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Article

Weed Interference in Semi-Erect and Semi-Prostate Cowpea Cultivars

Interferência de Plantas Daninhas em Cultivares de Feijão-Caupi de Portes Semiereto e Semiprostrado

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ABSTRACT - This study aimed to determine weed interference periods in semi-erect and semi-prostrate cowpea cultivars. Two simultaneous experiments were conducted with the cowpea cultivars BRS Guariba (semi-erect) and BRS Aracê (semi-prostrate). The experimental design was a randomized block design with four replications in a 7 × 2 factorial scheme, seven periods × two weed management (control and coexistence). Control and coexistence periods consisted of 0, 0-8, 0-16, 0-24, 0-32, 0-45, and 0-60 days after emergence (DAE) for the semi-erect cultivar and 0, 0-8, 0-16, 0-24, 0-32, 0-45, and 0-64 DAE for the semi-prostrate cultivar. Competition throughout the cycle reduced productivity by up to 39.81% for BRS Guariba and 37.27% for BRS Aracê. The cultivars BRS Guariba and BRS Aracê presented critical period of interference prevention of 9 to 41 DAE and 15 to 32 DAE, respectively. The semi-prostrate cultivar BRS Aracê was more competitive with weeds, requiring a shorter control period to express maximum productivity.

Keywords: *Vigna unguiculata*, competition, interference periods.

RESUMO - Objetivou-se com este trabalho determinar os períodos de interferência de plantas daninhas em cultivares de feijão-caupi de porte semiereto e semiprostrado. Foram conduzidos dois experimentos simultâneos com os cultivares BRS Guariba (semiereto) e BRS Aracê (semiprostrado). Para ambos os experimentos, o delineamento experimental foi em blocos casualizados com quatro repetições, em esquema fatorial 7 × 2, sete períodos × duas formas de manejo das plantas daninhas (controle e convivência). Os períodos de controle e convivência consistiram em 0, 0-8, 0-16, 0-24, 0-32, 0-45 e 0-60 dias após a emergência (DAE) para o cultivar de porte semiereto e 0, 0-8, 0-16, 0-24, 0-32, 0-45 e 0-64 DAE para o cultivar de porte semiprostrado. A competição durante todo o ciclo reduziu a produtividade em até 39,81% para o cv. BRS Guariba e 37,27% para o cv. BRS Aracê. Os cultivares BRS Guariba e BRS Aracê apresentaram período crítico de prevenção à interferência de 9 a 41 DAE e 15 a 32 DAE, respectivamente. O cv. BRS Aracê de porte semiprostrado foi mais competitivo com as plantas daninhas, necessitando de menor período de controle para expressar a máxima produtividade.

Palavras-chave: *Vigna unguiculata*, competição, períodos de interferência.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is one of the widely cultivated crops in tropical and subtropical regions, being a staple food essential for food security. It also stands out in the economic aspect, being an essential source of employment and income for the peoples of these regions (Lima et al., 2013).

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In Brazil, the North and Northeast regions stand out as the largest producers and consumers of cowpea. However, despite the social and economic importance for these regions, Brazilian productivity of 364.33 kg ha^{-1} is considered low (Conab, 2017), not reflecting the productive potential of the crop, which can reach productivity from 1,000 to 2,000 kg ha^{-1}. Low productivities are due to constraints such as low soil fertility, inadequate cropping techniques, climate restrictions, insufficient and poorly distributed precipitation, and biological restrictions caused by pests, diseases, and weeds (Abadassi, 2015).

The competition of weeds with crops has been considered the main biotic cause that causes productivity losses (Délye et al., 2013). Weed interference results in low productivity since it harms the crop directly due to the competition for essential factors, and indirectly, as weeds can host pests, diseases, and release allelopathic substances that interfere with seed germination and growth of cultivated plants, in addition to increasing production costs such as operations in harvesting, drying, and processing of grains (Freitas et al., 2009; Mirshekari et al., 2010).

The degree of weed interference in the competition with the crop depends on factors related to weed community (floristic composition, density, frequency, and dominance), crop (cultivar, spacing, and sowing density), environment (climate, soil, and management), and the period of coexistence between weeds and crop (season and duration).

Cowpea presents morphophysiological characteristics with wide variability, with different cycles and types of plant architecture. Freire Filho et al. (2005) reported that crop growth habits could vary from determined to indeterminate, presenting erect, semi-prostrate, prostrate, and semi-prostrate sizes, occurring a different number of nodes and branches, which contribute to form different types of architecture. These differences can play an important role in crop competitiveness with weeds.

The diversity of architecture characteristics of cowpea plants represents an excellent opportunity to use cultivars with higher weed suppression capacity (Wang et al., 2006a). Parreira et al. (2014) evaluated the competitive capacity of common bean (*Phaseolus vulgaris*) cultivars and found that cultivars with the highest soil cover were more competitive with weeds.

To define the periods in which weeds cause interference on crops due to various factors that may influence this competition, Pitelli and Duringan (1984) established the concept of the period before interference (PBI), total period of interference prevention (TPIP), and critical period of interference prevention (CPIP). Freitas et al. (2009) reported that, in addition to obtaining the competition periods, there is a concern in assessing the periods associated with other factors, which also change the degree of interference, such as the identification of species in the area, as it facilitates the use of adequate management for these species.

Thus, the competition periods between cowpea cultivars and weed and productivity losses due to the interference of these species should be studied taking into account the conditions of the growing region, weed community variation and cultivar characteristics such as growth habit, size, and development cycle, searching for cultivars more efficient in weed suppression and hence reducing control costs. In this sense, this study aimed to determine weed interference periods in semi-erect and semi-prostrate cowpea cultivars.

MATERIAL AND METHODS

Two experiments, one with the cowpea cultivar BRS Guariba and another with BRS Aracê, both with an early cycle (less than 70 days), were carried out simultaneously from August to October 2016 in the experimental field of the Universidade Federal de Roraima, Campus Cauamé, Boa Vista/RR, Brazil, at the geographical coordinates 2°52'15.49" N and 60°42'39.89" S, with 85 m altitude. According to Köppen classification, the regional climate is type Aw. No complementary irrigation was needed because of sufficient precipitation during the experimental period.

The soil of the experimental area is classified as a sandy clay loam textured typic dystrocohesive Yellow Latossolo (PAdx), with a wavy relief (Benedetti et al., 2011). Soil samples from the experimental area were collected in the layer of up to 0.20 m depth for chemical analysis, with the following results: pH in H_2O of 5.5, organic matter of 9 g dm^{-3}, P of 7 mg dm^{-3}, K of

62 mg dm^{-3}, S of 3 mg dm^{-3}, Ca of 13 $mmol_c$ dm^{-3}, Mg of 6 $mmol_c$ dm^{-3}, H+Al of 20 $mmol_c$ dm^{-3}, and Al of 0 $mmol_c$ dm^{-3}.

Conventional soil tillage was carried out with one plowing and two harrowing operations, followed by the broadcast application of 1.2 t ha^{-1} of dolomitic limestone. Sowing fertilization consisted of the use 500 kg ha^{-1} of the formulated fertilizer 4-14-8 (N-P-K) and 30 kg ha^{-1} of FTE BR 12 as micronutrient source. Potassium chloride was applied in the topdressing fertilization, with a dose of 20 kg ha^{-1} of K_2O. The supplied quantity was calculated taking into account the soil analysis and crop requirements, as recommended by Uchôa et al. (2009) for cowpea.

Before sowing, seeds were treated with the fungicide carbendazim (RODAZIM 500 SC) and inoculated with *Bradyrhizobium* BR 3262 strains in peat moss. Twelve seeds were manually sown per meter, and thinning was performed 12 days after crop emergence (DAE), leaving six plants per meter (120,000 plants per hectare).

Both experiments were conducted in a 7 × 2 factorial scheme (7 periods × 2 types of weed management), distributed in a randomized block design with four replications. The experimental units were composed of four rows 5 meters long and 2 meters wide, spaced 0.50 m from each other, totaling 10 m^2. Two central rows composed the useful area of each plot but discarding 0.50 m at each end.

Periods consisted of 0, 0-8, 0-16, 0-24, 0-32, 0-45, and 0-60 DAE and 0, 0-8, 0-16, 0-24, 0-32, 0-45, and 0-64 DAE for the cultivars BRS Guariba and BRS Aracê, respectively. Weed management consisted of periods of weed control and coexistence with the crop.

During the control periods, the crop was weeded from the emergence until the end of each described period. After this period, weed control was not performed. During the coexistence periods, cowpea coexisted with weed plants from the emergence until the end of the mentioned periods; after these periods, plots were maintained free from competition with weeds.

At the end of each coexistence period, weed samples were collected within two 0.5 × 0.5 m (0.25 m^2) iron frames placed on the interrows of the useful area of the plots. Weeds were cut close to the soil, collected, identified, separated by species, and quantified to determine the density of the main species and total weed density. Subsequently, these plants were conditioned in paper bags and dried in a forced air circulation oven at 70 ^oC until constant weight to determine the shoot dry matter of the main weed species and total.

The similarity index (SI) of weed species found in the experiments was calculated based on the formula proposed by Sorensen (1972): $SI = 2a/(b + c) \times 100$, where a is the number of species common to both areas, b is the total number of species in the first area, and c is the total number of species in the second area.

The following variables were evaluated for the cowpea crop: final stand, obtained by counting plants in the useful area of the plot; number of pods per plant; number of grains per pod, obtained by the mean number of grains of ten pods sampled in the useful area of the plot; pod length, obtained by the mean length of ten pods sampled in the useful area of the plot; 100 grain weight; and grain productivity, with moisture corrected to 13%.

The data were submitted to analysis of variance by F test at 5% probability and, when significant, the results were subjected to regression analysis. Models were chosen based on the significance of regression coefficients using the t test at 5% probability level in the coefficient of determination and biological phenomenon under study.

Limits of interference periods were determined by considering maximum losses of grain productivity of 5% in relation to the treatment maintained without weeds throughout the crop cycle. PBI, TPIP, and CPIP were determined from the regression equations. The regression analyses were performed using the program SIGMAPLOT 11.0.

RESULTS AND DISCUSSION

Eighteen species were identified in the survey carried out in the experiment with the cowpea cultivar BRS Guariba: *Acanthospermum hispidum*, *Amaranthus deflexus*, *Boerhavia diffusa*, *Cenchrus echinatus*, *Chamaesyce hirta*, *Cyperus* sp., *Desmodium* sp., *Desmodium tortuosum*, *Digitaria horizontalis*, *Digitaria insularis*, *Emilia coccinea*, *Mimosa invisa*, *Mimosa pudica*, *Phyllanthus niruri*, *Sida rhombifolia*, *Sida* sp., *Sida glaziovii*, and one unidentified species belonging to nine families, especially Fabaceae (four species), Poaceae (three species), and Malvaceae (three species).

In the experiment with the cultivar BRS Aracê, 21 weed species were found: *A. hispidum*, *Aeschynomene rudis*, *B. diffusa*, *C. echinatus*, *Cyperus* sp., *Desmodium* sp., *D. tortuosum*, *D. horizontalis*, *D. insularis*, *Eleusine indica*, *Indigofera hirsuta*, *M. invisa*, *M. pudica*, *Praxelis pauciflora*, *P. niruri*, *S. rhombifolia*, *Sida* sp., *S. glaziovii*, *Sidastrum micranthum*, *Tridax procumbens*, and an unidentified species, which were distributed into seven botanical families. The most representative families were Fabaceae (six species), Poaceae (four species), Malvaceae (four species), and Asteraceae (three species).

The similarity index (SI) was calculated as a function of the weeds that occurred in both experiments and had a value of 76.9%, with 15 species in both areas, evidencing that the cultivars were submitted to similar competition conditions. Batista et al. (2017) studied the phytosociology of weeds in the cowpea cultivation of erect and prostrate growth habit in the north of Minas Gerais and verified an SI of 72%, which would be due to the similarity of cultivation conditions to which cultivars were submitted, such as climate, soil, cultivation period, and seed bank.

The weed species *D. horizontalis*, *C. echinatus*, and *D. tortuosum* stood out both in terms of plant density (Figure 1) and dry matter accumulation (Figure 2) in experiments with cowpea cultivars of different sizes. *Cyperus* sp., which stood out in the cultivation of cowpea cv. BRS Guariba, showed a reduction in plant density from 32 DAE, not being observed at 60 DAE (Figure 1A). This reduction is due to the sensitivity of the species to the shading exerted by the crop. This species, with a C4 photosynthetic mechanism, has a preference by environments with high light intensity, in which few plants survive in shaded, low-light environments (Helfer and Longhi-Wagner, 2010).

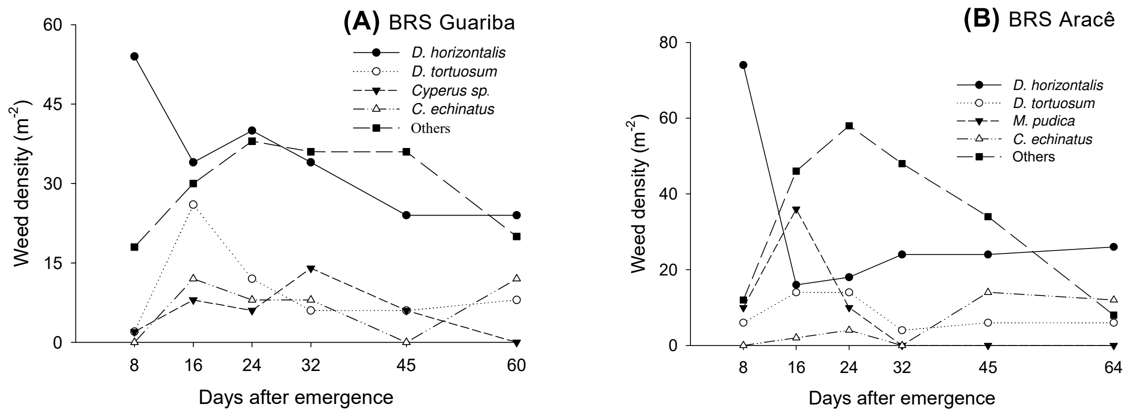

Figure 1 - Density of the main weeds at the end of the coexistence periods for cowpea cultivars. Boa Vista, RR, Brazil, 2016.

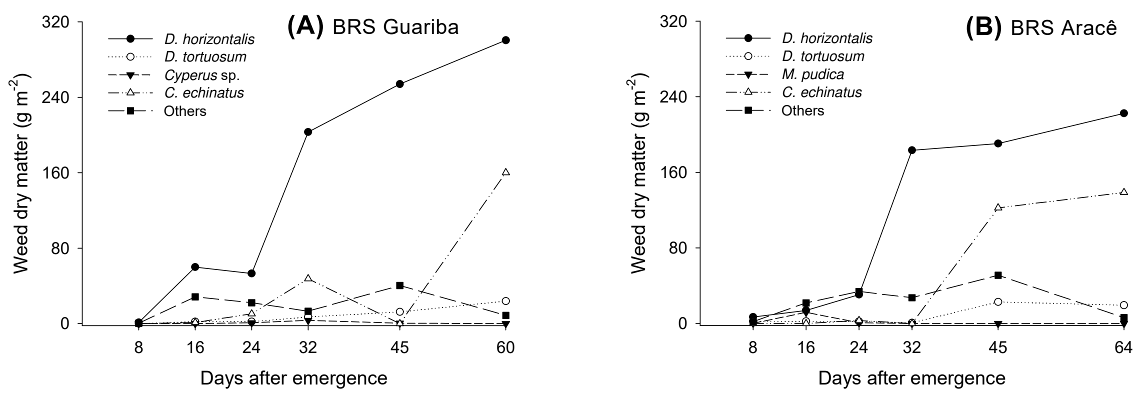

Figure 2 - Shoot dry matter of the main weeds at the end of the coexistence periods for the cowpea cultivars BRS Guariba (A) and BRS Aracê (B). Boa Vista, RR, Brazil, 2016.

Digitaria horizontalis was the species with the highest occurrence for both studied cultivars, with 54 and 74 individuals per m^2 for the cultivars BRS Guariba and BRS Aracê, respectively, at 8 DAE (Figure 1A, B), with the subsequent reduction due to intra- and interspecific competition. It is evidenced by an increase in dry matter accumulation of this species in both experiments (Figure 2A, B). According to Freitas et al. (2009), a plant density reduction at the end of the crop cycle is due to the presence of short-cycle species that germinate together with the crop, which entered into senescence at the end of the experimental period, and mainly to the competition of the most competitive species together with cowpea. In this case, the less competitive species are negatively affected.

The species *D. horizontalis* is one of the first weeds to appear in the area after soil tillage, competing from the early stages of crop development (Kissmann, 1997). Weeds that emerge along with the crop are the most competitive, thus reducing the availability of essential resources for the crop, using them earlier, shading the others, and dominating the area, which leads to higher productivity loss (Durigan et al., 1983).

The second species with the most prominence was *C. echinatus*, especially at the final periods of coexistence with the crop, showing a higher dry matter accumulation in relation to other species, behind only *D. horizontalis* (Figure 2A, B).

Kissmann (1997) reported that *C. echinatus*, in addition to having a high potential for dispersion and competition with crops, also presents a slow initial growth, reaching dry matter increase at the end of coexistence periods with cultivars. Cultivation conditions under a rainy season with good availability of moisture, high temperatures, and luminosity favored the establishment and development of these C4 species.

The total weed density showed a considerable decrease from the initial coexistence periods with the cultivar BRS Guariba until harvest, presenting 66 individuals per m^2 at 60 DAE (Figure 3A). Figure 3B shows a reduction in weed density at around 26 DAE until the end of the coexistence periods with the cultivar BRS Aracê, presenting a considerable decrease until harvest, with 54 individuals per m^2 at 64 DAE. This reduction in weed density was related to the significant mortality due to the competition for environmental resources.

A linear increase in the total dry matter (TDM) accumulation of weeds was verified during the coexistence periods with the cultivar BRS Guariba from 0 to 60 DAE, with a value at the end of the cycle of 493 g m^{-2} (Figure 4A). This increase in TDM accumulation was observed up to 45 DAE, with a subsequent tendency to stability, reaching 389 g m^{-2} at 64 DAE for the cultivar BRS Aracê (Figure 4B).

Weeds showed higher TDM accumulation under competition with the semi-erect cultivar BRS Guariba (Figure 4A). T he cultivar BRS Aracê, which has a semi-prostrate growth habit, was able to occupy the space better, being more competitive and reducing TDM of weeds by 21.1% in relation to the cultivar BRS Guariba. Wang et al. (2006b) reported that differences in cultivar characteristics, such as size, affect the competition and hence reduce weed dry matter

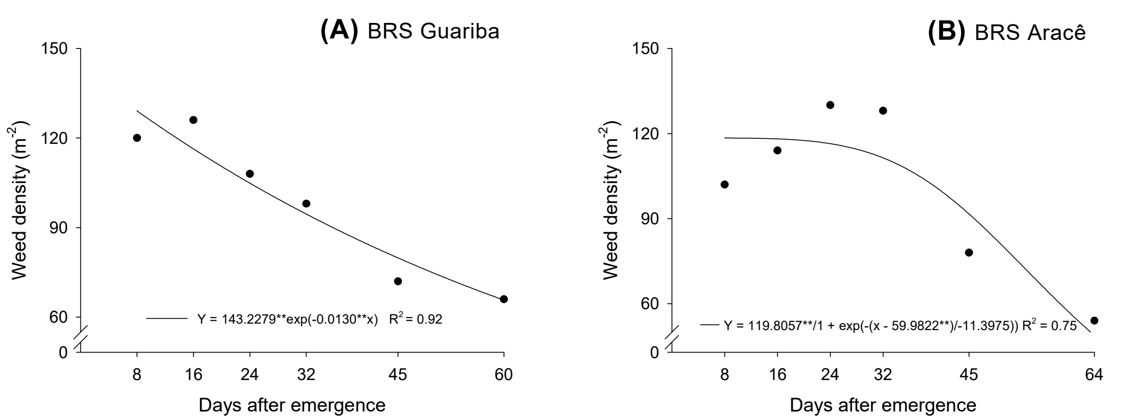

Figure 3 - Total density of weed species that composed the weed community at different coexistence periods with the cowpea cultivars BRS Guariba (A) and BRS Aracê (B). Boa Vista, RR, Brazil, 2016.

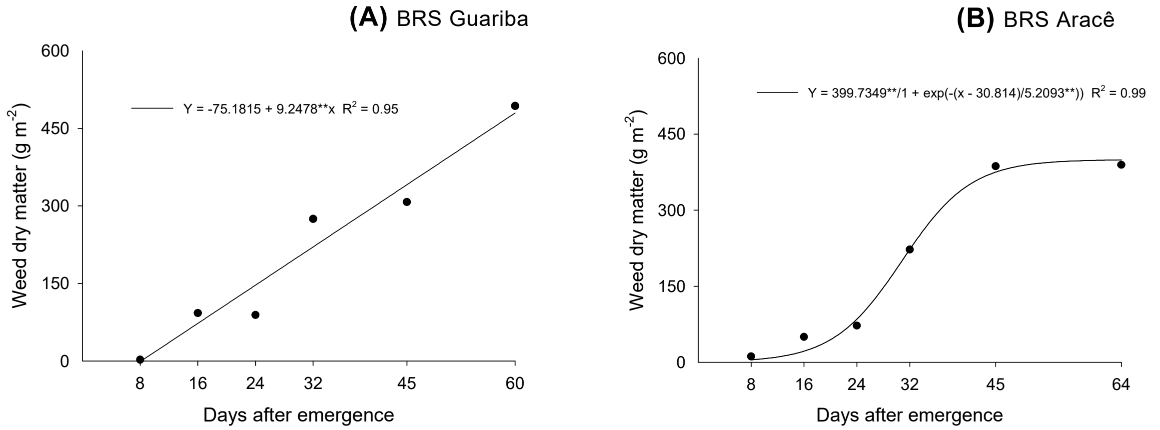

Figure 4 **-** Shoot dry matter of the total weeds that composed the weed community at different coexistence periods with the cowpea cultivars BRS Guariba (A) and BRS Aracê (B). Boa Vista, RR, Brazil, 2016

accumulation, i.e., the crop has the potential to limit weed development mainly through shading in the interrows.

The erect cultivar Iron-Clay and the prostrate cultivar UCR 779 of cowpea reduced more the biomass of common purslane (*Portulaca oleracea*) than the semi-erect IT89KD-288 (Wang et al., 2006b). Obadoni et al. (2009) evaluated the growth of guineagrass (*Panicum maximum*) in the presence of the prostrate cowpea cultivars IT87D-941-1, IT84S-2246-4, and IT90K-227-2 and the erect cultivar IT93K-452 and concluded that those prostrate were the most effective in reducing weed growth.

Control and coexistence periods of weeds for the cultivars BRS Guariba and BRS Aracê did not affect plant stand (38.83 and 36.52, respectively), pod length (22.42 and 19.94 cm, respectively), number of grains per pod (15.25 and 16.90, respectively), and 100-grain weight (21.53 and 17.31 g, respectively). However, the number of pods per plant and productivity were influenced by the different control and coexistence periods in both cultivars.

Weed interference reduced the number of pods per plant (NPP) in both cultivars (Figure 5A, B). There was influence of coexistence periods on NPP, which decreased as weed coexistence periods increased, being negatively influenced by the competition. The cultivars obtained positive responses in the control periods, at a level that increases the weed control periods, evidencing the need for weed control. The reduction in NPP verified in treatments under weed influence may be a consequence of the lower emission of inflorescences and flower abortion, as reported by Freitas et al. (2009).

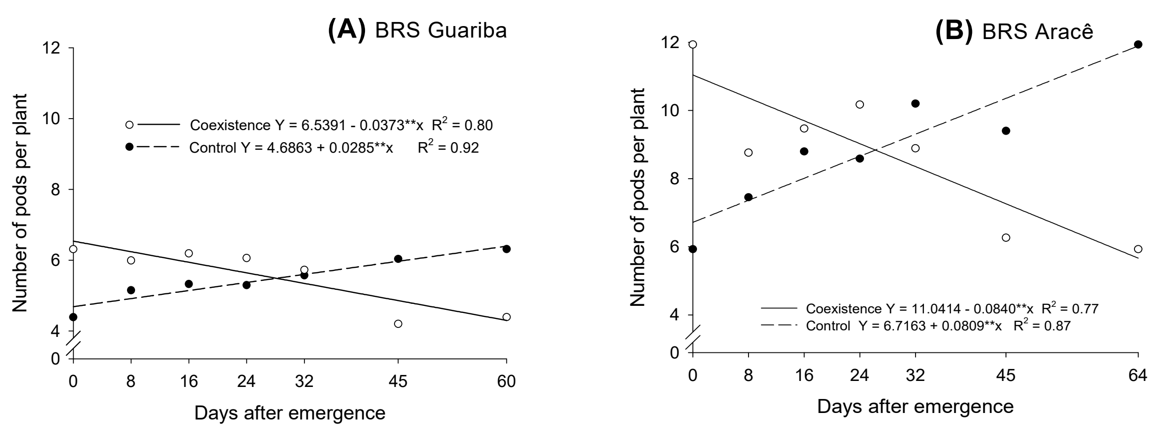

Figure 5 **-** Number of pods per plant of the cowpea cultivars BRS Guariba (A) and BRS Aracê (B) as a function of weed control and coexistence periods. Boa Vista, RR, Brazil, 2016.

The cultivar BRS Guariba presented an inferior behavior than that observed in the cultivar BRS Aracê, even without weed interference. In a study carried out with three cowpea cultivars under floodplain conditions in the Amazonas State, Oliveira et al. (2010) found different responses:

the erect cultivar EVx91-2E-2 presented a lower NPP, the semi-erect cultivar BR8 Caldeirão had an intermediate NPP, and the erect cultivar IP IPAN V69 presented a higher NPP. It evidences a variation in NPP due to the intrinsic characteristics of cultivars.

In the experiment with the cultivar BRS Guariba (Figure 6A), a curve was adjusted for productivity in the coexistence and control periods of weeds considering a 5% loss. In this sense, the period before interference (PBI) was determined to be 9 DAE, the total period of interference prevention (TPIP) occurred up to 41 DAE, and the critical period of interference prevention (CPIP) was between 9 and 41 DAE of this cultivar, totaling 32 days of weed control. Productivity obtained in the total weed absence was 1,451.16 kg ha^{-1}, but when the crop coexisted with weed plants, productivity decreased to 873.42 kg ha^{-1}, with a 39.81% reduction.

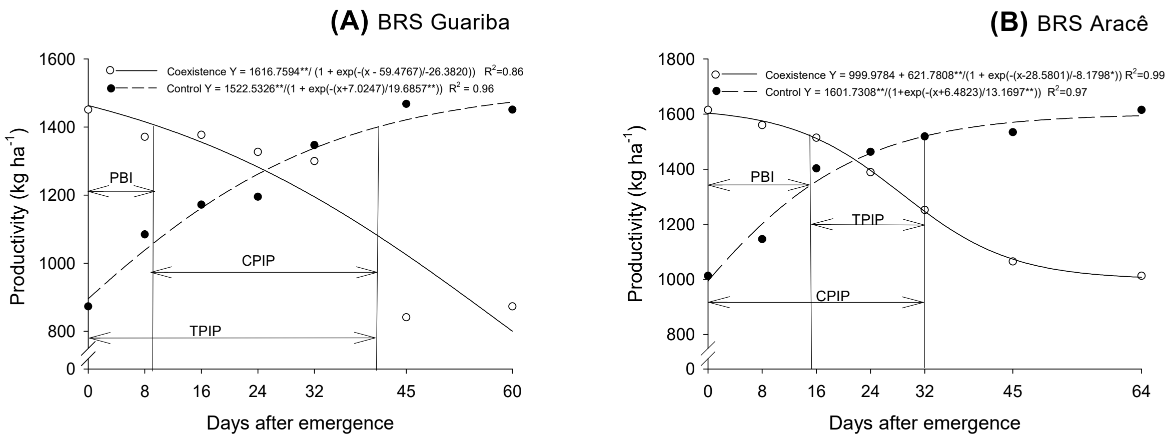

Figure 6 - Productivity of the cowpea cultivars BRS Guariba (A) and BRS Aracê (B) as a function of weed control and coexistence periods. Boa Vista, RR, Brazil, 2016.

In an experiment conducted by Oliveira et al. (2010) in the Amazonas State with the semi-erect cowpea cultivar BR8 Caldeirão, PBI was lower, with a productivity reduction higher than that found in this research, being able to coexist with weeds from 0 to 6 days after sowing, with a productivity loss of 68.18% when the crop coexisted with weeds during the entire cycle. It occurred due to the aggressiveness of some weed species present in the area.

Corrêa et al. (2015) studied the cultivar BRS Guariba and observed a CPIP from 8 to 53 DAE, with a 46% reduction in productivity. Differences between researches are caused, among other factors, by the density and dry matter accumulated by weeds, besides the distinct specific composition between experiments.

Figure 6B shows that PBI for the cultivar BRS Aracê was up to 15 DAE, TPIP was up to 32 DAE, and CPIP was between 15 and 32 DAE for this cultivar, requiring 17 days without infestation. Productivity in the absence of weeds during the cycle was 1,615.1 kg ha^{-1}, being reduced to 1,013.13 kg ha^{-1} in the presence of weeds during the entire cycle, with a 37.27% reduction.

In a study conducted by Freitas et al. (2009) with the prostrate cultivar BR 16, CPIP was between 11 to 35 days after crop emergence, and the decrease in grain productivity reached up to 90%.

The cultivar BRS Aracê was less susceptible to the weed community when compared to the cultivar BRS Guariba since they were subjected to similar conditions. CPIP for the semi-prostrate cultivar was shorter, requiring a lower period free from weeds to guarantee its maximum productivity. It is due to the cultivar characteristic, as BRS Aracê promotes the faster canopy closure to restrict the germination and establishment of weeds through shading, thus exerting the most efficient cultural control.

Wang et al. (2006a, b) evaluated the competitive capacity of erect, semi-erect, and prostrate cowpea cultivars on the weed species *Portulaca oleracea* (common purslane) and verified that the erect and prostrate cultivars were more competitive with common purslane when compared to the semi-erect cultivar. These authors also reported that erect cowpea cultivars are more competitive with a wide variety of weed species, especially those of smaller size.

It is assumed that this higher competitive capacity may have occurred because the research was carried out only with a weed species, i.e., the common purslane, which has a small size, and not with different weed compositions. When the species exhibit different growth habit, size, and demand for resources, it directly influences their competitive capacity.

Therefore, the species of significant importance in the areas were *D. horizontalis*, *C. echinatus*, and *D. tortuosum* for both cowpea cultivars. Weed interference in the crop during the entire cycle reduced the productivity of the cultivars BRS Guariba and BRS Aracê by 39.81 and 37.27%, respectively. The interference periods PBI, TPIP, and CPIP were 9, 41, and 9 to 41 DAE for BRS Guariba and 15, 32, and 15 to 32 DAE for BRS Aracê, respectively. The semi-prostrate cultivar BRS Aracê was more competitive with weeds.

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