

Floristic composition of weeds in a dystrophic Red-Yellow Argisol under the cultivation of cowpea, cv. BRS Novaera

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Abstract

Among the several factors that negatively influence cowpea culture, weeds have been responsible for the reduction of growth, development and productive performance of the crop, making it necessary to establish management strategies based on phytosociological studies of weed species in growing areas. Therefore, the objective of this research was to evaluate the floristic composition of weeds, aiming to identify the main species and their dynamics, and to consider their distribution in time and space as pertaining to the cultivation of a modern variety of cowpea, cv. BRS Novaera, in dystrophic Red-Yellow Argisol, in the Midnorth region of the state of Piauí, Brazil. The phytosociological survey of weeds was carried out in three sessions: the first one was immediately before the area was desiccated with glyphosate (15 days before sowing the cowpea), and the others were at 20 and 40 days after sowing (DAS). Following the quantification of species and number of individuals, the following phytosociological parameters were calculated: frequency and relative frequency; density and relative density; abundance and relative abundance; and importance value index. It was concluded that there were few changes in the floristic composition of the weed community according to the epoch of the phytosociological surveys. The main weed plants at 20 DAS of cowpea (vegetative phase) were *Chamaesyce hirta*, *Digitaria insularis*, *Alternanthera tenella*, *Cleome affinis*, *Mollugo verticillata* and *Portulaca oleracea*. At 40 days (reproductive phase), the weed species with a large establishment and acting as potential competitors with cv. BRS Novaera cowpea were *Digitaria insularis*, *Chamaesyce hirta* and *Mollugo verticillata*.

Keywords: management; phytosociology; relative frequency; *Vigna unguiculata* (L.) Walp.; weed community.

Abbreviations: Ab_Abundance; DAS_days after sowing; De_Density; NPK_ formulated fertilizer; F_Frequency; IVI_Importance value index; Rab_Relative abundance; Rf_Relative frequency; Rde_Relative density.

Introduction

The cowpea (*Vigna unguiculata* L. Walp) is a fundamental participant in Brazilian agriculture, with its cultivation mainly concentrated in the North and Northeast regions of the country, where it is used as a subsistence crop for human consumption due to the protein levels contained in its grains (Bonfim-Silva et al., 2018). However, with increasing market demand and the emergence of new cultivars adapted to mechanized cultivation, the crop has expanded cultivation to more technified agricultural areas of Brazil (Barros et al., 2013; Guerra et al., 2017;).

The presence of weeds in cultivated areas containing cowpea has been one of the main factors that negatively influence the growth, development and productive performance of both the green pods and grains of the crop, as well as hindering and burdening production costs with cultural practices and grain harvest (Gbaguidi et al., 2015). The seed bank of the weed community present in the soil is

very dynamic, being the result of input from the dispersion of seeds that often persist dormant in the soil awaiting the best environmental conditions to germinate. In addition to seeds, tubers, bulbs, rhizomes and other structures are also used by weeds to propagate. A decrease in the seed bank may Outflows result from seed germination, predation and deterioration or death (Mesquita et al., 2014; Hossain and Begum, 2015).

The degree of interference of weeds is influenced by their size, density and distribution in the area of cultivation, the environment (climate, soil and management), and the period of coexistence with the crop (Batista et al., 2017). The early stages of development of the crop are more critical due to the restriction of sunlight on the crop, resulting from the shade provided by the weed community (Fey et al., 2013).

In the establishment of weed management strategies, the identification of weed species is a sine qua non within the

growing environment and at the different stages of the crop, since the order of importance is established based on their frequency, density and dominance, as each species presents a different dynamic of growth and establishment in the area, and the individual aggressiveness of each species influences the cultivated species in a different way (Cunha et al., 2014; Albuquerque et al., 2017; Silva et al., 2018).

The modern varieties of cowpea developed by the Brazilian Agricultural Research Corporation (EMBRAPA) are characterized by the high potential of grain yield, cycle precocity and semi-erect or erect architecture, which is suitable for a cultivated crop and mechanized harvest, making cultivation in large areas possible, as already occurs in Piauí's savannas; in these locations, cowpea is used in the off-season after soybean cultivation (Bezerra et al., 2014; Benchimol et al., 2017). On the other hand, this architecture favours less shaded environments compared to pruned architecture cultivars, increasing the competition for water, light, nutrients and space between the cowpea cultivation and the weed community. Considering the low number of phytosociological surveys of weeds in modern varieties of cowpea in the various edaphoclimatic environments under cultivation in Brazil, the objective of this research was to evaluate the floristic composition of the weeds, aiming to identify the main species and to understand their dynamics, considering the distribution in time and space. This research was performed with respect to the cultivation of a modern variety of cowpea, cv. BRS Novaera, in a dystrophic Red-Yellow Argisol, in the Midnorth region of the state of Piauí, Brazil.

Results and discussion

Evaluations before sowing

Fifteen days before the sowing of cv. BRS Novaera, a wide diversity of initial floristic composition was observed and was found to be composed of ten infesting species from the seed bank of the study area (Table 1), of which 60% of the infesting species presented an importance value index (IVI) above 20%: *Cleome affinis* DC. (70.00%), *Mollugo verticillata* L. (69.10%), *Portulaca oleracea* L. (45.80%), *Alternanthera tenella* Colla (35.50%), *Chamaesyce hirta* L. (35.00%) and *Digitaria insularis* L. (20.20%). These results are listed in increasing order of importance since they are derived from the sum of the phytosociological parameters of frequency, dominance and relative abundance (Silva et al., 2018).

The four other species (*Amaranthus deflexus*, *Hyptis suaveolens*, *Boerhavia diffusa* and *Cenchrus echinatus*), although present in the seed bank, presented low invasive potential. The high number of weed species developing concomitantly in one area favours inter- or intraspecific competition, where the more aggressive ones stand out and delay or suppress the establishment of the other weed species (Freitas et al., 2009; Bastiani et al., 2016).

Evaluations in the vegetative phase

Precisely twenty days after the sowing of cowpea cv. BRS Novaera, corresponding to the vegetative phase of the crop, the six weed species identified in the previous phase remained (*Chamaesyce hirta*, *Digitaria insularis*, *Alternanthera tenella*, *Cleome affinis*, *Mollugo verticillata*

and *Portulaca oleracea*); however, the order of importance in the weed community was altered. It was observed that species of the family *Euphorbiaceae* (*Chamaesyce hirta*) and *Poaceae* (*Digitaria insularis*) dominate the area (Table 1). According to Jakelaitis et al. (2014), these species present a perennial and short life cycle, in addition to producing large amounts of disseminated seeds and presenting dormancy, which makes them highly aggressive as weeds in agricultural areas. The dormancy presented by these species results in seed germination in a staggered form (Vivian et al., 2008), and the bean sowing operation itself may be sufficient to stimulate the germination of weed seeds. At this stage, the species *Boerhavia diffusa*, which had already presented a low value of importance (IVI = 4.5%) before the introduction of the cowpea (Table 1), was possibly suppressed by the presence of dead cover due to desiccation. This result is corroborated by results found by Martins et al. (2016) who, when evaluating the effect of mulching on the weed community in the maize crop, verified that the vegetal residues left on the soil reduced or suppressed the emergence of monocotyledon and eudicotyledon weeds in the no-tillage system. On the other hand, in the vegetative phase, three new weed species (*Turnera ulmifolia*, *Commelina benghalensis* and *Cyperus diffusus*) emerged from the seed bank (Table 1), demonstrating that the seeds of these species needed more time to germinate and settle, which was reflected in their low value in this period. Dias et al. (2009) report that *C. benghalensis* is a species that presents a wide distribution in agricultural areas, being difficult to control because it has resistance to the herbicide glyphosate. In addition, its reproduction occurs by seeds (aerial and subterranean), as well as by the production of shoots originating from the cauline bundles. Evaluating the floristic composition of weeds in cowpeas in the municipality of Zé Doca, Marques et al. (2010) verified that *C. diffusus* was the species with the highest IVI in the 2007/08 crop, unlike the results found in this work, where *C. diffusus* had a low establishment in the area.

Evaluations in the vegetative reproductive

At 40 days after sowing, the most frequent species were *Digitaria insularis*, *Chamaesyce hirta* and *Mollugo verticillata* (Table 1), where *D. insularis* had an IVI (72.60%) higher than the others. *D. insularis* is a weed that shows high potential for infestation due to its ability to reproduce by seeds and rhizomes, making it more problematic and more efficient in soil colonization. The rhizome reproduction method has favoured the resistance of *D. insularis* to glyphosate since the translocation of the herbicide is limited (Oreja et al., 2017). The resistance of this weed to glyphosate was described by Carvalho et al. (2011) in corn and soybean crops, suggesting that the initial desiccation of the area, carried out with glyphosate before sowing cowpea, only slows the germination of the species but does not suppress it. Similarly, Silveira et al. (2018) confirm that this species presents high resistance to glyphosate and indicate the use of this herbicide in high concentrations, above 720 g ha⁻¹ of the active principle, as the main factor for resistance. These authors suggest applying the dose recommended by the manufacturer in order to minimize the selection pressure exerted by glyphosate.

Table 1. Relative frequency (Rf), relative density (Rde), relative abundance (Rab) and importance value index of weed plants found in cowpea production area at 15 days before sowing and at 20 and 40 DAS, 2018.

N.	Species	Rf	Rde	Rab	IVI*
----- (%) -----					
15 days before sowing					
1	<i>Cleome affinis</i> DC.	24.10	29.20	16.70	70.00
2	<i>Mollugo verticillata</i> L.	17.70	29.00	22.40	69.10
3	<i>Portulaca oleracea</i> L.	19.00	15.60	11.30	45.80
4	<i>Alternanthera tenella</i> Colla	15.20	10.70	9.60	35.50
5	<i>Chamaesyce hirta</i> L.	15.20	10.40	9.40	35.00
6	<i>Digitaria insularis</i> L.	3.80	3.60	12.80	20.20
7	<i>Amaranthus deflexus</i> L.	1.30	0.50	5.90	7.70
8	<i>Hyptis suaveolens</i> L.	1.30	0.50	5.90	7.70
9	<i>Boerhavia diffusa</i> L.	1.30	0.30	3.00	4.50
10	<i>Cenchrus echinatus</i> L.	1.30	0.30	3.00	4.50
Mean		-	-	-	30.00
20 DAS (vegetative phase)					
1	<i>Chamaesyce hirta</i> L.	21.95	25.36	12.47	59.78
2	<i>Digitaria insularis</i> (L.)	19.51	21.55	12.00	53.05
3	<i>Alternanthera tenella</i> Colla	7.32	14.64	21.60	43.56
4	<i>Cleome affinis</i> DC.	4.88	11.07	24.50	40.45
5	<i>Mollugo verticillata</i> L.	14.63	12.14	8.96	35.73
6	<i>Portulaca oleracea</i> L.	9.76	10.71	11.85	32.32
7	<i>Hyptis suaveolens</i> (L.) Poit.	12.20	3.21	2.84	18.25
8	<i>Turnera ulmifolia</i> L.	4.88	3.93	8.69	17.50
9	<i>Commelina benghalensis</i> L.	4.88	3.21	7.11	15.20
10	<i>Cyperus diffusus</i> Vahl	4.88	1.43	3.16	9.47
11	<i>Amaranthus deflexus</i> L.	2.44	0.36	1.58	4.38
12	<i>Cenchrus echinatus</i> L.	2.44	0.36	1.58	4.38
Mean		-	-	-	27.84
40 DAS (reproductive phase)					
1	<i>Digitaria insularis</i> L.	23.40	33.00	16.10	72.60
2	<i>Chamaesyce hirta</i> L.	17.00	23.40	15.80	56.20
3	<i>Mollugo verticillata</i> L.	6.40	16.20	29.00	51.60
4	<i>Alternanthera tenella</i> Colla	8.50	11.60	15.50	35.60
5	<i>Commelina benghalensis</i> L.	17.00	5.30	3.60	25.90
6	<i>Turnera ulmifolia</i> L.	8.50	3.60	4.90	17.00
7	<i>Portulaca oleracea</i> L.	8.50	3.30	4.40	16.30
8	<i>Cenchrus echinatus</i> L.	4.30	2.30	6.20	12.80
9	<i>Cyperus diffusus</i> Vahl	4.30	1.00	2.70	7.90
10	<i>Amaranthus deflexus</i> L.	2.10	0.30	1.80	4.20
Mean		-	-	-	27.80

N. – number.

Table 2. Floristic survey of weeds by family, species, common name and botanical class, under cultivation of cowpea, cv BRS Novaera, at 15 days before sowing and in the vegetative (V) and reproductive (R) phases at 20 and 40 DAS, respectively, Teresina - PI, Brazil, 2018

N.	Family	Species	Common name	Phase		Cl.
				V	R	
1	Amaranthaceae	<i>Alternanthera tenella</i> Colla	Apaga fogo	P	P	E
		<i>Amaranthus deflexus</i> L.	Caruru	P	P	E
2	Brassicaceae	<i>Cleome affinis</i> DC.	Mussambê	P	-	E.
3	Commelinaceae	<i>Commelina benghalensis</i> L.	Trapoeraba	P	P	E
4	Cyperaceae	<i>Cyperus diffusus</i> Vahl	Tiririca	P	P	M
5	Euphorbiaceae	<i>Chamaesyce hirta</i> L.	Erva-de-Santa-Luzia	P	P	E
6	Lamiaceae	<i>Hyptis suaveolens</i> L.	Bamburral	P	-	E
7	Molluginaceae	<i>Mollugo verticillata</i> L.	Capim Tapete	P	P	E
8	Nyctaginaceae	<i>Boerhavia diffusa</i> L.	Erva tostão	-	-	E
9	Poaceae	<i>Cenchrus echinatus</i> L.	Capim Carrapicho	P	P	M
		<i>Digitaria insularis</i> L.	Capim Colchão	P	P	M
10	Portulacaceae	<i>Portulaca oleracea</i> L.	Beldroega	P	P	E
11	Turneraceae	<i>Turnera ulmifolia</i> L.	Chanana	P	P	E

M – monocotyledons; E – Eudicotyledons; N. – Number; P – presence; Cl. – Class.

Cyperus diffusus and *Amaranthus deflexus* presented lower importance values within the weed community (Table 1). In this evaluation, at 40 DAS, the *Boerhavia diffusa* that had already been suppressed in the vegetative phase of cowpea was suppressed, along with the species *Hyptis suaveolens* and *Cleome affinis* that were present at 15 days before sowing and 20 days after sowing (Table 2), indicating that the cycle of these species is probably shorter than those of the other weed types present in the area, or possibly that the competitive capacity of these species in relation to the bean crop may have been impaired due to the greater leaf cover of cowpea at this time point.

In Table 2 we can observe the relation of weeds found in the three periods of evaluation, having identified 13 weed species distributed in 13 genera and 11 families. Of the 13 species, 76.92% belong to the class of eudicots (10 species) and 23.08% belong to the botanical class of monocotyledons (3 species). According to Pitelli (1987), weed species with botanical characteristics very similar to the cultivated species present greater competitive potential with the crop. These results are consistent with those found by Marques et al. (2010) who, when performing a floristic survey in area of no-till and cultivated with cowpea, found that the eudicot class had a predominance of 74.51%.

The highest number of species was observed for the families *Poaceae* and *Amaranthaceae*, which were both represented by two species while the other families were represented by a single species. The families and species found infesting cowpea cultivation resemble those identified in several other studies performed on beans, such as those of Marques et al. (2010) and Borchardt et al. (2011).

Materials and methods

Plant material

In this study, a variety of cowpea, cv. BRS Novaera, was used. This variety presents a semi-erect size; has high resistance to lodging, good natural defoliation, and short lateral branches; and features insertion of the pods slightly above the level of the foliage. Although cv. BRS Novaera is a recommended crop for business agriculture because it facilitates mechanical harvesting; it is also suitable for family farming due to its early cycle (approximately 65 to 70 days), and due to the uniform concentration of pod maturity in a single period, it can be harvested at one time by arranging or cutting the plants. Hand picking is also facilitated by pods being placed on top of plants. In addition, the grains are white, large and well-formed, which follows the pattern of preference of a large range of consumers, both in national and international markets (BRS Novaera, 2007; Benchimol et al., 2017).

Description of the study environments

This study was conducted during the agricultural year 2013/14, in the municipality of Teresina located in the Midnorth region of the state of Piauí, Brazil. The specific location was a dystrophic Red-Yellow Argisol with a five-year history of cultivation with cassava and no use of herbicides. The climate of the municipality, according to the Koppen

climate classification is C1sA'a', which is characterized as dry sub-humid, with moderate water surplus in the summer.

Design and trial management

An area of 480 m² was desiccated with glyphosate at a dose of 1736.0 g ai ha⁻¹, fifteen days before sowing the cowpea, using a syrup volume of 3 L ha⁻¹. The sowing of cowpea, cv. BRS Novaera, was carried out on July 11, 2013, on dried straw, using a plantation plot adapted for a no-till system on straw. The base fertilization was 150 kg ha⁻¹ of NPK in the formulation 05-30-15 (N, P₂O₅, K₂O). The spacing used between cultivation lines was 0.5 m, with a density of 240,000 ha⁻¹ plants (12 seeds per metre).

At 35 days after sowing, cover fertilization with 60 kg ha⁻¹ of P₂O₅ and 40 kg ha⁻¹ of K₂O was carried out. In the experimental period, the culture was irrigated by spraying, every two days, with a 10 mm blade, suspending the water supply soon after the formation of the pod and beginning the senescence process, thus avoiding the onset of fungal diseases in the plants.

Evaluations carried out

The floristic survey of the weed community was carried out at three distinct times; first, at 15 days before sowing the cowpea, just before the area was desiccated; second, at 20 DAS, which corresponded to the vegetative phase of the crop; and lastly, at 40 DAS (beginning of flowering). For the sampling of the weed community, the inventory square method (an iron square with 0.5 m sides and an internal area of 0.25 m²) was randomly released 16 times per evaluation period via zigzag walking. Subsequently, the plants present in each sample unit were cut at the soil level, separated, quantified and identified through specific literature on family, genus and species (Lorenzi, 2014).

Statistical analysis

The following phytosociological parameters were calculated from the quantification of the species and the total number of individuals per sampled area: i) frequency (index of the occurrence of species in each square); ii) density (number of individuals of the same species in each square); iii) abundance (concentration of species at different points in the total area); iv) relative frequency; v) relative density; vi) relative abundance (relates one species to all others found in the area) and vii) importance value index (Mueller-Dombois and Ellenberg, 1974). These parameters were calculated as follows:

$$\begin{aligned} \text{(i) Frequency (F)} &= \frac{\text{number of samplings containing the species}}{\text{total number of releases}} \\ \text{(ii) Relative frequency (Rf)} &= \frac{(\text{frequency of a species} \times 100)}{(\text{frequency of a species} \times 100)} \\ \text{(iii) Density (De)} &= \frac{\text{number of individuals of a species}}{\text{total area sampled}} \\ \text{(iv) Relative density (Rde)} &= \frac{(\text{density of a species} \times 100)}{\text{total density}} \\ \text{(v) Abundance (Ab)} &= \frac{\text{number of individuals of a species}}{\text{total number of releases containing the species}} \end{aligned}$$

(vi) Relative abundance (Rab) =

$$\frac{\text{Abundance of a species} \times 100}{\text{total abundance}}$$

(vii) Importance Value Index (IVI) = Rf + Rde + Rab

Conclusion

It was concluded that there were few changes in the floristic composition of the weed community during the period of the phytosociological surveys. The main weed plants at 20 DAS of cowpea (vegetative phase) were *Chamaesyce hirta*, *Digitaria insularis*, *Alternanthera tenella*, *Cleome affinis*, *Mollugo verticillata* and *Portulaca oleracea*. At 40 days (reproductive phase), weed species with a large establishment and acting as potential competitors with cv. BRS Novaera cowpea were *Digitaria insularis*, *Chamaesyce hirta* and *Mollugo verticillata*.

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