil with and without mulch, respectively (Figure 2B). The high yield for the soil saturated by water may have occurred because cowpea is classified as a crop moderately tolerant to the excess of water in the soil (Boyer 1978, Nascimento 2009). These results were similar to those found by Locatelli *et al*. (2014) and Santos *et al*. (2009), who observed means of 7.96 and 12.5 grains per pod, respectively.



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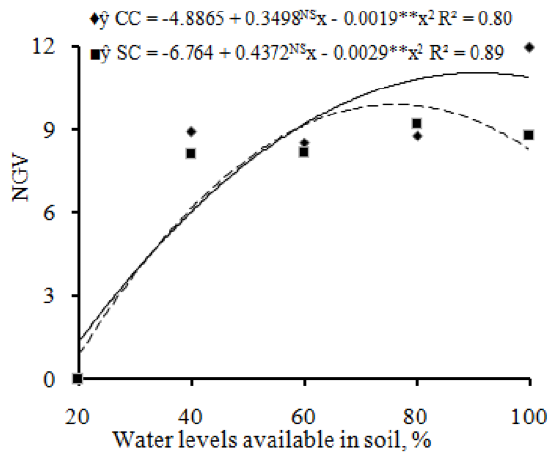
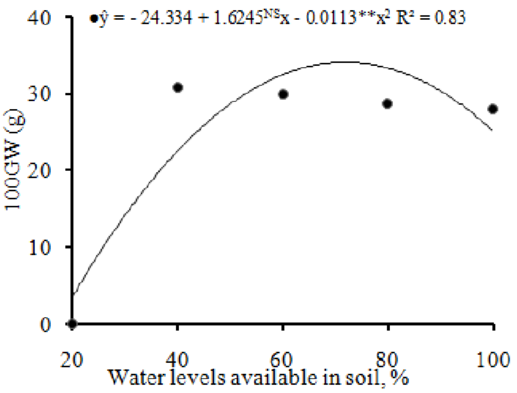


B

NS, * and ** = not significant and significantat 1 and 5% ($p <0.01$ and $p <0.05$) probability, respectively.

Figure2. Number of pods per plant-NP/P (A) and number of grains per pod-NG/P (B) of cowpea, cv. 'BRS Pujante', at 60 DAS, cultivated under different levels of available water, in soil with (WM) and without (WOM) mulch

As to the 100-grain weight, there was influence from the levels of available water, regardless of soil cover condition, with maximum grain weight (34.1 g) obtained at the estimated level of 71.9% AW (Figure 3A). Results lower than those of the present study were reported by Vilarinho *et al*. (2009), Santos *et al*. (2009) and Locatelli *et al*. (2014), who observed mean 100-grain weights of 20.11, 23.51 and 22 g, respectively. In addition, at levels lower than 40% AW, 100GW was drastically reduced, which is due to the effects of water deficit (Figure 3A), reducing the photosynthetic rate, causing decrease in plant growth and affecting grain formation and development, but without stopping it (Ramos *et al*., 2012; Arruda *et al*., 2015). In study conducted by Freitas *et al.* (2014), they observed that the water stress in both soil cover and conventional systems negatively affects the dry weight of cowpea grains, being a determinant factor in the physiological quality of the grain.



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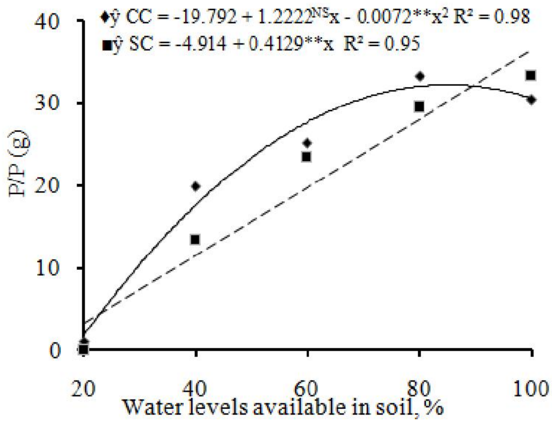

NS, * and ** = not significant and significantat 1 and 5% ($p < 0.01$ and $p < 0.05$) probability, respectively.

B

Figure 3.100-grain weight-100GW (A) and production per plant-P/P (B) of cowpea, cv. 'BRS Pujante' at 60 DAS, cultivated under different levels of available water, in soil with (WM) and without (WOM) mulch

The production per plant showed a response similar to that of leaf area (Figure 1)and the number of pods and grains (Figures 2A and B). The results observed for leaf area (Figure 1) and production components (Figures 2 and 3) are similar to those reported by Bastos *et al.* (2012), who evaluated different water regimes in the cowpea crop and concluded that the increase in LA has a positive correlation with grain yield. In addition, at levels lower than 60% AW, the water stress was very intense, reducing the production to zero at the level of 20% AW (Figure 3B). Increasing levels of water deficit drastically affect the performance of the plant, causing alterations in the properties of the membranes, increase in respiration, inhibition of photosynthesis, lower dry matter production, premature senescence and, as a consequence, reduction in the production and in its components (Tagliaferre *et al*., 2013; Duarte *et al*., 2013; Pereira Junior *et al*., 2015).There was an increasing linear response of the plants cultivated in soil without mulch as a function of the increase in AW levels, with increment of 8.3 g for every 20% increase in water availability (Figure 3B). In the cultivation with mulch, plants responded quadratically to the increase in AW levels, with maximum production (32.1 g) estimated at the level of 84.9% AW (Figure 3B). The linear behavior observed in plants cultivated in soil without mulch is due to the high daily evapotranspiration demand, reducing the water availability more rapidly in relation to plants cultivated in soil with cover (Bertino *et al*., 2015).

Conclusions

Growth and production components of cowpea, cv. 'BRS Pujante', are influenced by the levels of available water and soil cover. The highest growth and production of 'BRS Pujante' cowpea were observed at mean levels of 80 and 100% of available water in the soil with and without mulch, respectively. Mulching reduces water consumption by 'BRS Pujante' cowpea plants, promoting satisfactory production at lower levels of available water in relation to the soil without mulch. The responses of production components of 'BRS Pujante' cowpea were similar to that of its leaf area.

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