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Coverage plants in coffee production systems as weed control

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ABSTRACT

The aim of this study was to evaluate the floristic and phytosociological compositions of weeds and the influence of cover crops between rows of organic and conventional coffee plantations. The assessment of weeds was carried out in two seasons (dry and rainy) in 2019 and 2020. A square made from welded iron bars of 0.50 x 0.50 m (0.25 m^2) was launched four times in each block randomly, avoiding overlap, totaling 4.0 m^2 of sampled area. A total of 41 weed species were found and described, which were distributed in 38 genera and 19 families with the predominance of Poaceae and Asteraceae. The most abundant species were *Cyperus* sp. and *Urochloa decum*bens that occurred simultaneously in all treatments and showed greater importance (IVI) among weeds. The similarity index is generally low, indicating that the weed community was affected by the presence and absence of cover crops.

Key words: Phytosociology; *Coffea arabica*; Organic agriculture; Cover crops.

1 INTRODUCTION

Arabica coffee holds a prominent position in Brazilian agriculture, representing not only an important economic engine but also a crop that demands meticulous attention with respect to management, as pointed out by Pires et al. (2017). Among the various factors that can impact the productivity and quality of coffee, weeds emerge as a significant threat. These plants directly compete with crops for essential resources such as water, light, carbon dioxide, and nutrients, often demonstrating a remarkable ability to sustain their growth even under unfavorable conditions, according to Lanza, Machado, and Martelleto (2017).

The impact of weeds goes beyond mere competition for resources. They can cause considerable losses in both yield and quality of coffee. This is because weeds reduce the efficiency of agricultural equipment, affect soil fertility, may increase the need for the use of agricultural inputs, and can even inhibit the germination of crop seeds through the production and release of allelochemicals, as discussed by Ahmad et al. (2016) and Welch et al. (2016).

In this context, each management practice acts as a filter on weed communities, removing, limiting, or favoring specific species, as demonstrated by Derrouch et al. (2021) and Smith and Gross (2007). Various approaches to weed control have been explored, including cultural, physical, mechanical, biological, and chemical methods, especially in areas between rows of coffee trees, as discussed by Martins et al. (2015) and Pires et al. (2017). Chemical control, often perceived as more economical than manual or biological methods, has been traditionally favored, according to Ghorai (2008). However, the use of herbicides raises significant concerns about environmental impact, challenging researchers and rural producers to seek more sustainable alternatives.

In this light, the use of cover crops emerges as a promising alternative to chemical control. These plants, which may be legumes, grasses, or even mixtures of these species, are specifically cultivated to protect the soil against erosion, improve its structure, and increase its fertility, as observed by Dozier et al. (2017) and Staver et al. (2020). Additionally, they can decrease the leaching of nitrate and other nutrients from the root zone, as noted by Kaspar et al. (2012), and suppress pests and weeds, as reported by Ngosong et al. (2019) and Taak et al. (2021). Some legumes like crotalaria and grasses like Pennisetum glaucum produce different root systems that explore various soil depths, thereby enhancing the efficiency of nutrient absorption and use, as stated by Kaspar et al. (2012) and Wutke et al. (2009), acting on soil unpacking, according to Gonçalves et al. (2006), and suppressing the growth and development of weeds.

Given this complex and multifaceted scenario, the present study seeks to understand the efficacy of cover crops as an alternative method for weed control in Arabica coffee systems, both organic and conventional. The aim is to provide valuable insights that can contribute to more sustainable and effective management strategies, aligned with the environmental, economic, and social demands of the 21st century.

2 MATERIAL AND METHODS

The study was conducted on the Cachoeira farm situated in Santo Antônio do Amparo County in Minas Gerais, Brazil, in two areas of arabica coffee adopting organic and conventional management. The conventional crop was in the coordinates of 20°90'42,20'' S and 44°94'59,51'' W at an altitude of 1,008 m, and the organic one in the coordinates of 20° 88'78,35 ''S and 44 ° 95'12,36'' W at an altitude of 1,018.5 m. The climate in the region, according to the Köeppen classification, is humid subtropical (Cwa) with a mean annual temperature of 19.4 ºC and average annual precipitation of 1,530 mm.

The conventional arabica coffee plantation was implemented in 2016/2017 and the organic one in 2015/2016, and both with a spacing of 3.80 m x 0,70 m between rows and plants, forming a stand of 3,759 plants ha^{-1}.

The implantation and management of the experimental areas followed the technical recommendations for coffee crops. The phytosanitary operations were carried out preventively or curatively using chemical products with recommended dosages and following the seasonality of pests and diseases.

The experiment was installed in November 2018 when the cover crops consisting of sunflower (*Helianthus annuus* L.), Jade Princess (*Pennisetum glaucum*), buckwheat (*Fagopyrum esculentum* Moench) and crotalaria (*C. ochroleuca*, *C. breviflora* and *C. juncea*) were introduced. The first mowing was carried out in February 2019, in November 2019 was carried out the second planting with a new mowing in February 2020, and the plants were only used as mulch in both years.

The experiment was carried out in a randomized block design in a factorial scheme (2x2x2) with two cultivars (Catiguá MG2 and Paraíso MG H419-1), two types of management (organic and conventional), two different managements regarding the presence and absence of cover crops and four replications. The square made of iron bars was thrown four times in each repetition, giving a total of 128 samples. The assessment of species was carried out in two different seasons (the dry and rainy season in the years of 2019 and 2020), using a square made of welded iron bars with a dimension of 0.50 x 0.50 m (0.25 m^2), which was launched four times at random in each block, avoiding overlapping, totaling 4.0 m^2 of sampled area The weeds inside the square were quantified according to the number of individuals, and the species were identified regarding the class, family, and genus, using specialized bibliography.

From the data, we calculated phytosociological parameters (Table 1). The similarity index, which ranges from 0 to 100%, indicates that all species are common in both areas (maximum) or that there are no species in common (minimum) (Sørensen, 1948).

Table 1: Formulas used to perform phytosociology parameter calculations according to Brandão Brandão and Laca-Buendia (1998).

Frequency (F) =	nº of squares that contain the species/ total nº of squares obtained
Relative Frequency (FR) =	100 x frequency the species/ total frequency of all species
Density (D) =	Total number of individuals by species/ total nº of square obtained
Relative Density (DR) =	100 x density of species/ total density of all species
Abundance (A) =	Total nº of individuals by species/ Total nº of squares containing the species
Relative Abundance (AR) =	100 x abundance the species/ Total abundance of all species
Importance Value Index (IVI) =	FR + DR + AR
Similarity Index (IS) =	(2a/(b+c)) x 100 a is the number of species common to both areas, b and c is the total number of species in both areas compared

The floristic parameters and the phytosociological structure (frequency, density, abundance, relative frequency, relative density, relative abundance, and importance value index) were analyzed descriptively using a two-year-experiment average.

3 RESULTS

The characterization of the weed flora in the arabica coffee plantations cv. Catiguá revealed the presence of 41 distinct species, distributed across 38 genera and 19 families. The families of Poaceae and Asteraceae were the most predominant, showcasing a rich diversity of weed species in the evaluated cultivation systems (Table 2).

In the dry season, the weed vegetation composition in cv. Catiguá coffee exhibited notable differences between organic and conventional management systems, both in the presence and absence of cover crops. In the organic system with cover crops, *Urochloa decumbens* predominated, with an Importance Value Index (IVI) of 38.61, followed by *Erogrotis pilosa* . and *Neonotonia wightii* with IVIs of 62.59 and 115.59, respectively. Notably, *Neonotonia wightii* was the species with the highest IVI, highlighting its dominance in systems with cover crops. In the absence of cover crops in the same system, *Cyperus* sp. showed a significant increase in IVI, reaching 107.6, while *Urochloa decumbens* and *Digitaria horizontalis* were also prominent with IVIs of 34.55 and 62.77, respectively (Table 3).

In the conventional system, the situation was somewhat different. *Urochloa decumbens*. and *Cyperus* sp. dominated in both scenarios, with and without cover crops, with IVIs of

86.15 and 136.89, and 84.54 and 166.68, respectively (Table 3). Interestingly, although *Urochloa decumbens* maintained its dominance, *Cyperus* sp. showed a more significant increase in IVI in the conventional system compared to the organic one.

Table 2: Family, scientific, and popular names of 42 weed species registered in Santo Antônio do Amparo County – MG in 2019 and 2020.

Family	Scientific name	Brazilian Popular name
Amaranthaceae	*Alternanthera tenella* Colla.	Apaga Fogo
Amaranthaceae	*Amaranthus* sp.	Caruru de Mancha
Asteraceae	*Conyza* sp.	Buva
Asteraceae	*Parthenium hysterophorus* L.	Coentro do Mato
Asteraceae	*Emília fosbergii* Nicolson	Falsa Serralha
Asteraceae	*Galinsoga quadriradiata* Ruiz & Pav.	Fazendeiro Peludo
Asteraceae	*Gamochaeta coarctata* (Willd.).	Macela
Asteraceae	*Ageratum conyzoides* L.	Mentrasto
Asteraceae	*Galinsoga parviflora* Cav.	Picão Branco
Asteraceae	*Bidens* sp.	Picão Preto
Asteraceae	*Sonchus oleraceus* L.	Seralha
Brassicaceae	*Raphanus raphanistrum* L.	Nabo/ Nabiça
Commelinaceae	*Commelina benghalensis* L.	Trapoeraba
Convolvulaceae	*Ipomoea* sp.	Corda de Viola
Cruciferae	*Lepidium virginicum* L.	Mastruz
Cyperaceae	*Cyperus sp.*	Tiririca
Euphorciaceae	*Chamaesyce hirta* (L.) Small	Erva de Santa Luzia
Euphorciaceae	*Euphorbia heterophylla* L.	Leiteiro
Euphorciaceae	*Ricinus communis* L.	Mamona
Fabaceae	*Aeschynomene denticulata* Rudd.	Angiquinho
Fabaceae	*Senna obtusifolia* (L.) Irwin & Barneby	Fedegoso
Fabaceae	*Neonotonia wightii* (Wight & Arn.) Lackey.	Soja perene
lamiaceae	*Leonurus sibiricus* L.	Rubin
Malvaceae	*Sida* sp.	Vassoura
Oxalidaceae	*Oxalis latifolia* Kunth.	Trevo
Phyllantaceae	*Phyllanthus tenellus* Roxb	Quebra-Pedra
Poaceae	*Digitaria insularis* (L.) Fedde.	Capim Amargoso
Poaceae	*Eragrotis pilosa* (L.) P.Beauv.	Capim Barbicha de Alemão
Poaceae	*Urochloa decumbens* Staf.	Capim Braquiária
Poaceae	*Digitaria horizontalis* Willd.	Capim Colchão
Poaceae	*Panicum maximum* L.	Capim Colonião
Poaceae	*Pennisetum purpureum* Schum	Capim Elefante
Poaceae	*Urochloa plantaginea (*Link) Hitchc.	Capim Marmelada
Poaceae	*Eleusine indica (*L.) Gaertn.	Capim Pé de Galinha
Poaceae	*Setaria parviflora* (Poir.) Kerguélen	Capim Rabo de Raposa
Poaceae	*Cynodon dactylon* (L.) Pers	Grama Seda
Polygonaceae	*Fagopyrum esculentum* Moench	Trigo Mourisco
Portulacaceae	*Portulaca oleraceae* L.	Beldroega
Rubiaceae	*Richardia brasiliensis* Gomes	Poaia-Branca
Solanaceae	*Solanum americanum* Mill.	Maria-Pretinha
Talinaceae	*Talinum paniculatum* (Jacq.) Gaertn.	Maria Gorda

Additionally, some species were exclusive to certain systems and management conditions. For example, *Talinum paniculatum* and *Conyza* sp. were observed only in the organic system with cover crops, while species like *Amaranthus* sp. and *Bidens* sp. were identified only in the conventional system in the absence of cover crops.

The presence of cover crops in the organic system was effective in suppressing weed species such as *Alternanthera tenella* and *Panicum maximum*, which showed a reduction in IVI from 14.79 to 6.82 and from 20.5 to 9.4, respectively (Table 3). This suppressive effect was less evident in the conventional system.

Table 3: Scientific name, relative frequency (FR), relative density (DR), relative abundance (AR) and importance value index (IVI) of weed species recorded in cv. Catiguá under different managements in the dry season.

	Catiguá organic – dry season							
Scientific Name	*Presence of cover crops*				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Alternanthera tenella Colla.	3.47	0.51	2.84	6.82	7.27	2.55	4.97	14.79
Talinum paniculatum (Jacq.) Gaertn.	2.23	0.20	1.86	4.29				
Urochloa decumbens Staf.	19.85	9.88	8.88	38.61	18.16	9.08	7.31	34.55
Conyza sp.	4.47	0.79	1.86	7.12				
Eragrotis pilosa (L.) P.Beauv.	9.93	29.72	22.94	62.59	2.44	0.84	3.71	6.99
Digitaria horizontalis Willd.					3.65	23.85	35.27	62.77
Panicum maximum L.	3.72	1.86	3.82	9.4	6.68	4.64	9.18	20.5
Cynodon dactylon (L.) Pers	8.93	20.08	23.77	52.78	7.23	14.36	20.52	42.11
Ricinus communis L.					2.44	0.84	1.86	5.14
Lepidium virginicum L.	4.71	2.98	9.53	17.22	4.84	2.87	8.86	16.57
Raphanus raphanistrum L.	1.24	0.31	1.91	3.46				
Eleusine indica (L.) Gaertn.	3.72	2.17	4.45	10.34	7.31	4.18	3.10	14.59
Sonchus oleraceus L.	14.14	5.71	6.63	26.48	2.44	2.51	5.57	10.52
Neonotonia wightii (Wight & Arn.) Lackey.	11.66	58.32	45.61	115.59	14.55	11.59	10.50	36.64
Cyperus sp.	6.95	6.08	15.50	28.53	12.11	57.83	37.66	107.6
Commelina benghalensis L.	4.96	3.10	4.78	12.84	1.22	0.42	1.86	3.5
Oxalis latifolia Kunth.					7.23	5.78	8.26	21.27
Sida sp.					2.44	0.84	3.71	6.99
	Catiguá conventional - dry season							
Urochloa decumbens Staf.	18.68	44.28	23.19	86.15	25.38	41.15	18.01	84.54
Conyza sp.					1.25	0.57	1.90	
Eragrotis pilosa (L.) P.Beauv.	1.04	0.42	1.64	3.10				0.00
Digitaria horizontalis Willd.	1.04	1.26	4.93	7.23				0.00
Amaranthus sp.					1.25	1.14	3.79	
Ipomoea sp.	2.09	0.84	1.64	4.57				0.00
Emília fosbergii Nicolson	2.09	3.35	6.58	12.02	1.25	2.86	9.48	13.59
Galinsoga quadriradiata Ruiz & Pav.	2.09	0.84	3.29	6.22	3.75	1.71	1.90	7.36
Senna obtusifolia (L.) Irwin & Barneby	1.04	0.84	3.29	5.17				0.00
Cynodon dactylon (L.) Pers	1.73	1.98	7.87	11.58	1.92	1.27	4.74	7.93
Gamochaeta coarctata (Willd.).					1.92	0.42	1.58	
Solanum americanum Mill.	1.04	0.42	1.64	3.10				0.00

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Table 3: Continuação.

Scientific Name	Catiguá organic – dry season							
	Presence of cover crops				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Urochloa plantaginea (Link) Hitchc.	3.13	2.93	3.83	9.89				0.00
Lepidium virginicum L.	1.04	2.93	11.51	15.48	2.50	1.14	3.79	7.43
Ageratum conyzoides L.	4.49	1.63	4.86	10.98	1.92	0.42	1.58	3.92
Raphanus raphanistrum L.	5.89	7.42	13.21	26.52	2.50	4.00	6.64	13.14
Eleusine indica (L.) Gaertn.	7.62	9.58	10.21	27.41	15.19	9.81	6.55	31.55
Bidens sp.					3.17	5.99	20.22	
Richardia brasiliensis Gomes	13.83	8.09	6.41	28.33	8.84	9.39	10.42	28.65
Leonurus sibiricus L.	15.23	41.82	27.92	84.97	15.77	40.35	21.29	77.41
Sonchus oleraceus L.	2.77	0.81	3.22	6.80	1.92	0.84	3.16	5.92
Cyperus sp.	10.71	67.80	58.38	136.89	10.19	77.22	79.27	166.68
Commelina benghalensis L.	4.49	2.79	6.37	13.65	1.25	1.71	5.69	8.65

In the rainy season, the cultivation of Catiguá showed significant differences in weed composition under different management regimes, both in organic and conventional systems. In the organic system with the presence of cover crops between coffee rows, *Urochloa decumbens* dominated the environment with an Importance Value Index (IVI) of 56.87, followed by *Neonotonia wightii* (IVI = 106.84) and *Bidens* sp. (IVI = 44.82). Interestingly, the presence of *Cyperus* sp. was less prominent in this system, with an IVI of 7.04 (Table 4).

In contrast, in the absence of cover crops in the organic system, *Cyperus* sp. emerged as the most invasive weed, with an impressive IVI of 109.60, indicating greater adaptability to unprotected environments. *Urochloa decumbens* also maintained its presence, with an IVI of 54.45, while *Cynodon dactylon* increased its relative importance, registering an IVI of 46.57 (Table 4).

In the conventional system, the trends were even more elucidating. *Urochloa decumbens* maintained its dominance with an IVI of 101.00, more than double the second most dominant weed, *Euphorbia heterophylla* (IVI = 43.11). However, most notably was the overwhelming presence of *Cyperus* sp., with an IVI of 180.70, suggesting that this weed may be particularly adapted to intensive agricultural systems (Table 4).

In the agricultural systems studied in cv. Paraíso during the dry season, a diversified profile of weed species was observed, both under organic and conventional management. In the organic fields with the presence of cover crops, *Urochloa decumbens* was the dominant species, displaying an Importance Value Index (IVI) of 115.42. This species was followed by *Digitaria horizontalis* and *Cynodon dactylon* with IVIs of 75.84 and 128.48, respectively. *Talinum paniculatum* and *Sonchus oleraceus* also showed significant IVIs of 24.69 and 25.82, respectively (Table 5).

In contrast, in the organic fields without cover crops, *Urochloa decumbens* remained the predominant species but with a higher IVI of 148.15. This was followed by *Digitaria horizontalis* with an IVI of 48.00 and *Cynodon dactylon* with an IVI of 85.80. Interestingly, *Lepidium virginicum* showed a considerably high IVI of 83.02 in systems without cover crops, whereas in systems with cover crops the IVI was 20.59 (Table 5).

In the conventional cropping system during the same season, the dominant species was *Sonchus oleraceus* with an IVI of 96.24, closely followed by *Richardia brasiliensis* with an IVI of 31.64. *Eleusine indica* and *Lepidium virginicum* also displayed significant IVIs of 31.88 and 13.55, respectively (Table 5). It's worth noting that some species such as *Portulaca oleraceae* and *Alternanthera tenella* were present only in organic systems, while others like *Conyza* sp. and *Aeschynomene denticulata* were exclusive to the conventional system. Moreover, the presence or absence of cover crops in organic systems appeared to significantly influence the weed profile, suggesting a potential effect of these crops on weed management.

The analysis of the floristic composition of weeds under different management systems in coffee cv. Paraíso during the rainy season revealed a series of significant observations. In organic systems with the presence of cover crops between the rows of coffee, *Urochloa decumbens* displayed the highest importance, with an Importance Value Index (IVI) of 116.53, followed by *Panicum maximum* and *Cynodon dactylon*, with IVI scores of 54.45 and 73.32, respectively (Table 6). These species showed high Relative Frequency (FR), Relative Density (DR), and Relative Abundance (AR), highlighting their dominant role under these conditions.

Table 4: Scientific name, relative frequency (FR), relative density (DR), relative abundance (AR) and importance value index (IVI) of weed species recorded in cv. Catiguá under different managements in the rainy season.

Scientific name	Catiguá organic - rainy season							
	Presence of cover crops				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Alternanthera tenella Colla.					5.66	1.81	3.13	10.60
Talinum paniculatum (Jacq.) Gaertn.	3.38	0.26	0.7	4.34	5.66	0.96	1.66	8.28
Urochloa decumbens Staf.	20.99	16.09	19.79	56.87	17.34	20.72	16.39	54.45
Digitaria insularis (L.) Fedde.					1.96	0.39	1.18	3.53
Erogrotis pilosa (L.) P.Beauv.	2.17	0.51	1.12	3.80				
Digitaria horizontalis Willd.	6.50	20.3	14.87	41.67	7.83	16.54	12.34	36.71
Amaranthus sp.	2.17	1.52	3.35	7.04				
Panicum maximum L.	1.70	0.13	0.7	2.53	7.76	2.78	9.47	20.01
Ipomoea sp.	3.86	0.64	1.82	6.32	1.89	0.96	0.55	3.40
Cynodon dactylon (L.) Pers	6.77	10.55	14.01	31.33	9.44	18.23	18.9	46.57
Euphorbia heterophylla L.	1.70	0.13	0.7	2.53	1.96	1.18	3.53	6.67
Urochloa plantaginea (Link) Hitchc.	2.17	3.05	6.69	11.91	3.91	3.94	5.88	13.73
Lepidium virginicum L.	1.70	0.13	0.7	2.53				
Eleusine indica (L.) Gaertn.	6.50	2.03	1.48	10.01	1.96	0.79	2.35	5.10
Bidens sp.	4.33	19.29	21.2	44.82				
Sonchus oleraceus L.	12.80	11.33	12.29	36.42	3.91	1.18	1.76	6.85
Neonotonia wightii (Wight & Arn.) Lackey.	8.32	53.84	44.68	106.84	11.60	8.51	7.53	27.64
Cyperus sp.	2.17	1.52	3.35	7.04	9.55	54.46	45.59	109.60
Commelina benghalensis L.	5.08	2.9	5.14	13.12	1.89	0.53	2.76	5.18
Oxalis latifolia Kunth.	3.38	0.4	1.05	4.83	5.80	11.59	20.84	38.23
Fagopyrum esculentum Moench	4.33	1.52	1.67	7.52	1.89	0.96	0.55	3.40
	Catiguá conventional - rainy season							
Alternanthera tenella Colla.	1.25	0.23	1.28	2.76				
Portulaca oleraceae L.	2.50	0.47	1.28	4.25	1.64	0.81	4.04	6.49
Urochloa decumbens Staf.	27.22	50.87	22.91	101.00	22.24	35.38	17.61	75.23
Conyza sp.					1.76	1.32	2.61	5.69
Digitaria horizontalis Willd.					1.76	1.32	2.61	5.69
Amaranthus sp.	5.00	2.11	2.87	9.98	1.64	0.40	2.02	4.06
Panicum maximum L.					1.76	1.32	2.61	5.69
Ipomoea sp.					1.64	0.20	1.01	2.85
Galinsoga quadriradiata Ruiz & Pav.					1.76	2.63	5.23	9.62
Cynodon dactylon (L.) Pers	1.25	0.23	1.28	2.76				
Euphorbia heterophylla L.	5.55	15.71	21.85	43.11	5.26	23.68	15.69	44.63
Ricinus communis L.	8.33	15.71	14.58	38.62	3.51	3.95	3.92	11.38
Urochloa plantaginea (Link) Hitchc.	3.75	2.34	4.25	10.34	8.43	11.23	12.52	32.18
Lepidium virginicum L.	1.25	0.23	1.28	2.76				
Ageratum conyzoides L.	1.25	0.47	2.55	4.27				
Eleusine indica (L.) Gaertn.	5.00	1.41	1.91	8.32				
Galinsoga parviflora Cav.	1.25	0.47	2.55	4.27	3.39	6.78	14.08	24.25
Bidens sp.					1.64	0.40	2.02	4.06

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Table 4: Continuação.

Scientific name	Catiguá organic - rainy season							
	Presence of cover crops				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Richardia brasiliensis Gomes	7.78	4.24	7.80	19.82	11.60	5.05	7.25	23.90
Leonurus sibiricus L.					1.76	3.95	7.84	13.55
Neonotonia wightii (Wight & Arn.) Lackey.					1.76	1.32	2.61	5.69
Cyperus sp.	14.30	89.65	76.75	180.70	11.60	79.55	71.02	162.17
Commelina benghalensis L.	9.03	9.93	20.48	39.44	6.79	5.36	7.46	19.61
Oxalis latifolia Kunth.	5.28	5.93	16.38	27.59	10.07	14.05	15.22	39.34

Table 5: Scientific name, relative frequency (FR), relative density (DR), relative abundance (AR) and importance value index (IVI) of weed species recorded in cv. Paraíso under different managements in the dry season.

Scientific name	Paraíso organic – dry season							
	Presence of cover crops				Absence of cover crops			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Alternanthera tenella Colla.					1.28	0.66	3.85	5.79
Portulaca oleraceae L.	1.11	1.04	4.89	7.04				
Talinum paniculatum (Jacq.) Gaertn.	7.15	6.31	11.23	24.69				
Urochloa decumbens Staf.	27.94	53.55	33.93	115.42	33.79	73.32	41.04	148.15
Erogrotis pilosa (L.) P.Beauv.	1.11	0.52	2.45	4.08				
Digitaria horizontalis Willd.	8.89	42.19	24.76	75.84	10.26	21.85	15.89	48.00
Amaranthus sp.	1.11	0.52	2.45	4.08	1.28	0.66	3.85	5.79
Panicum maximum L.					1.28	0.66	3.85	5.79
Ipomoea sp.	1.11	2.08	9.78	12.97	2.94	0.76	2.21	5.91
Chamaesyce hirta (L.) Small	1.11	0.52	2.45	4.08				
Cynodon dactylon (L.) Pers	14.29	60.36	53.83	128.48	14.71	45.04	26.05	85.80
Urochloa plantaginea (Link) Hitchc.	1.11	1.56	7.34	10.01	2.57	1.99	5.78	10.34
Lepidium virginicum L.	6.67	7.81	6.11	20.59	4.23	19.75	59.04	83.02
Eleusine indica (L.) Gaertn.	6.67	8.33	6.53	21.53	6.41	6.62	7.71	20.74
Sonchus oleraceus L.	6.99	5.45	13.38	25.82	1.28	0.66	3.85	5.79
*Neonotonia wightii (*Wight & Arn.) Lackey.	10.32	7.67	16	33.99	10.26	23.84	17.34	51.44
Commelina benghalensis L.	2.22	1.04	2.45	5.71	3.85	2.65	5.12	11.62
Oxalis latifolia Kunth.					2.94	0.76	2.21	5.91
Sida sp.	2.22	1.04	2.45	5.71	2.94	0.76	2.21	5.91
	Paraíso conventional – dry season							
Aeschynomene denticulata Rudd.	0.76	0.41	1.96	3.13				
Alternanthera tenella Colla.	0.76	0.41	1.96	3.13	0.85	0.4	1.81	3.06
Portulaca oleraceae L.	1.51	1.23	2.94	5.68				
Urochloa decumbens Staf.	11.53	19.06	13.28	43.87	10.69	22.19	15.15	48.03
Conyza sp.	0.76	1.23	5.89	7.88				
Erogrotis pilosa (L.) P.Beauv.	1.51	0.82	1.96	4.29	1.69	1.21	2.72	5.62
Digitaria horizontalis Willd.	1.51	1.23	2.94	5.68				

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Table 5: Continuação.

Scientific name	Paraíso organic – dry season							
	Presence of cover crops				Absence of cover crops			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Amaranthus sp.	6.04	9.84	5.89	21.77	3.39	8.5	9.51	21.40
Panicum maximum L.	0.76	0.41	1.96	3.13	0.85	0.4	1.81	3.06
Chamaesyce hirta (L.) Small					2.61	0.59	1.52	4.72
Emilia fosbergii Nicolson	4.26	1.36	5.04	10.66	6.45	4.01	6.24	16.70
Galinsoga quadriradiata Ruiz & Pav.	1.51	1.23	2.94	5.68				
Euphorbia heterophylla L.	0.76	0.41	1.96	3.13				
Gamochaeta coarctata (Willd.).	2.27	2.05	3.28	7.60	0.85	0.4	1.81	3.06
Solanum americanum Mill.	0.76	0.41	1.96	3.13	0.85	0.4	1.81	3.06
Urochloa plantaginea (Link) Hitchc.	3.02	2.46	2.94	8.42				
Lepidium virginicum L.	6.25	2.83	4.47	13.55	8.15	9.57	9.78	27.50
Ageratum conyzoides L.					0.85	0.4	1.81	3.06
Eleusine indica (L.) Gaertn.	10.64	11.24	10	31.88	10.76	6.7	6.35	23.81
Bidens sp.	2.88	7.54	31.74	42.16	2.15	5.74	26.29	34.18
Richardia brasiliensis Gomes	14.14	10.42	7.08	31.64	13.30	16.08	10.66	40.04
Leonurus sibiricus L.	10.16	8.98	7.26	26.40	8.54	7.47	5.92	21.93
Sonchus oleraceus L.	7.14	53.91	35.19	96.24	14.61	96.24	74.63	185.48
Cyperus sp.	1.37	0.27	1.11	2.75	2.61	0.88	2.28	5.77
Commelina benghalensis L.	7.62	7.67	7.97	23.26	8.65	18.88	23.19	50.72
Oxalis latifolia Kunth.	0.76	0.41	1.96	3.13	0.85	0.4	1.81	3.06
Sida sp.	1.37	0.27	1.11	2.75	1.30	0.29	1.52	3.11

In the absence of cover crops in the organic system, the species *Urochloa plantaginea* gained prominence with an IVI of 64.54, closely followed by *Pennisetum purpureum* Schum and *Digitaria insularis*, with IVI scores of 17.75 and 11.21, respectively (Table 6). This shift in dominance suggests that the absence of cover crops can significantly alter the weed community composition.

In conventional systems, the species *Urochloa decumbens* also proved to be predominant, with an IVI of 77.85 in the presence of cover crops and 80.86 in their absence. Notably, the species *Cyperus* sp. had a dramatic leap in IVI to 197.09 in the absence of cover crops (Table 6), indicating a potential resistance or adaptation to conventional systems without cover crops.

It is also worth noting that some species, such as *Alternanthera tenella* and *Portulaca oleraceae*, were present only in organic systems, possibly suggesting an affinity for less intensive management practices. Similarly, *Parthenium hysterophorus* and *Solanum americanum* were exclusive to the conventional system with cover crops (Table 6).

4 DISCUSSION

The importance of this study is not limited to identifying predominant species and their dynamics but also offers a deep analysis of the implications for sustainable management strategies. The results point to the need for integrated weed management, combining cultural methods such as the use of cover crops with other management practices, to achieve more effective and sustainable weed control.

Weed management in coffee systems, whether in organic or conventional environments, is a complex issue involving various biological and environmental factors. In our study, a notable difference in weed composition under different systems and seasons was observed, corroborating the findings of Albuquerque et al. (2017) who also reported the impact of different managements on weed composition.

We identified 41 weed species, distributed across 38 genera and 19 families, predominantly from the Poaceae and Asteraceae families. This diversity profile is in line with that reported by Maciel et al. (2010) in organic coffee crops. The high diversity can be attributed to the large seed bank formed in the soil, whose seeds are less sensitive to light and can germinate even under low solar radiation conditions, as explained by Amorim et al. (2018). Specifically, the Asteraceae family has the characteristic of anemochory, facilitating long-distance seed dispersal by the wind, as observed by Derrouch et al. (2021).

Table 6: Scientific name, relative frequency (FR), relative density (DR), relative abundance (AR) and importance value index (IVI) of weed species recorded in cv. Paraíso under different managements in the rainy season.

	Paraíso organic - rainy season							
Scientific name	*Presence of cover crops*				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Alternanthera tenella Colla.	2.09	0.88	3.50	6.47				
Portulaca oleraceae L.	1.85	2.44	4.74	9.03				
Talinum paniculatum (Jacq.) Gaertn.	2.09	0.29	1.17	3.55				
Urochloa decumbens Staf.	15.74	55.48	45.31	116.53	14.14	40.52	30.10	84.76
Conyza sp.					1.56	2.27	6.24	10.07
Digitaria insularis (L.) Fedde.					3.12	3.41	4.68	11.21
Digitaria horizontalis Willd.	1.85	14.63	28.46	44.94				
Pennisetum purpureum Schum					4.69	6.82	6.24	17.75
Amaranthus sp.	5.56	9.76	6.33	21.65				
Panicum maximum L.	8.34	23.10	23.01	54.45	7.89	16.32	12.71	36.92
Ipomoea sp.	4.17	0.58	1.17	5.92				
Cynodon dactylon (L.) Pers	12.50	36.55	24.27	73.32	13.16	31.09	14.53	58.78
Euphorbia heterophylla L.	7.87	5.12	6.47	19.46	4.69	15.91	14.58	35.18
Ricinus communis L.					2.63	3.11	7.27	13.01
Urochloa plantaginea (Link) Hitchc.	7.41	10.98	5.34	23.73	10.44	25.95	28.15	64.54
Lepidium virginicum L.	3.71	2.44	2.37	8.52	1.56	2.27	6.24	10.07
Eleusine indica (L.) Gaertn.	3.71	2.44	2.37	8.52				
Bidens sp.	7.41	18.29	8.89	34.59	4.69	11.36	10.40	26.45
Phyllanthus tenellus Roxb	2.09	0.29	2.33	4.71	2.63	5.18	12.11	19.92
Setaria parviflora (Poir.) Kerguélen					2.63	5.18	12.11	19.92
Sonchus oleraceus L.	3.71	2.44	2.37	8.52	3.12	4.55	6.24	13.91
Neonotonia wightii (Wight & Arn.) Lackey.	2.09	0.29	2.33	4.71	6.25	4.55	4.15	14.95
Cyperus sp.	1.85	9.76	18.97	30.58				
Commelina benghalensis L.	3.94	3.95	9.44	17.33	3.12	2.27	3.12	8.51
Sida sp.	2.09	0.29	1.17	3.55	13.65	19.24	21.11	54.00
	Paraíso conventional - rainy season							
Alternanthera tenella Colla.	1.34	0.65	3.31	5.30				
Portulaca oleraceae L.	1.34	0.16	0.83	2.33	1.35	0.14	0.88	2.37
Urochloa decumbens Staf.	23.17	36.99	17.69	77.85	25.46	35.65	19.75	80.86
Amaranthus sp.	1.34	0.16	0.83	2.33	1.35	0.72	4.4	6.47
Parthenium hysterophorus L.	2.06	3	5.93	10.99				
Ipomoea sp.	4.74	2.32	4.78	11.84	2	1.11	3.4	6.51
Euphorbia heterophylla L.	1.34	0.16	0.83	2.33	4	4.44	6.81	15.25

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Table 6: Continuação.

Scientific name	Paraíso organic - rainy season							
	Presence of cover crops				*Absence of cover crops*			
	FR (%)	DR (%)	AR (%)	IVI	FR (%)	DR (%)	AR (%)	IVI
Ricinus communis L.	2.06	3	5.93	10.99	2	5.56	17.02	24.58
Solanum americanum Mill.	2.06	1	1.98	5.04				
Urochloa plantaginea (Link) Hitchc.	8.24	10	4.94	23.18	10	22.22	13.62	45.84
Lepidium virginicum L.	4.02	0.97	1.66	6.65	4.055	1.58	5.28	10.915
Eleusine indica (L.) Gaertn.	4.74	4.65	9.56	18.95	1.35	0.14	0.88	2.37
Bidens sp.	1.34	0.16	0.83	2.33	1.35	0.29	1.76	3.4
Richardia brasiliensis Gomes	10.81	8.88	8.92	28.61	8.11	4.15	4.25	16.51
Leonurus sibiricus L.	3.40	2.16	4.78	10.34				
Sonchus oleraceus L.	2.06	13	25.7	40.76				
Cyperus sp.	1.34	0.16	0.83	2.33	13.46	91.24	92.39	197.09
Commelina benghalensis L.	7.42	8.04	13.08	28.54	8.055	4.19	6.87	19.115
Oxalis latifolia Kunth.	8.03	1.61	2.32	11.96	17.46	28.56	22.71	68.73
Fagopyrum esculentum Moench	2.06	2	3.95	8.01				
Sida sp.	7.11	50.46	40.66	98.23				

Several weed species, including *Urochloa decumbens*, exhibited high vegetative and photosynthetic growth rates. These characteristics, pointed out by Ramesh et al. (2017) and Silberg et al. (2019), enable rapid phenotypic adjustments and physiological plasticity, allowing these weeds to grow and flower even in environments with low light availability.

Our findings indicate that the presence of cover crops in organic systems was effective in suppressing certain weed species. This finding is supported by the literature, which suggests that cover crops modify the quantity and quality of radiation reaching the weed canopy and the soil surface, resulting in stem elongation inhibition and early flowering induction, as noted by Sharma and Banik (2013). Moreover, cover crops can also modify the microclimate by reducing evaporation and increasing soil moisture, as reported by Silberg et al. (2019).

Among the weeds evaluated, *Cyperus* sp. stood out for its abundance and adaptability to different systems and soil conditions, as indicated by Ahmad et al. (2016). We also observed that *Urochloa decumbens* was present in all treatments, corroborating the studies by Santos and Silva (2018) about its highly competitive capacity and adaptation to different management systems.

Prior knowledge of the floristic composition of weeds in organic coffee systems can assist in organizing preventive strategies to adopt more sustainable control measures, as suggested by Maciel et al. (2010). In agreement with the observations by Pires et al. (2017), maintaining cover crops was the only weed control method that improved water storage without causing damage to soil pores.

Our results also suggest that the intensity and longevity of weed suppression by cover crops are influenced by various factors, including the seed bank, the timing of practice implementation, and the competitive capacity of the selected crops. This complex set of factors highlights the need for an Integrated Weed Management approach, as proposed by Demelash (2018), which is environmentally sound, economically viable, and socially acceptable for sustainable coffee production.

In a broader landscape, this work sheds light on the importance of ecological and agronomic knowledge in choosing more sustainable and effective management strategies. Moreover, it paves the way for future research focused on better understanding the relationship between the seed bank composition, weed phenology, and the efficacy of different cover crops.

In summary, the complexity of weed management in coffee systems should not be underestimated, and this study significantly contributes to our understanding of this complexity. The findings presented here not only provide valuable insights for the scientific community but also have direct practical implications for farmers, who can now make more informed management decisions.

5 CONCLUSIONS

This study unveiled the complex interaction between weed species, management systems, and seasons in cv.

Catiguá and cv. Paraíso coffee plantations, both in organic and conventional systems. The diversity and abundance of weeds were significantly influenced by the presence or absence of cover crops, demonstrating the potential of this management method for the effective suppression of undesirable species. *Urochloa decumbens* emerged as a dominant species across various scenarios, indicating its high adaptive capacity and potentially beneficial or detrimental role depending on the management system.

6 AUTHORS' CONTRIBUTION

Conceptual idea: Barros, V.M.S.; Carvalho, G.R. ; Methodology design: Barros, V.M.S.; Gonçalves, A.H.; Carvalho, G.R.; Data collection: Barros, V.M.S.; Gonçalves, A.H.; Rodrigues, R.J.A.; Ferreira, A.D.; Data analysis and interpretation: Barros, V.M.S.; Medeiros, F.C.L.; Rodrigues, R.J.A.; Ferreira, A.D.; Writing and editing: Barros, V.M.S.; Thimothee, J.A.; Medeiros, F.C.L.

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