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Weed phytosociology in the cultivation of black beans under seeding densities in semi-arid

Marcos Lopes de Campos[1*], Marina Borges de Oliveira Silva[1], Abner José de Carvalho[1], Thiago Lívio Pessoa Oliveira de Souza[2], Ignacio Aspiazú[1], Simônica Maria de Oliveira[1]

[1] Universidade Estadual de Montes Claros, Janaúba, MG, Brasil. E-mail: agronomarcos@gmail.com; mariunim@yahoo.com.br; abner.carvalho@unimontes.br; ignacio.aspiazu@unimontes.br; simonica.agronomia@gmail.com
[2] Embrapa Arroz e Feijão, Santo Antônio de Goiás, GO, Brasil. E-mail: thiago.souza@embrapa.br

ABSTRACT: The objective of this study was to characterize the phytosociology of weeds in irrigated cultivation of black beans, under different sowing densities in semi-arid region of Minas Gerais, Brazil. The experiments were conducted in the autumn-winter harvest. The treatments consisted of four bean sowing densities (50, 100, 200, and 500 thousand seeds ha^{-1}), in a randomized block design, with four repetitions. Weed plants with complete structure were collected using the standard method of the square inventory and phytosociological parameters were estimated, studied using descriptive analysis. Lower sowing densities favored the development of species with C4 metabolism, while higher density suppressed their diversity, especially promoting *Sena obtusifolia*. The sowing density of black beans alters the dynamics of weeds in semi-arid conditions in Minas Gerais, Brazil. The density of black beans at 500 thousand seeds ha^{-1} suppresses the diversity of weed species, especially those with C4 metabolism. The species *S. obtusifolia*, *Eleusine indica*, *Amaranthus* spp., and *Brachiaria plantaginea* have higher importance value indices (IVI) and coverage value indices (IVC) in different densities of black beans in the semi-arid region of Minas Gerais, Brazil.

Key words: BRS Esteio; integrated weed management; *Phaseolus vulgaris* L.; phytosociological survey

Fitossociologia de plantas daninhas no cultivo de feijão-preto sob densidades de semeadura no semiárido

RESUMO: Objetivou-se com este estudo caracterizar a fitossociologia de plantas daninhas em cultivo irrigado de feijão-preto, sob diferentes densidades de semeadura no semiárido mineiro. Os experimentos foram conduzidos na safra de outono-inverno. Os tratamentos consistiram em quatro densidades de semeadura do feijoeiro (50, 100, 200 e 500 mil sementes ha^{-1}), em delineamento de blocos casualizados, com quatro repetições. Foram coletadas plantas daninhas com estrutura completa pelo método do quadrado inventário e estimados parâmetros fitossociológicos, estudados por análise descritiva. As menores densidades de semeadura favoreceram o desenvolvimento de espécies de metabolismo C4, enquanto a maior densidade suprimiu a diversidade destas, promovendo especialmente a *Sena obtusifolia*. A densidade de semeadura do feijão-preto altera a dinâmica de plantas daninhas nas condições do semiárido mineiro. O adensamento do feijão-preto em 500 mil sementes ha^{-1} suprime a diversidade de espécies, especialmente aquelas de metabolismo C4. As espécies *S. obtusifolia*, *Eleusine indica*, *Amaranthus* spp. e *Brachiaria plantaginea* apresentam maiores índices de valor de importância (IVI) e índices de valor de cobertura (IVC) nas diferentes densidades de feijão-preto no semiárido mineiro.

Palavras-chave: BRS Esteio; manejo integrado de plantas daninhas; *Phaseolus vulgaris* L.; levantamento fitossociológico

* Marcos Lopes de Campos - E-mail: agronomarcos@gmail.com (Corresponding author)
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Introduction

Common beans (*Phaseolus vulgaris* L.) are a staple of the Brazilian diet. Cultivated in different production systems, climatic and technological conditions, it is of great socio-economic importance in the country and is a low-cost source of vegetable protein (Zeffa et al., 2020).

According to surveys by Conab (2023), it is estimated that national production of common beans in the 2021/2022 harvest was 2.36 million tons, in a planted area of 1.57 million hectares. From this production, there are different types of bean, which are used and consumed according to regional preferences. Although Brazil is one of the main producers, it is also one of the biggest consumers of beans, which leads to an imbalance in supply and demand relations, requiring the import of beans, mainly from the black group, and limiting further consolidation in the export market (Conab, 2023).

This situation can be aggravated by factors that compromise crop productivity and, consequently, grain supply. For example, climatic adversities, common to semi-arid regions, as well as inadequate plant density and arrangement, which directly influence intra- and interspecific competitive relationships for resources in the environment (Baez-Gonzalez et al., 2020; LeQuia et al., 2020; Rai et al., 2020).

Increasing sowing density is a strategy to boost competitive capacity and, consequently, reduce crop losses due to weed interference (Scavo & Mauromicale, 2020). However, high sowing density can encourage intraspecific competition, with a consequent reduction in productivity. The ideal, then, is to have an adjustment, in compliance with the influence on the level of interference, which includes both factors inherent to the crop (cultivar, size, and growth habit) and the weed community itself (density, distribution, and specific composition) (Castro et al., 2019; Kouam & Tsague-Zanfack, 2020).

Generating information in this regard can be fundamental for the development of integrated weed management programs, based on the identification and study of the weed community through phytosociological surveys. This process consists of identifying weed species and determining their degree of importance in the production area, according to phytosociological parameters (Concenço et al., 2017).

Although the phytosociology of weeds has already been explored by some researchers in the common bean crop (Tavares et al., 2013; Batista et al., 2016; Batista et al., 2017; Santos et al., 2017), there are few studies relating weed flora to bean sowing densities, especially in semi-arid conditions. In view of the above, the objective of this study was to characterize the phytosociology of weeds in irrigated black bean crops, under different sowing densities in the semi-arid region of Minas Gerais, Brazil.

Materials and Methods

The study was carried out at the Experimental Farm of the Universidade Estadual de Montes Claros – Unimontes, in the municipality of Janaúba, northern Minas Gerais – Brazil. The experimental area is located at the following geographical coordinates: latitude - 15° 48’ 13” S, longitude - 43° 19’ 3” O and an altitude of 510 m. The region climate is tropical, characterized by rainy summers and dry winters, of the Aw type, according to the Köppen-Geiger classification (Alvares et al., 2013).

The soil in the experimental area is classified as ‘Latossolo Vermelho Eutrófico’, whose main chemical characteristics at a depth of 0-20 cm are: pH in water: 5.2; P (mg dm^{-3}): 30.7; P-rem - remaining phosphorus (mg dm^{-3}): 43.3; K (mg dm^{-3}): 189.0; Ca^{2+} ($cmol_c$ dm^{-3}): 2.3; Mg^{2+} ($cmol_c$ dm^{-3}): 0.9; Al^{3+} ($cmol_c$ dm^{-3}): 0; H + Al ($cmol_c$ dm^{-3}): 1.8; SB - sum of bases ($cmol_c$ dm^{-3}): 3.8; t - effective cation exchange capacity ($cmol_c$ dm^{-3}): 3.8; T- cation exchange capacity at pH 7.0 ($cmol_c$ dm^{-3}): 5.6; m - aluminum saturation (%): 0; V - base saturation (%): 68; organic matter (dag kg^{-1}): 1.7.

The treatments consisted of four bean sowing densities (50, 100, 200, and 500 thousand seeds ha^{-1}), in a randomized block design with four replications. The experimental plots were composed of four lines 4 m long, spaced 0.5 m apart, making up a total area of 8 m^2. The useful area consisted of the two central rows, totaling 4 m^2.

The common bean cultivar BRS Esteio from the black commercial group was used, which has high productive potential, erect architecture, indeterminate type II growth habit, adaptation to direct mechanical harvesting and a total cycle of approximately 85-94 days (Embrapa, 2017).

The study was carried out in the autumn-winter season (winter crop) for two consecutive years, with planting taking place in June 2016 and May 2017. The experimental area was the same in both years and the plots were randomized. The cropping system adopted in the area was crop succession, with sorghum planted in the summer-autumn crop and beans in the autumn-winter crop.

The soil was prepared conventionally, with one plowing and two harrowing operations before sowing. The area was then harrowed and fertilized using a mechanical seeder-fertilizer. Fertilization was carried out according to the chemical analysis of the soil and the crops needs, considering technological level 3 (Chagas et al., 1999). During sowing, 250 kg ha^{-1} of formula 04-30-10 were used. Top dressing was done manually, applying urea as a source of N (30 kg ha^{-1}) next to the planting line with the soil moist and foliar fertilizer based on Co (4.2 g ha^{-1}) and Mo (42 g ha^{-1}) with the aid of a backpack sprayer, at stage V4 (3rd trifoliate leaf) of the bean plant.

Sowing was carried out using manual seed drills, adjusting the number of seeds per meter of row according to the sowing density of the treatments, using a graduated ruler. The seedlings emerged seven days after sowing.

Initial weed control was carried out in a total area, using manual weeding, 15 days after the emergence (DAE) of the bean plant, in order to promote better crop establishment. After this period, there was no weed control. Other phytosanitary measures were carried out according to the crop needs and recommendations.

The experiment used conventional sprinkler irrigation from planting to the physiological maturity of the grains. Irrigation was managed according to the crop coefficients (Kc) of the bean plant, using 0.6 (beginning of the cycle; constant), variable in vegetative development, 1.15 in flowering/fruiting, and 1.00 at the end of the cycle. The reference evapotranspiration averages were calculated by Penman-Monteith (256.6) and Hargreaves-Samani (407.4), with 350 mm being the total net blade (NB) in 2016, and 347 mm of NB in 2017.

After the physiological maturity of the bean plant, weeds with complete structure (root system and aerial part) were collected using the standard inventory square method (0.5 × 0.5 m), randomly placed in each plot, as proposed by Braun-Blanquet (1979).

The weeds collected were identified in terms of family, species, class, and photosynthetic metabolism, and the total density of weeds per m^2 was determined. Afterwards, they were packed in paper bags and taken to a forced-air oven at 65 °C until they reached a constant mass, and then weighed and their dry matter determined on a 0.001 g precision scale.

After identifying and counting the species, the phytosociological variables were calculated according to Pitelli & Bianco (2013) and Muller-Dombois & Ellenberg (1974):

Relative frequency (RF): expresses the frequency (number of samples containing the species ÷ total number of samples) in which individuals of a species were detected in relation to the total frequency of all species (Equation 1):

$$RF = \frac{(\text{species frequency})}{(\text{total frequency of all species})} \times 100 \quad (1)$$

Relative density (RD): expresses the density (total number of individuals per species ÷ total number of samples) of a species in relation to the other species collected (Equation 2):

$$RD = \frac{(\text{species density})}{(\text{total density of all species})} \times 100 \quad (2)$$

Relative abundance (RA): expresses the abundance (total number of individuals per species ÷ total number of samples containing the species) of a species in relation to the others collected (Equation 3):

$$RA = \frac{(\text{species abundance})}{(\text{total abundance of all species})} \times 100 \quad (3)$$

Relative dominance (RDO): indicates the dominance of each species in relation to the biomass production accumulated by the weed community (Equation 4):

$$RDO = \frac{(\text{species biomass})}{(\sum \text{total biomass of all species})} \times 100 \quad (4)$$

Importance value index (IVI): indicates which species are most important within the area studied (Equation 5):

$$IVI = RF + RD + RA \quad (5)$$

Coverage value index (CVI): expresses the coverage of species in relation to their biomass production and number of individuals per area (Equation 6):

$$CVI = RDO + RD \quad (6)$$

The species diversity index (H’) was calculated according to the theory proposed by Shannon & Weaver (1949) to measure the diversity or entropic distribution of species in categorical data, using information theory (Equation 7):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \quad (7)$$

where: p_i - relative abundance of the i-th species; S - number of species (richness); and, ln - neperian base logarithm.

The phytosociological data from the two years of assessment were processed together and studied using descriptive analysis.

The diversity index values (H’) were compared using Hutcheson (1970) t-test ($p < 0.05$).

Results and Discussion

A total of 21 weed species were found in twelve families in the black bean plots at different sowing densities. Of these species, 57.1% were eudicotyledons and 42.9 monocotyledons (Table 1). According to Lacerda et al. (2021), because they belong to the same class as the crop, eudicotyledonous weeds can have similarities that make their control challenging. It is therefore necessary to adopt specific integrated management strategies, such as crop rotation and the selection of selective herbicides, in order to minimize their impact on bean cultivation.

Some monocot species belonging mainly to the Poaceae family and eudicots belonging to the Fabaceae family managed to establish themselves at all sowing densities (Table 1). This may be related to the competitive potential of these weeds, the large number of diaspores produced and the larger seed bank in the area.

According to Concenço et al. (2017), the composition of weed flora can be influenced by a number of factors, such as soil and climate differences, land use history, seed bank, intensity, and duration of interference and cultural practices adopted. Exploiting these factors in favor of agricultural activity can be a strategy to mitigate weed interference and, consequently, improve crop production (Campos et al., 2023).

The species diversity index (H’) at the different bean sowing densities (50, 100, 200, and 500 thousand seeds ha^{-1}) was 2.20, 2.05, 2.02, and 1.54, respectively. The highest density resulted in lower weed diversity than the others, according to

Table 1. Classification of weeds collected at different black bean sowing densities in the autumn-winter crops in the semi-arid region of Minas Gerais, Brazil.

Classification			Class	FM
Common name	Scientific name	Family		
Density of 50 thousand seeds ha^{-1}				
Leiteiro	*Euphorbia heterophylla*	Euphorbiaceae	Magnoliopsida	C3
Malva	*Sida* spp.	Malvaceae	Magnoliopsida	C3
Capim-tapete	*Mollugo virticillata*	Molluginaceae	Liliopsida	C4
Caruru	*Amaranthus* spp.	Amaranthaceae	Magnoliopsida	C4
Mata-pasto	*Senna obtusifolia*	Fabaceae	Magnoliopsida	C3
Beldoegra	*Portulaca oleracea*	Portulacaceae	Magnoliopsida	C4/CAM
Capim-mão-de-sapo	*Dactyloctenium aegyptium*	Poaceae	Liliopsida	C4
Poaia	*Richardia brasiliensis*	Rubiaceae	Magnoliopsida	C3
Capim-marmelada	*Brachiaria plantaginea*	Poaceae	Liliopsida	C4
Capim-pé-de-galinha	*Eleusine indica*	Poaceae	Liliopsida	C4
Falsa-serralha	*Emilia fosbergii*	Asteraceae	Magnoliopsida	C3
Trapoeraba	*Commelina benghalensis*	Commelinaceae	Liliopsida	C3
Erva-de-santa-luzia	*Commelina erecta*	Commelinaceae	Liliopsida	C3
Fedegozo verdadeiro	*Cassia occidentalis*	Fabaceae	Magnoliopsida	C3
Density of 100 thousand seeds ha^{-1}				
Malva	*Sida* spp.	Malvaceae	Magnoliopsida	C3
Capim-marmelada	*Brachiaria plantaginea*	Poaceae	Liliopsida	C4
Poaia	*Richardia brasiliensis*	Rubiaceae	Magnoliopsida	C3
Mata-pasto	*Senna obtusifolia*	Fabaceae	Magnoliopsida	C3
Beldoegra	*Portulaca oleracea*	Portulacaceae	Magnoliopsida	C4/CAM
Capim-mão-de-sapo	*Dactyloctenium aegyptium*	Poaceae	Liliopsida	C4
Capim-colchão	*Digitaria horizontalis*	Poaceae	Liliopsida	C4
Capim-pé-de-galinha	*Eleusine indica*	Poaceae	Liliopsida	C4
Caruru	*Amaranthus* spp.	Amaranthaceae	Magnoliopsida	C4
Trapoeraba	*Commelina benghalensis*	Commelinaceae	Liliopsida	C3
Erva-de-santa-luzia	*Commelina erecta*	Commelinaceae	Liliopsida	C3
Sorgo	*Sorghum bicolor*	Poaceae	Liliopsida	C4
Density of 200 thousand seeds ha^{-1}				
Beldoegra	*Portulaca oleracea*	Portulacaceae	Magnoliopsida	C4/CAM
Malva	*Sida* spp.	Malvaceae	Magnoliopsida	C3
Capim-mão-de-sapo	*Dactyloctenium aegyptium*	Poaceae	Liliopsida	C4
Poaia	*Richardia brasiliensis*	Rubiaceae	Magnoliopsida	C3
Caruru	*Amaranthus* spp.	Amaranthaceae	Magnoliopsida	C4
Mata-pasto	*Senna obtusifolia*	Fabaceae	Magnoliopsida	C3
Capim-marmelada	*Brachiaria plantaginea*	Poaceae	Liliopsida	C4
Capim-pé-de-galinha	*Eleusine indica*	Poaceae	Liliopsida	C4
Falsa-serralha	*Emilia fosbergii*	Asteraceae	Magnoliopsida	C3
Erva-de-santa-luzia	*Commelina erecta*	Commelinaceae	Liliopsida	C3
Diodella	*Diodella teres*	Rubiaceae	Magnoliopsida	C3
Leiteiro	*Euphorbia heterophylla*	Euphorbiaceae	Magnoliopsida	C3
Capim-carrapicho	*Cenchrus echinatus*	Poaceae	Liliopsida	C4
Sorgo	*Sorghum bicolor*	Poaceae	Liliopsida	C4
Picão-preto	*Bidens pilosa*	Asteraceae	Magnoliopsida	C3
Density of 500 thousand seeds ha^{-1}				
Malva	*Sida* spp.	Malvaceae	Magnoliopsida	C3
Beldoegra	*Portulaca oleracea*	Portulacaceae	Magnoliopsida	C4/CAM
Caruru	*Amaranthus* spp.	Amaranthaceae	Magnoliopsida	C4
Mata-pasto	*Senna obtusifolia*	Fabaceae	Magnoliopsida	C3
Capim-marmelada	*Brachiaria plantaginea*	Poaceae	Liliopsida	C4
Falsa-serralha	*Emilia fosbergii*	Asteraceae	Magnoliopsida	C3
Trapoeraba	*Commelina benghalensis*	Commelinaceae	Liliopsida	C3
Erva-de-santa-luzia	*Commelina erecta*	Commelinaceae	Liliopsida	C3
Corda-de-viola	*Ipomoea* spp.	Convolvulaceae	Magnoliopsida	C3
Fedegozo verdadeiro	*Cassia occidentalis*	Fabaceae	Magnoliopsida	C3
Maxixe	*Cucumis anguria*	Cucurbitaceae	Magnoliopsida	C3
Capim mão-de-sapo	*Dactyloctenium aegyptium*	Poaceae	Liliopsida	C4
Capim pé-de-galinha	*Eleusine indica*	Poaceae	Liliopsida	C4

FM - Photosynthetic metabolism.

Hutcheson (1970) t-test ($p < 0.05$). These results may indicate changes in the abundance, composition, and dynamics of the weed community as a result of bean sowing density (Tampubolon et al., 2022).

A graphic description was made of the species with the highest number of plants in the weed community at the different bean sowing densities (Figure 1). At densities of 50, 100, and 200 thousand seeds ha^{-1}, it was observed that weed species with a C4 photosynthetic metabolism, especially *E. indica*, *Amaranthus* spp., *B. plantaginea*, and *P. oleracea*, played a greater role in the composition of the weed community. On the other hand, at a density of 500 thousand seeds ha^{-1}, part of these were suppressed, promoting the *Senna obtusifolia* species, which accounted for almost 60% of the total weed community (Figure 1). In addition, this species managed to establish itself at all bean sowing densities, proving to be dominant in the area.

In general, species with a C4 photosynthetic metabolism are more efficient at using radiation and can have some competitive advantages when they occur in crops with plants with a C3 photosynthetic metabolism (Santos et al., 2017), such as bean plants. However, the results of this study showed that increasing sowing density can provide greater suppression of weeds with C4 metabolism (Figures 1 and 2). This is due to the lower light availability to them (LeQuia et al., 2020), which inhibits their development and dry matter deposition, consequently reducing the pressure on the crop.

The total dry matter of the weeds at a density of 50 thousand seeds ha^{-1} was 925.15 g m^{-2}. This value was higher than those found for other sowing densities, which may suggest greater development of weeds at the lower bean sowing density. On the other hand, as the sowing density of the crop increased, there was a gradual reduction in the total dry matter of the weeds (Figure 2). As a result, the densification of the bean plant

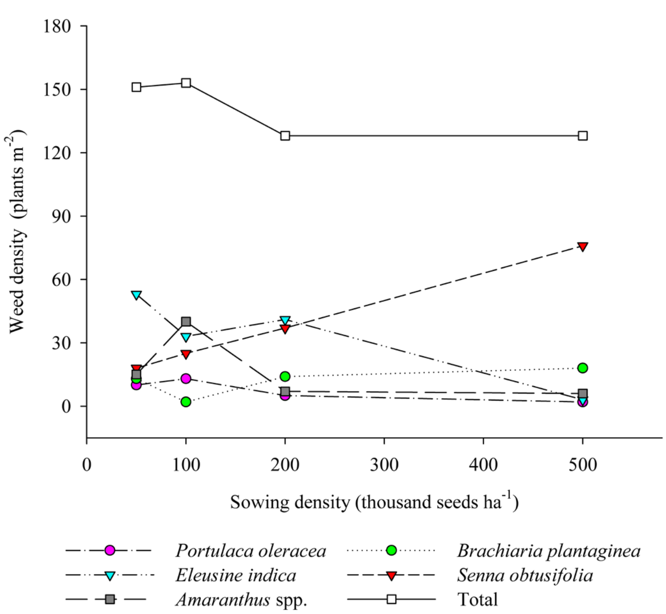


Figure 1. Density of the main weed species present in the different sowing densities of black beans, in the autumn-winter crops, in the semi-arid region of Minas Gerais, Brazil.

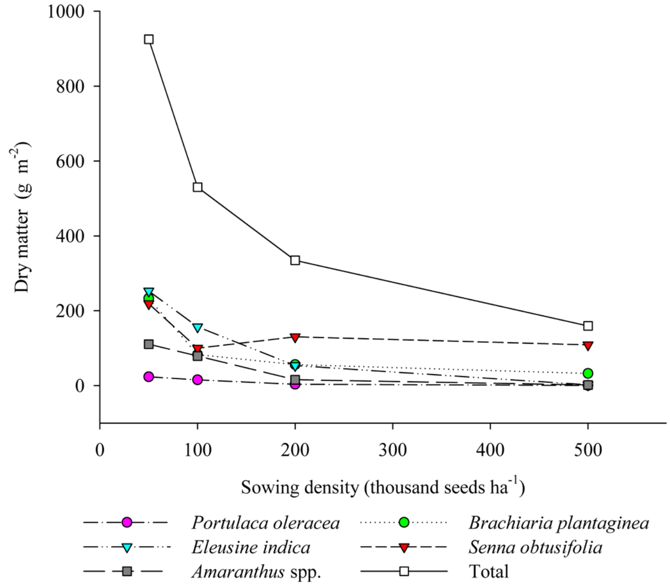


Figure 2. Dry mass of the main weed species present in the different sowing densities of black beans, in the autumn-winter crops, in the semi-arid region of Minas Gerais, Brazil.

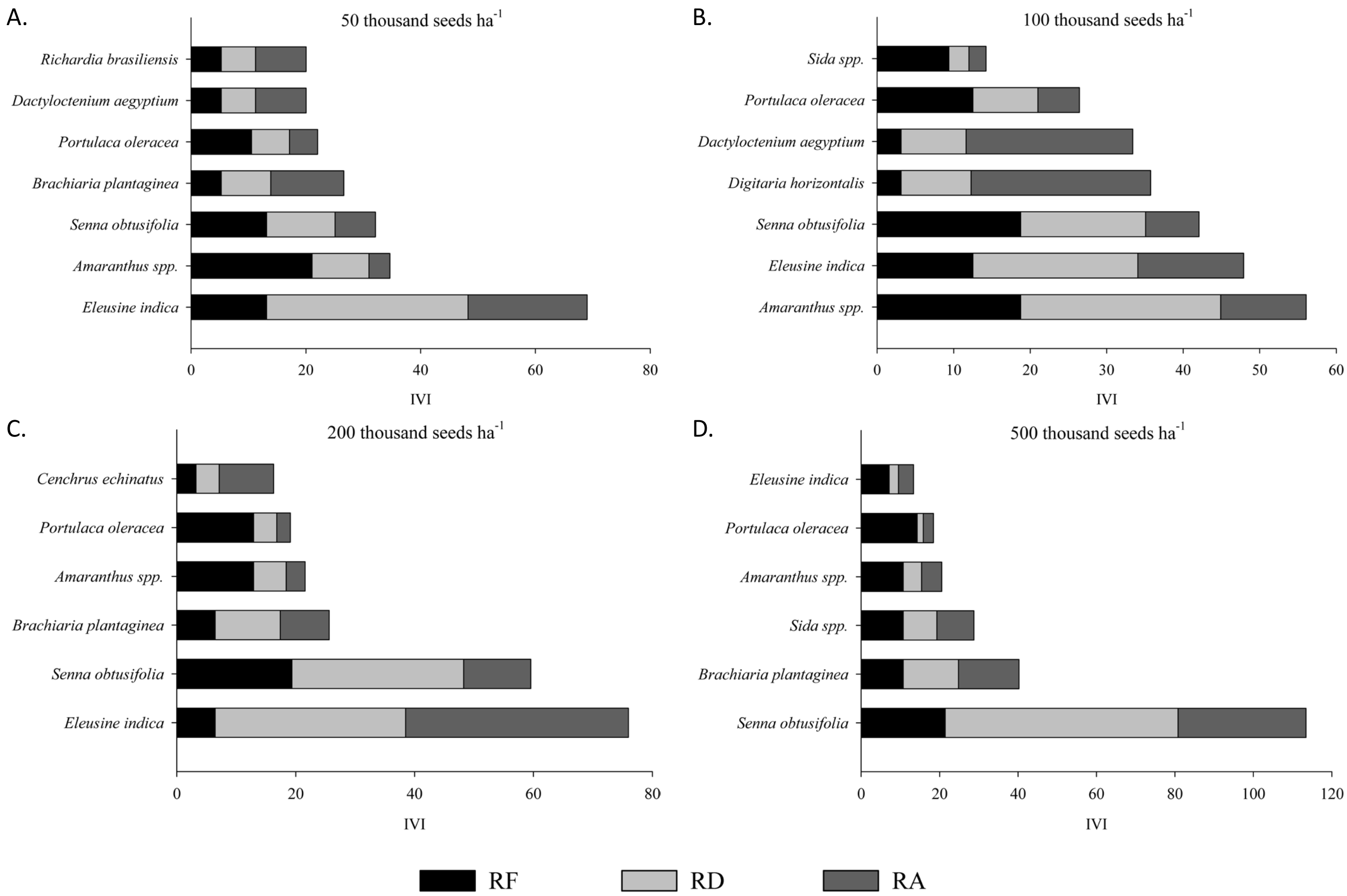
favors the faster closure of the area, creating a greater physical barrier through its canopy, which reduces access to light and hinders the growth of weeds in the crop rows (LeQuia et al., 2020; Scavo & Mauromicale, 2020), especially those with late emergence and positive photoblastism.

Cultivars with type II indeterminate growth habit, such as the one used in this study, tend to be more competitive than cultivars with type I determinate growth habit. This can be attributed to the fact that type II cultivars have a greater number of branches and, consequently, more ground cover (Batista et al., 2016). A possible alternative to improve light interception and thus the competitive capacity of determinate-growth cultivars would be to plant them more densely.

The most obvious and immediate benefit that adjusting sowing density can bring is optimizing crop yields and minimizing weed interference. In addition, the inclusion of plant densification in integrated management helps to reduce the use of herbicides, control costs, and cases of resistance (Iqbal et al., 2020).

In order to understand the dynamics, concentration and/or dispersion of the weed species in the area and thus define the order of priority for their control, the importance value index (IVI) was determined. This varied according to sowing density (Figure 3).

At densities of 50 and 100 thousand seeds ha^{-1}, *E. indica* and *Amaranthus* spp. had the highest IVI, mainly due to their higher RD than the other species (Figure 3). These species are highly competitive and stand out for the large quantity of seeds they produce and their ability to adapt to different environmental conditions (Hao et al., 2017; Ma et al., 2019). In addition, because they have a C4 photosynthetic metabolism, they are more likely to grow when exposed to light (Loddo et al., 2020), which warns of their potential for interference, especially at lower sowing densities.



RF - Relative frequency; RD - Relative density; RA - Relative abundance.

Figure 3. Importance value index (IVI) of the main weed species identified in different black bean sowing densities, in the fall-winter crops, in the semi-arid region of Minas Gerais, Brazil.

At a density of 200 thousand seeds ha^{-1}, the species *E. indica* had the highest IVI. At a density of 500 thousand seeds ha^{-1}, it was the species *S. obtusifolia* (Figure 3). The higher sowing density may have led to the suppression of some weed species, especially those that are more sensitive to the closure of the bean canopy and have late emergence. On the other hand, the species least affected by sowing density had a higher IVI, which may mean that they have great competitive potential, even in unfavorable conditions for their development.

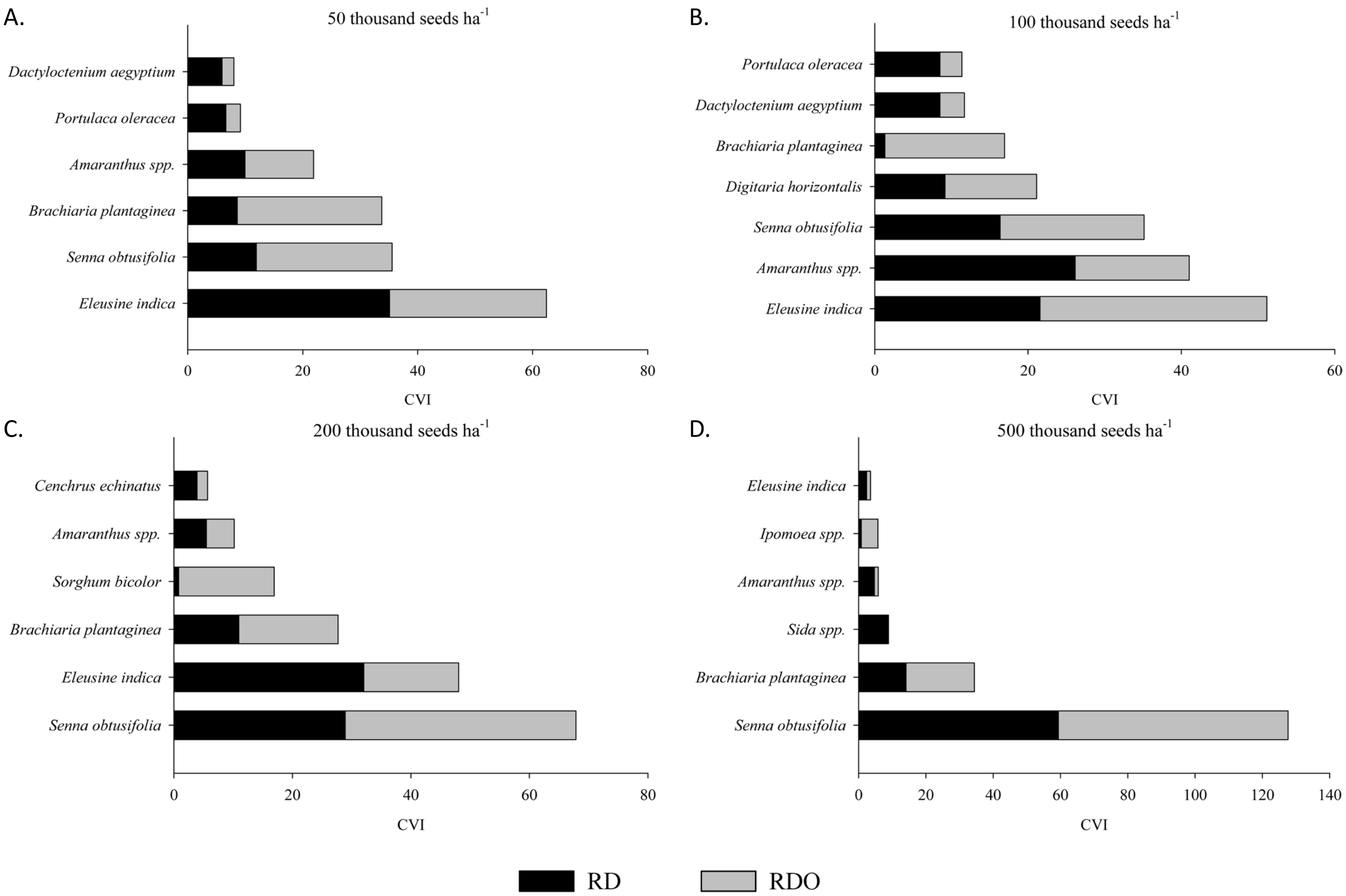
An example of this is the high IVI of *S. obtusifolia* at a density of 500 thousand seeds ha^{-1} (Figure 3), highlighting its highly developed root system, occupying a large volume of soil and presumably resulting in a greater competitive advantage in the acquisition of water and nutrients (Wright et al., 1999). This highlights the imminent problems that can be caused by this species, especially when the availability of resources is limited, as is the case in semi-arid regions. Therefore, it is important to take greater care with efficient strategies for its integrated management.

In addition to the IVI results, the coverage value index (CVI) was also determined, in order to define the priority for control and strategic planning of the actions to be taken. It was possible to observe that the CVI of the species varied according to the sowing density. The species that had a higher RDO than RD in the composition of the CVI showed that their biomass was more effective than the number of individuals in covering the area, or vice versa (Figure 4).

These results elucidate the potential for dominance of the area and, consequently, the competitive capacity of a given species, influenced by varying the sowing density of the crop. According to Souza et al. (2020), the predominance of a weed species in the cultivated area is defined according to its aggressiveness, propagation strategies, metabolism, and efficiency in the use of resources (water, light, and nutrients). Thus, identifying the weeds with the highest IVI and CVI, and possibly the highest biomass accumulation, can direct the targets with the greatest impact and dominance to be controlled in the area.

The highest CVI at densities of 50 and 100 thousand seeds ha^{-1} were from the *E. indica* species, while at densities of 200 and 500 thousand seeds ha^{-1} they were from the *S. obtusifolia* species. In addition, the CVI of the *E. indica* species was persistently high up to the density of 200 thousand seeds ha^{-1} and, with the densification of 500 thousand seeds ha^{-1}, there was a drastic reduction (Figure 4).

In the context of integrated management, the practice adopted minimized some competitive situations. However,



RD - Relative density; RDO - Relative dominance.

Figure 4. Cover value index (CVI) of the main weed species identified in different black bean sowing densities, in the autumn-winter crops, in the semi-arid region of Minas Gerais, Brazil.

some more aggressive species managed to establish themselves at the different sowing densities and require special attention when defining control strategies due to their high potential for dominating the area and high competitiveness.

Based on these results, it is suggested that adjusting sowing density can be an efficient cultural practice to mitigate the competitive effects on bean crops. According to MacLaren et al. (2020), this is due to the increased uptake of resources from the environment by the crop and the suppression of weeds due to the sowing density or plant arrangement adopted. Therefore, the information generated can be useful for developing integrated weed management programs for black beans in semi-arid conditions.

Conclusions

Black bean sowing density alters weed dynamics under semi-arid conditions in Minas Gerais, Brazil.

Black bean densification at 500 thousand seeds ha^{-1} suppresses the diversity of weed species, especially those with a C4 metabolism.

The species *Sena obtusifolia*, *Eleusine indica*, *Amaranthus* spp., and *Brachiaria plantaginea* have the highest importance value indices (IVI) and cover value indices (CVI) in the different black bean densities in the semi-arid region of Minas Gerais, Brazil.

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Compliance with Ethical Standards

Author contributions: Conceptualization: AJC, TLPOS; Data curation: MBOS, SMO; Formal analysis: Funding acquisition: AJC; MLC; Investigation: MLC, MBOS, SMO; Methodology: AJC, IA; Project administration: AJC, IA; Resources: TLPOS; Supervision: MBOS; Validation: AJC, IA; Visualization: SMO; Writing – original draft: MBOS; Writing – review & editing: MLC.

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