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ORIGINAL ARTICLE

# Cowpea growth and production under water stress and soil mulching[1]

## Crescimento e produção do feijão-caupi sob estresse hídrico e cobertura de solo

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*HIGHLIGHTS:*
*Soil mulching improves cowpea leaf area and yield under drought.*
*Soil mulching reduces water use by 20% without loss in cowpea yield.*
*The BRS Pujante cowpea genotype outperforms Costela de Vaca in yield under drought conditions.*

**ABSTRACT:** Cowpea is a crop of high socioeconomic importance for the semi-arid region of Brazil, although facing significant yield losses due to drought, requiring management strategies to overcome this scenario. From this perspective, this study aimed to evaluate the growth and yield of cowpea genotypes under drought in different cultivation systems. The statistical design was randomized blocks arranged in a 2 × 4 × 2 factorial scheme corresponding to two cowpea genotypes (BRS Pujante and Costela de Vaca), four levels of crop evapotranspiration (40, 60, 80, and 100%), and two cultivation systems (with and without soil mulching). The BRS Pujante showed a higher leaf area and 100-grain weight than Costela de Vaca under all levels of crop evapotranspiration. The cowpea yield parameters showed the best results at 80 and 100% crop evapotranspiration. Regardless of the genotype, soil mulching provided higher cowpea 100-grain weight values. Soil mulching combined with 80% crop evapotranspiration is an appropriate strategy for cowpea production.

**Key words:** *Vigna unguiculata*, drought, BRS Pujante, Costela de Vaca

**RESUMO:** O feijão-caupi tem grande importância socioeconômica para o semiárido brasileiro, porém sofre perdas significativas de produção pelo estresse por seca, necessitando de estratégias de manejo para superar esse cenário. Nessa perspectiva, o presente estudo teve como objetivo avaliar o crescimento e a produção de genótipos de feijão-caupi sob estresse hídrico em diferentes sistemas de cultivo. O delineamento estatístico adotado foi o de blocos casualizados, em arranjo fatorial 2 × 4 × 2, correspondendo a dois genótipos de feijão-caupi (BRS Pujante e Costela de Vaca), quatro níveis de evapotranspiração da cultura (40, 60, 80 e 100%) e dois sistemas de cultivo (com e sem cobertura morta do solo). O genótipo de feijão-caupi BRS Pujante apresentou maior área foliar e peso de 100 grãos do que o genótipo Costela de Vaca em todos os níveis de evapotranspiração da cultura. Os parâmetros de produção do feijão-caupi apresentaram os melhores resultados a 80 e 100% da evapotranspiração da cultura. Independentemente do genótipo, a cobertura morta do solo proporcionou maiores valores de peso de 100 grãos de feijão-caupi. A cobertura do solo combinada com 80% da evapotranspiração da cultura é uma estratégia adequada para a produção de feijão-caupi.

**Palavras-chave:** *Vigna unguiculata*, seca, BRS pujante, Costela de Vaca

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## Introduction

Cowpea (*Vigna unguiculata* (L.) Walp), known in Brazil as 'feijão-de-corda', 'feijão-macassar', or 'fradinho', is a legume crop highly adapted to the semi-arid conditions of Northeastern Brazil (Souza et al., 2016; Horn & Shimelis, 2020). Cowpea is the primary subsistence crop in Northeastern Brazil despite serious problems with severe drought events due to the local semi-arid climate of the region (Santos et al., 2022). However, cowpea production is still small in Brazil due to limited soil water availability and the irrigation volume required to obtain satisfactory production (Sá et al., 2017; Andrade et al., 2021; Praxedes et al., 2022).

Nevertheless, cowpea is grown in almost all microregions in the Paraíba state (Brazil), yielding between 300 to 700 kg ha$^{-1}$ (Pereira Junior et al., 2015). However, the water deficit is one of the main limiting factors for cowpea production in Northeastern Brazil (Melo et al., 2018; Soares et al., 2021), with irrigation increasing cowpea yield and quality (Silva et al., 2016; Melo et al., 2018).

In this scenario, drought-tolerant genotypes and crop management practices can improve cowpea performance under drought. Furthermore, introducing a mulch layer on top of the soil surface creates a physical barrier that prevents the direct incidence of solar radiation, maintaining a stable soil temperature and reducing natural water losses through evaporation (Locatelli et al., 2014; Iqbal et al., 2020). From this perspective, this study aimed to evaluate the growth and yield of cowpea genotypes under drought conditions in different cultivation systems.

## Material and Methods

The experiment was conducted in a greenhouse at the Center of Agrifood Sciences and Technology of the Federal University of Campina Grande - UFCG, Campus Pombal, from April to July 2018 for one crop cycle. The following coordinates define the geographic location: 06°46'13" S, 37°48'06" W, at a mean altitude of 242 m a.s.l. According to Köppen's classification, the climate is classified as BSh-type (semi-arid), i.e., hot and dry, with a mean annual rainfall of 850 mm per year, irregular rainfall events, and mean annual temperatures of 25 °C (Alvarez et al., 2013).

The statistical design adopted for the experiment was randomized blocks arranged in a 2 × 4 × 2 factorial scheme with four replications corresponding to two cowpea genotypes (BRS Pujante - PJA; Costela de Vaca - CVA), four levels of crop evapotranspiration (ETc) (40, 60, 80, and 100%), and two cultivation systems (with and without soil mulching), totaling 64 experimental units.

The BRS Pujante cowpea genotype has an indeterminate growth habit, semi-branching, globular leaves, purple and uneven flowers, green leaves at the beginning of flowering, immature green pods, and dry brown pods (Medeiros et al., 2021).

The Costela de Vaca cowpea genotype has an erect, semi-prostrate, and indeterminate growth habit with no tendency to curl up at the tutor (Araújo et al., 2016). The apical leaflet has a subglobose shape with an average length of 98 mm and a width of 69 mm on its surface (glabrous), but short compressed hairs on the stem, express a light green color, have a membranous texture and "V" marks on the leaflets. Flowering occurs approximately 54 to 59 days after plant emergence in its white flowers lasts 3 to 4 days after the flower bud opens, and the mature pod is straw-colored (Araújo et al., 2016).

The mulch used on the soil surface consisted of *Urochloa brizantha* Stapf (syn. *Brachiaria brizantha* Stapf) grass at 40 g of dry leaves per pot, applied soon after sowing, resulting in a 3- to 5-cm thick layer.

The experimental units were composed of pots (12 dm$^3$) containing soil from the 0-20 cm layer of an Entisol (Fluvent) according to United States (2014) equivalent to a Neossolo Flúvico (EMBRAPA, 2018), whose chemical characteristics were determined according to Teixeira et al. (2017): pH ($H_2O$) = 8.2; EC of saturated extract = 0.07 dS m$^{-1}$; phosphorus (mg dm$^{-3}$) = 177.0; potassium (cmol$_c$ dm$^{-3}$) = 0.41; sodium (cmol$_c$ dm$^{-3}$) = 0.65; calcium (cmol$_c$ dm$^{-3}$) = 3.9; magnesium (cmol$_c$ dm$^{-3}$) = 1.5; $H^+ + Al^{+3}$ (cmol$_c$ dm$^{-3}$) = 0; CEC (cmol$_c$ dm$^{-3}$) = 6.5; organic matter (g kg$^{-1}$) = 31.95; exchangeable sodium percentage ESP (%) = 10.0. Mean particle size composition: 795.0 g kg$^{-1}$ of sand, 117.0 g kg$^{-1}$ of silt, and 88.0 g kg$^{-1}$ of clay. Also, the soil presented the following physical characteristics: bulk density (kg dm$^{-3}$) = 1.48; porosity (%) = 43.94; moisture content at field capacity (% weight) = 17.11; moisture content at permanent wilting point (% weight) = 3.43; available water (mm cm$^{-1}$) = 2.50.

Four seeds were sown per pot at a depth of 2.0 cm, with seedling emergence stabilizing on the fifth day after sowing. Irrigation was performed with a two-day interval (ECw = 0.3 dS m$^{-1}$). The reference volume was determined based on the average crop evapotranspiration obtained by weighing the reference treatment (100% ETc), and the other irrigation depths were calculated concerning that since the first day after sowing.

The water volume applied (Va) per pot was obtained by the difference between the mean weight of the pots under conditions of maximum water retention (Pwr) and the mean weight of the pots at the current condition (Pcr) divided by the number of pots (n) (Eq. 1). The Pwr was pre-established before sowing, with pots at 100% ETc. The pots were saturated with water, covered with plastic film to avoid evaporation, and weighed after 24 hours.

$$Va = \frac{Pwr - Pcr}{n} \quad (1)$$

where:

Va - volume applied (L);
Pwr - maximum water retention (kg);
Pcr - current weight (kg); and,
n - number of pots.

The fertilization consisted of 20.0 kg ha$^{-1}$ of $P_2O_5$ applied only once before sowing. Regarding N and $K_2O$, 30.0 and 35.0 kg ha$^{-1}$ were applied, respectively. These amounts of N and $K_2O$ were divided into three equal parts and applied at three different times: before, at 20, and at 40 days after sowing (Santos et al., 2022). Urea (45% N), monoammonium phosphate (10%

N and 48% $P_2O_5$), and potassium chloride (60% $K_2O$) were the fertilizers used. The plants were thinned 15 days after sowing (DAS), leaving one plant per plot. The crop management and phytosanitary practices were performed to maintain the crop free of weeds, diseases, and pests during the conduction of the experiment.

The following growth parameters were evaluated 45 DAS: stem diameter (SD), determined as mm using a digital caliper and measured at 1.0 cm from the ground; main stem length (MSL), determined as cm between the base of the plant and the apex of the main stem using a graduated ruler; number of leaves per plant (NL), determined by counting all fully-expanded leaves; leaf area per plant (LA), determined as $cm^2$ (Eq. 2) and estimated using the mathematical model proposed by Lima et al. (2008).

$$LA = \sum\left[0.9915\left(L \times W\right)^{0.9134}\right] \quad (2)$$

where:

LA - leaf area ($cm^2$);
L - leaf length (cm); and,
W - leaf width (cm).

The following yield components were evaluated 60 DAS: number of pods per plant (NP), determined by counting all harvested pods; pod length (PL), determined as cm based on five pods collected randomly from each plot; number of grains per pod (NGP), determined based on the number of grains contained within the five pods used to measure the PL (Abreu et al., 2021), and 100-grain weight (100GW), expressed as grams by weighing 100 dry grains and calculated based on five pods collected (Eq. 3).

$$100GW = \frac{(GW5P)}{(NG5P)} \times 100 \quad (3)$$

where:

100GW - 100-grain weight (g);
GW5P - grain weight of five pods (g); and,
NG5P - number of grains in five pods (g).

The results were evaluated by analysis of variance, and the significance was determined by the F-test ($p \leq 0.05$). The means relative to levels of crop evapotranspiration were evaluated by regression analysis. The Tukey test compared the means relative to cowpea genotypes and soil mulching ($p \leq 0.05$). The statistical analyses were performed using the software SISVAR 5.6 (Ferreira, 2019).

## Results and Discussion

The interaction between cowpea genotypes, crop evapotranspiration, and soil mulching was significant for the number of leaves (NL, $p \leq 0.05$). The interactions between cowpea genotypes and crop evapotranspiration ($p \leq 0.01$) and between crop evapotranspiration and soil mulching ($p \leq 0.01$) were significant for leaf area (LA). The interaction between cowpea genotypes and crop evapotranspiration was significant for main stem length (MSL, $p \leq 0.01$), number of leaves (NL, $p \leq 0.01$), and stem diameter (SD, $p \leq 0.05$) (Table 1). These results highlight genetic variation between the cowpea genotypes evaluated due to the different alleles present in their genotype (Santana et al., 2019). This situation is highly favorable for breeding as it enables the selection of the best genotype for the conditions under which the experiment was carried out.

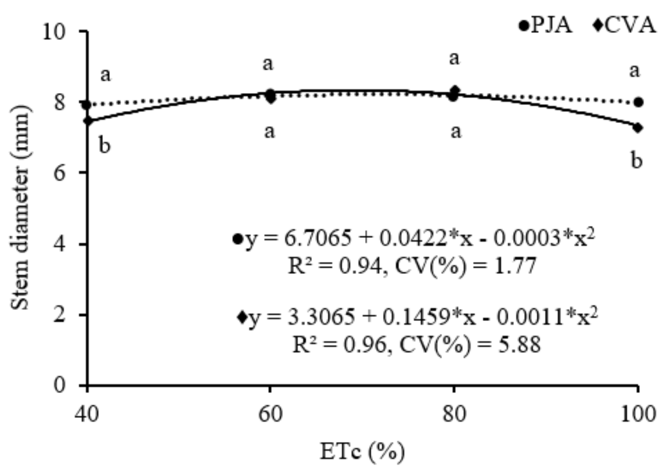
The highest stem diameter of the genotypes was estimated at 70.33 and 66.32% of crop evapotranspiration for BRS Pujante and Costela de Vaca, respectively (Figure 1). The reduction in soil water availability decreases turgor pressure, thus reducing sap flow through the conducting vessels (Andrade et al., 2021; Santos et al., 2022) and decreasing cell elongation, plant growth, and yield (Melo et al., 2018).

For the main stem length (MSL), both genotypes showed maximum values at 80% ETc, with Costela de Vaca showing the higher value (Figure 2). It should be noted that the better performance of this genotype is related to its morphology; BRS Pujante shows an indeterminate, semi-branched growth habit, and Costela de Vaca shows an indeterminate semi-prostate growth habit.

**Table 1.** Summary of the analysis of variance (F-test) for stem diameter (SD), main stem length (MSL), number of leaves (NL), and leaf area (LA) of cowpea plants 45 days after sowing according to the crop evapotranspiration (ETc), genotypes (G), and soil mulching (M)

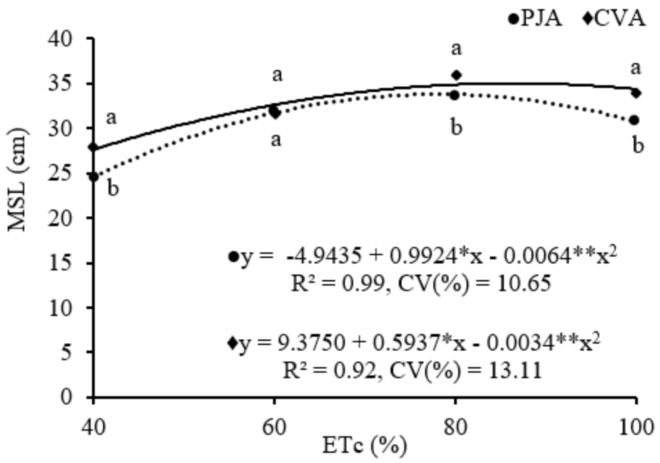
| Source of variation | DF | F-test | | | |
|---|---|---|---|---|---|
| | | SD | MSL | NL | LA |
| G | 1 | * | ** | ns | ** |
| ETc | 3 | ** | ** | ** | ** |
| M | 1 | ** | ** | ** | ** |
| G × ETc | 3 | * | ** | ** | ** |
| ETc × M | 3 | ns | ns | ** | ** |
| G × M | 1 | ** | ns | ** | ns |
| G × ETc × M | 3 | ns | ns | * | ns |
| CV (%) | - | 5.87 | 5.95 | 8.11 | 9.29 |

DF – Degrees of freedom; CV - Coefficient of variation; **, * - Significant at $p \leq 0.01$ and $p \leq 0.05$ and ns - not significant, respectively, by the F-test




* - Significant at $p \leq 0.05$, by the F-test. Means in the same ETc with same letters do not differ by the Tukey test ($p < 0.05$)

**Figure 1.** Stem diameter (SD) according to the crop evapotranspiration for the cowpea genotypes BRS Pujante (PJA) and Costela de Vaca (CVA)




**, * - Significant at $p \leq 0.01$ and $p \leq 0.05$, respectively, by the F-test. Means in the same ETc with same letters do not differ by the Tukey test ($p < 0.05$)

**Figure 2.** Main stem length (MSL) according to the crop evapotranspiration for the cowpea genotypes (BRS Pujante (PJA) and Costela de Vaca (CVA))

Both genotypes evaluated showed a decrease in the MSL as evapotranspiration replacement decreased. From the highest value (80% ETc) to the lowest value (40% ETc), the reduction in the MSL corresponded to 26.80 and 21.16% for BRS Pujante and Costela de Vaca, respectively, indirectly highlighting their sensitivity to water deficit (Figure 2). These results agree with Purcell et al. (1997), who observed that the translocation of photoassimilates from leaves to other plant parts was compromised by the reduction in the use efficiency of soil water available, resulting in reduced growth and yield.

In the genotype and mulching interaction, BRS Pujante outperformed Costela de Vaca only without soil mulching regarding stem diameter (SD). Soil mulching increased stem diameter for both genotypes, indicating reduced adaptation without soil mulching (Table 2).

Regarding number of leaves (NL), BRS Pujante showed an increase of 58.16% in the presence of soil mulching at 100% crop evapotranspiration compared to the lowest crop evapotranspiration (40% ETc) under the same conditions (Table 3). On the other hand, Costela de Vaca showed the highest NL increase (14.29%) in the presence of soil mulching under 80% compared to 40% of ETc (Table 3). BRS Pujante showed a growing linear effect only in the presence of soil mulching and a quadratic behavior without soil mulching. However, a quadratic effect was observed for Costela de Vaca in both cultivation systems (Table 3).

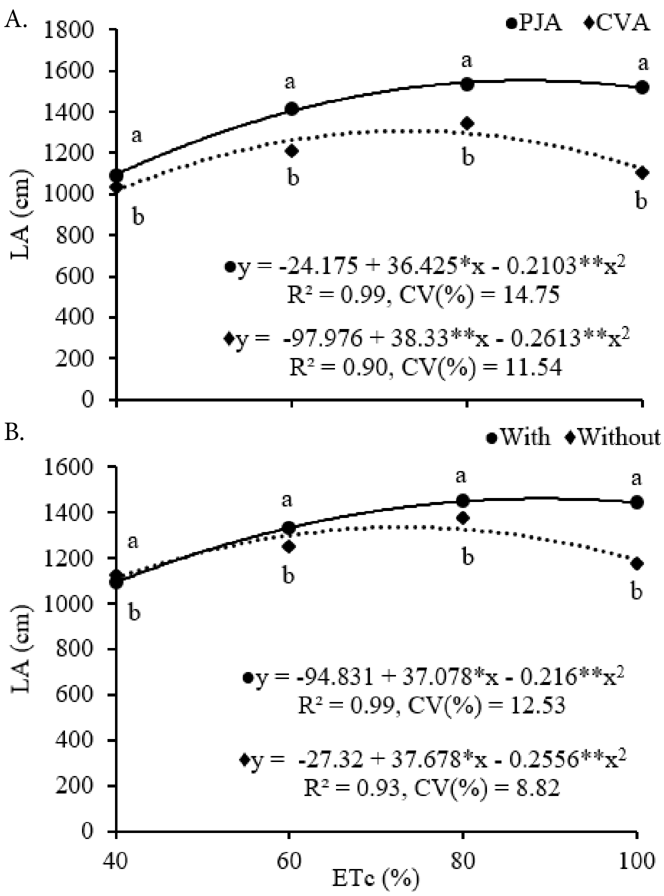
**Table 2.** Stem diameter (SD) of cowpea genotypes (BRS Pujante (PJA) and Costela de Vaca (CVA)) grown with and without soil mulching

| Genotype | Soil mulching SD (mm) | |
|---|---|---|
| | With | Without |
| PJA | 8.39 aA | 7.81 aB |
| CVA | 8.60 aA | 7.05 bB |

Means followed by the same lowercase letters in the columns for genotypes and uppercase letters in the lines for soil mulching do not differ by the Tukey test ($p < 0.05$)

These results corroborate with the study of Souza et al. (2016), in which the authors observed reductions in the number of leaves per plant at lower levels of water availability, which were more drastic in the absence of soil mulching, indicating the greater severity of water deficit on plants. These results are likely due to the larger soil surface exposed to evapotranspiration, intensifying water loss by plants and soil.

The highest leaf area (1,553.07 and 1,307.68 cm²) was observed at 86.60 and 73.34% of crop evapotranspiration for BRS Pujante and Costela de Vaca, respectively (Figure 3A). The




**, * - Significant at $p \leq 0.01$ and $p \leq 0.05$, respectively, by the F-test. Means in the same ETc with same letters do not differ by the Tukey test ($p < 0.05$)

**Figure 3.** Leaf area (LA) according to the interaction between crop evapotranspiration and cowpea genotypes (BRS Pujante and Costela de Vaca) (A) and the interaction between crop evapotranspiration and soil mulching (with and without soil mulching) (B)

**Table 3.** Number of leaves (NL) of cowpea plants according to the interaction among crop evapotranspiration (ETc), genotypes (BRS Pujante (PJA) and Costela de Vaca (CVA)), and soil mulching (with and without soil mulching)

| Genotype | Soil mulching | Crop evapotranspiration (%) | | | | Equation | $R^2$ | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | | | |
| PJA | With | 26.05 bA | 31.10 bA | 36.15 aA | 41.20 aA | $y = 15.95 + 0.2525^*x$ | 0.96 | 19.77 |
| | Without | 27.17 aA | 28.58 aA | 28.54 aB | 27.07 aB | $y = 20.045 + 0.2502^*x - 0.0018^*x^2$ | 0.82 | 3.36 |
| CVA | With | 32.83 aA | 36.10 aA | 37.52 aA | 37.11 aA | $y = 20.785 + 0.3932^*x - 0.0023^*x^2$ | 0.95 | 5.98 |
| | Without | 22.89 bB | 26.92 aB | 26.70 aB | 22.25 bB | $y = 2.125 + 0.7312^*x - 0.0053^*x^2$ | 0.98 | 10.14 |

Means followed by the same lowercase letters in the columns for genotypes and uppercase letters in the columns for soil mulching do not differ by the Tukey test ($p < 0.05$).
* - Significant at $p \leq 0.05$ by the F-test

interaction between soil mulching and crop evapotranspiration resulted in the highest leaf area values (1,496.35 and 1,361.21 $cm^2$) at 85.83 and 73.71% of ETc under the conditions with and without soil mulching, respectively (Figure 3B). According to Peres et al. (2010), water loss at the upper soil layers is reduced by up to 53.3% due to soil mulching, justifying the maintenance of this cover. As a result, cowpea cultivation with soil mulching results in higher water-use efficiency and grain yield in semi-arid regions (Freitas et al., 2019).

There was a significant interaction between cowpea genotypes and crop evapotranspiration for the number of pods per plant (NP, $p \le 0.01$) (Table 4). The interaction was significant between crop evapotranspiration and soil mulching ($p \le 0.01$) and genotypes and soil mulching ($p \le 0.05$) only for the number of grains per pod. A significant interaction was observed between cowpea genotypes, crop evapotranspiration, and soil mulching ($p \le 0.05$) only for the 100-grain weight parameter (Table 4). There was a significant difference in PL, NGP, and 100GW, indicating the occurrence of genetic variability and allowing selection and the recommendation of superior genotypes (Table 4).

The isolated factor ETc significantly influenced the NP, NGP, and 100GW. On the other hand, the soil mulching factor only influenced the 100GW. This result was expected since these are quantitative traits that, by nature, are highly influenced by the environment. In this case, the crop evapotranspiration and mulching worked as contrasting environments (Table 4).

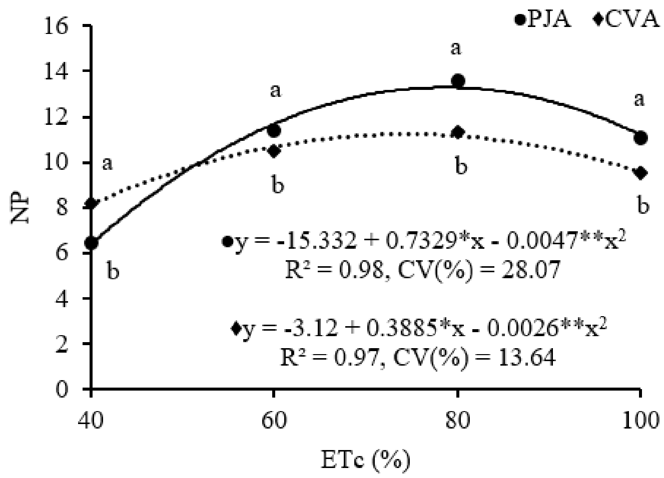
BRS Pujante and Costela de Vaca genotypes showed the highest number of pods at 80% crop evapotranspiration, with 13.22 and 11.32 pods per plant, respectively (Figure 4). Locatelli et al. (2014) observed similar results for the number of pods per plant with increased irrigation depths for cowpea plants.

The increase in the number of pods per plant according to the crop evapotranspiration is related to their genetic constitution since each genotype specifically responds to irrigation and favorable cultivation conditions, demonstrating all their yield potential (Locatelli et al., 2014; Soares et al., 2021; Melo et al., 2022). However, due to water restriction, it is possible to observe a significant reduction in NP in both studied genotypes, from the highest value (80% ETc) to the lowest value (40% ETc), amounting to 51.07% and 27.03% for BRS Pujante and Costela de Vaca, respectively (Figure 4). Water

**Table 4.** Summary of the analysis of variance (F-test) for the number of pods per plant (NP), pod length (PL), number of grains per pod (NGP), and 100-grain weight (100GW) of cowpea according to the crop evapotranspiration (ETc), genotypes (G), and soil mulching (M)

| Source of variation | DF | F-test | | | |
|---|---|---|---|---|---|
| | | NP | PL | NGP | 100GW |
| G | 1 | ns | * | ** | ** |
| ETc | 3 | ** | ns | ** | ** |
| M | 1 | ns | ns | ns | * |
| G × ETc | 3 | ** | ns | ns | ns |
| ETc × M | 3 | ns | ns | ** | ns |
| G × M | 1 | ns | ns | * | ns |
| G × ETc × M | 3 | ns | ns | ns | * |
| CV (%) | - | 15.24 | 20.09 | 10.33 | 16.85 |

DF – Degrees of freedom; CV - Coefficient of variation; **, * - Significant at $p \le 0.01$ and $p \le 0.05$ and ns - not significant, respectively, by the F-test



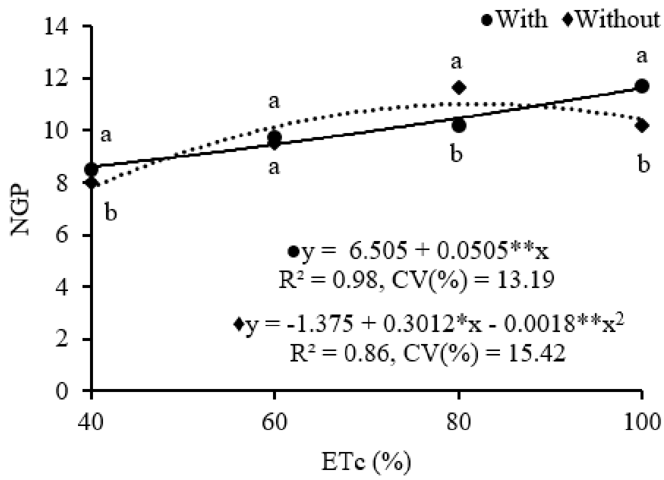

**, * - Significant at $p \le 0.01$ and $p \le 0.05$, by the F-test. Means in the same ETc with same letters do not differ by the Tukey test ($p < 0.05$)

**Figure 4.** Number of pods per plant (NP) of cowpea according to the interaction between crop evapotranspiration and genotypes (BRS Pujante and Costela de Vaca)

deficit conditions limit physiological activity and consequently affect growth, dry matter accumulation, and yield of crops (Andrade et al., 2021; Oguz et al., 2022; Santos et al., 2022).

The number of grains per pod showed a growing linear effect for the soil mulching treatments, with a maximum value of 11.56 grains per pod at 100% crop evapotranspiration (Figure 5). The effect was quadratic in the treatment without soil mulching, with the highest number of grains per pod (11.23 grains) occurring at 83.7% crop evapotranspiration (Figure 5). These results are similar to those of Tagliaferre et al. (2013), who observed the maximum value of 11.96 grains per pod for cowpea at 72% of crop evapotranspiration.

In the presence of soil mulching, Costela de Vaca performed better than BRS Pujante for the number of grains per pod (Table 5). However, when observing the means within genotypes, the cultivation system had no significant influence (Table 5). Pod length in BRS Pujante was 11.4% higher than in Costela de Vaca, with mean values of 19.64 and 17.63 cm per pod, respectively (Table 5).




**, * - Significant at $p \le 0.01$ and $p \le 0.05$ by the F-test. Means in the same ETc with same letters do not differ by the Tukey test ($p < 0.05$)

**Figure 5.** Number of grains per pod (NGP) according to the interaction between crop evapotranspiration and soil mulching (with and without)

**Table 5.** Number of grains per pod (NGP) of genotypes (G) with and without soil mulching and pod length (PL) of the BRS Pujante (PJA) and Costela de Vaca (CVA)

| Genotype | Soil mulching | | |
|---|---|---|---|
| | NGP | | PL (cm) |
| | With | Without | |
| PJA | 8.99 bA | 9.39 bA | 19.64 a |
| CVA | 11.09 aA | 10.40 aA | 17.63 b |

Means followed by the same lowercase letters in the columns for genotypes and uppercase letters in the lines for soil mulching do not differ by the Tukey test ($p > 0.05$)

BRS Pujante showed a higher number of pods per plant and higher pod length values than Costela de Vaca (Figure 4 and Table 5). However, the number of grains per pod of BRS Pujante was lower than Costela de Vaca (Table 5). These results are explained by the higher grain weight of BRS Pujante, which shows larger and denser grains than Costela de Vaca (Table 6).

BRS Pujante (PJA) showed a linear increasing effect in the presence of soil mulching and a quadratic behavior in its absence. On the other hand, Costela de Vaca showed a quadratic effect in both cultivation systems (Table 6).

BRS Pujante surpassed Costela de Vaca in the 100-grain weight, with maximum values of 32.47 and 28.98 g at 100% crop evapotranspiration with and without soil mulching, respectively (Table 6). For BRS Pujante, the decrease between 100% and 80% of ETc in 100-grain weight was only 6.62% and 0.69% with and without soil mulching, respectively (Table 6).

Costela de Vaca had 100-grain weight values of 24.64 and 20.31 g at 80% crop evapotranspiration (maximum efficiency) with and without soil mulching, respectively (Table 6). These results highlight that the differences between means could be related to the traits of each genotype analyzed. Ramos et al. (2012) reported that the 100-grain weight is unaffected by water deficiency when the genotypes have adequate soil water levels for their vital functions. In the presence of soil mulching, the genotypes decreased evapotranspiration, resulting in higher water availability. The results of the present study corroborate with the study of Cruz & Oliveira (2014), who observed higher 100GW means in the treatments with soil mulching concerning its absence.

## Conclusions

1. BRS Pujante showed a higher leaf area and 100-grain weight than Costela de Vaca under all levels of crop evapotranspiration.

2. The cowpea yield parameters showed the best results at 80 and 100% crop evapotranspiration.

3. Regardless of the genotype, soil mulching provided higher cowpea 100-grain weight values. Soil mulching combined with 80% crop evapotranspiration is appropriate for cowpea production.

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**Table 6.** 100-grain weight (100GW) of cowpea plants according to the interaction among crop evapotranspiration (ETc), genotypes (BRS Pujante (PJA) and Costela de Vaca (CVA)), and soil mulching (with and without soil mulching)

| Genotype | Soil mulching | Crop evapotranspiration (%) | | | | Equation | $R^2$ | CV (%) |
|---|---|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | | | |
| PJA | With | 26.03 aA | 28.18 aA | 30.32 aA | 32.47 aA | $y = 21.739 + 0.1073^*x$ | 0.95 | 9.97 |
| | Without | 25.97 aA | 27.77 aA | 28.78 aA | 28.98 aB | $y = 19.954 + 0.1903^*x - 0.001^*x^2$ | 0.98 | 4.81 |
| CVA | With | 18.26 bA | 22.89 bA | 24.64 bA | 23.51 bA | $y = 0.3685 + 0.5914^*x - 0.0036^*x^2$ | 0.96 | 13.44 |
| | Without | 14.67 bB | 19.69 bB | 20.31 bB | 16.53 bB | $y = -8.57 + 0.801^*x - 0.0055^*x^2$ | 0.95 | 16.08 |

Means followed by the same lowercase letters in the columns for genotypes and uppercase letters in the columns for soil mulching do not differ by the Tukey test ($p < 0.05$). * - Significant at $p \le 0.05$ by the F-test

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