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Phytosociological characterization of weed species as affected by soil management

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Abstract

Under tropical environments, the soil seed bank ensures floristic diversity and raises the ability of weeds to infest the area repeatedly whn weed/soil management practices are applied. The objective of this study is to identify weed species emerged phyto-sociologically from different depths in soils with distinct uses. The trial was carried out with soil samples collected from four agricultural areas with contrasting activities (1) Silvopastoral system composed by coconut trees with *Brachiaria decumbens* subjected to grazing; (2) same as 1, but without grazing; (3) sugarcane field; and (4) area with conventional tillage used for annual crops. The experiment was set up at the Campus II of the Vale do Rio Doce University, Minas Gerais, Brazil. Phytosociological characterization of weed species emerged from soil seed bank was carried out at soil depths of 0-5, 5-10 and 10-15 cm in each area. The results showed that a total of 32 species were emerged in the samples. The higher similarity of plant species was observed in the upper layer of soil by decreasing in the total number of species where depth increased. For areas with lower machine traffic and/or trampling by animals, i.e, with less compaction, the greatest similarity of plant species was observed in the upper layer, indicating either a decrease in number of seeds or increase in seed dormancy as depth increased/ or both of them. Results showed that the management applied in each area promotes changes in the seed bank also as a function of soil depth.

Keywords: intercropping; integration systems; land use.
Abbreviations: ABR_relative abundance; RSD_relative density; FRR_relative frequency; SI_similarity index.

Introduction

Studies on weed behavior are essential for agriculture in tropical soils, once their interference can cause significant yield losses, especially for crops with smaller competitive ability (Silva et al., 2007). One of the mechanisms to ensure survival of a given species under constantly disturbed environments, especially for annual plants, is the high number of seeds produced (Souza, 1984). Many weeds have high seed production, such as *Amaranthus* spp. – 100,000 seeds plant^{-1} (Brainard and Bellinder, 2004), *Senna obtusifolia* – 11,400 seeds plant^{-1} (Bararpour and Oliver, 1998) and *Portulaca oleracea* – over 2,000,000 seeds plant^{-1} (Norris, 2007). The large amount of seeds produced, spread and stored in soil, allows new infestations of the area after a practice, which reduces the canopy in the area. This is called soil seed bank. The soil seed bank has a great ecological importance in the regeneration of weed communities in an agro-ecosystem. According to Baskin and Baskin (2014), the seed bank is a reservoir, consisted of all living seeds, dormant or not, present in the soil or associated with plant residues. These seeds have spatial dimension with vertical and horizontal distribution which reflects the initial dispersion in the surface and subsequent movement in the soil. They also have temporal dimension through the dormancy that distributes seed germination over time. Cropping systems can modify the soil microenvironment, which results in changes to the soil seed bank (Davis et al., 2005; Auškalnienė and Auškalnis, 2009). No-till cropping systems change the dynamics of weed species in the seed bank and effectiveness of pre-emergence herbicides, due to soil coverage by crop residues (Johnson et al., 1989; Refsell and Hartzler, 2009). Unlike no-till system, the conventional tillage system incorporates uniformly to the soil profile seeds of weed species at the depth of the tillage, both horizontally and vertically (Jakelaitis et al., 2003). Persistence of seeds composition and distribution throughout soil profile depend on the frequency of tillage. In silvo-pasture systems, the presence of the tree component interferes with sunlight incidence, humidity and temperature; factors which most influence the germination of weed seed (Vivian et al., 2008). However, the presence of species intercropped in the same agricultural system (such as *Brachiaria* genus) is highly competitive and more tolerant to variations in the above cited conditions. This initiates an unfavorable environment for weeds emergence due to a dense canopy, directly affecting soil seed bank dynamics. This is intensified by infrequent plowing and harrowing. Similar to systems, in which there is no constant soil tillage, sugarcane cropping provides formation of soil coverage by straw and crop residues. This coverage interferes in weed seeds germination, mainly due to changes in moisture, light and soil temperature, which are main controllers of seed dormancy and germination (Correia and Durigan, 2004; Toledo et al., 2009). It can also affect seedling development by acting as a physical barrier, causing etiolation and stems weakening, making them more prone to mechanical damage. Furthermore, chemical issues may arise from changes in the C/N ratio and allelopathy, as well as creating favorable environment for insects and microorganisms, which can either host on weeds or feed from seeds (Correia and Rezende, 2002). Phytosociological studies allow assessing species composition of a given canopy and obtaining frequency, relative frequency, density, relative density, abundance, relative abundance and relative importance index for each species in the community, supporting inferences about a given group of plants (Gomes et al., 2010). This study aimed to evaluate the soil seed bank potential of weed infestation as a function of different soil management systems and sampling depths.

Results

A total of 32 species from 14 botanical families were detected, showing variation both between areas and soil depths. In the area 1 (silvopasture system, grazed brachiaria/coconut (*Cocus nucifera*), 18 species belonging to 11 families were identified at 0-5 cm depth, being the Poaceae the most abundant (five species in total). For the depth of 5-10 cm, a reduction in the number of emerged weed species was observed in relation to the first layer, with 15 species belonging to 11 families. At the depth of 10-15 cm, the number of species decreased dramatically, observing seven species in six families (Table 1). Several species are considered as troublesome weeds in pastures. The most important ones are included in one of the following families: Leguminosae, Gramineae, Malvaceae, Myrtaceae, Cyphaceae, Asteraceae, Cyperaceae, Rubiaceae and Labiateae (Lara et al., 2003). *Stemodia trifoliata* had a higher density and relative abundance relative density (RSD) and relative abundance (ABR) at depths of 0-5 and 5-10 cm. However, the species with the highest relative frequency (FRR) at the depth of 0-5 cm were *Richardia brasiliensis*, *Phyllanthus tenellus* and *Eleusine indica* and at the depth of 5-10 cm *Phyllanthus tenellus* and *Mollugo verticillata* can be highlighted. *Phyllanthus tenellus* showed higher FRR at the depth of 10-15 cm.

At the area 2 [silvopasture system, ungrazed brachiaria/coconut (*Cocus nucifera*)], a moderate decrease in the number of species was observed where the depth increased. It was 16, 12 and 11 at 0-5, 5-10 and 10 -15 cm layers, respectively, differing from area 1. Therefore, the reduction in number of species was more pronounced as the depth increased. In this area, species were distributed in 12, nine and nine families, for depths of 0-5, 5-10 and 10-15 cm, respectively (Table 1).

Mollugo verticillata was the species with the higher DER and ABR in all soil depths. However, with respect to FRR, *P. tenellus, E. indica* and *Acalypha communis* can be highlighted at 0-5, 5-10 and 10-15 cm, respectively.

At the area 3, (sugarcane crop under green system with no burning and ~13 t ha^{-1} of straw, a reduction in the number of species was also observed when depth increased. A total of 15 species in 11 families, 13 species in eight families, and eight species in eight families were observed for depths of 0-5 cm, 5-10 cm and 10-15 cm, respectively (Table 1). *Cyperus rotundus* was the species with the highest DER and ABR at 0-5 cm. The *S. arudinacium* species showed higher FRR at this depth. At the depth of 5-15 cm, *A. communis* and *C. rotundus* were the species with the highest DER. *A. communis* also showed higher ABR and *C. rotundus* and *E. indica* featured with higher FRR. We found a higher DER, FRR and ABR for *C. rotundus* at the depth of 10-15 cm. Thus, the most important species (highest IVI) at 0-5 and 10-15 cm was *C. rotundus* and at the 5-10 cm depth, *A. communis* featured (Fig 3). At the area 4 (conventional soil tillage, with plowing and harrowing), at the depth of 0-5 cm, the presence of 12 families and 21 species of weeds was detected. At 5-10 cm, 19 species were found in 11 families and at the deeper layer, the number of species dropped to 11 involving ten families (Table 1). At the 0-5 cm depth, the most important species was *A. communis* with higher DER, ABR and IVI. At the depth of 5-10 cm, there was a predominance of *M. verticillata*, *E. indica*, *Digitaria horizontalis* and *Amaranthus hybridus.* These species can be highlighted, showing higher DER, FRR, ABR and importance value (IVI). At the higher depths, the predominant species were *E. indica* and *A. communis*, with higher DER, ABR and IVI. The species with highest FRR were *A. hybridus* and *M. verticillata* (Fig 4).

Discussion

In area 1, the most important species was *Stemodia trifoliata* with the highest IVI at 0-5 and 10-15 cm. At the depth of 10-15 cm, *Phyllanthus tenellus* showed the highest IVI (Fig. 1). According to Lorenzi (2000), *S. trifoliata* is a rare species. It is usually considered as undesirable and tolerant to shading, infesting orchards, coffee plantations and gardens, besides requiring soil with good moisture and organic matter content. According to Pandey and Singh, (1991) and Belsky, (1992), protected areas tend to have lower species richness than corresponding grazed areas, but this change is directly related to the intensity of grazing. The denser canopy in preserved areas in relation to grazing occurs due to the presence of dominant species.

Toledo et al. (2009), aiming to define local patterns of edaphic and vegetation characteristics in a sub-basin at the city of Rio Pardo de Minas (Minas Gerais State, Brazil), divided the environments in two groups with very different phytosociological composition, according to the nature of the source material: quartz-sandstone; and sandy-clay and clay sediments.

In area 2, *Mollugo verticillata* and *S. trifoliata* were the species with highest IVI at 0-5 and 5-10 cm and *M. verticillata* and *P. tenellus* featured in greater depth (Fig 2). *M. verticillata* is very common at the Brazilian Northeast region being present mainly in lighter soils. It grows continuously over a long period of the year, with a short vegetative cycle. Comparing the two areas (with and without grazing), it can be stated that there were differences in the prevalence of species between areas and variation in the number of species as soil depth increased. In the grazed area, a sharp decrease in number of species was observed, while in the not grazed a slight variation was found with increasing depth. Marchezan et al. (2003) determined that cattle trampling did not affect the distribution or the seed bank dynamics of red rice in the soil profile. Theses authors also observed that the fallow periods can determine the period of permanence of seeds in the soil, a factor responsible for changes in the seed bank, which revealed a 90 % reduction

Table 1. Number of species present in the assessed areas (in bold, the predominant species according to the highest importance value - IVI), number of families in the area followed by the number of species per family in four areas under different management of land use: Brachiaria with intercropped coconut (*Cocus nucifera*), grazed (1) and ungrazed (2), sugarcane cultivation (3) and conventional tillage soil, with plowing and harrowing (4). Cronquist (1988)

(Área) Depth	Species	Nº of species	Families (Nº of species)	Nº de famílias
(1) 0-5 cm	*Stemodia trifoliata, Eclipta alba, Acalypha communis, Amaranthus hybridus, Brachiária decumbens, Brachiária plantaginea, Chamaesyce hyssopifolia, Commelina benghalensis, Cyperus rotundus, Datura stramonium, Digitária horizontalis, Eleusine indica, Mollugo verticillata, Phyllanthus tenellus, Physalis angulata, Richárdia brasiliensis, Solanum americanum, Sorghum arundinaceum*	*18*	Euphorbiaceae (2), Amarantaceae (1), Poaceae (5), Commelinaceae (1), Cyperaceae (1), Solanaceae (3), Asteraceae (1), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Scrophularaceae (1)	*11*
(1) 5-10 cm	*Stemódia trifoliata, Phyllanthus tenellus, Acalypha communis, Amaranthus deflexus, Amaranthus hybridus, Commelina benghalensis, Cyperus rotundus, Datura stramonium, Echinochloa colonum, Eclipta alba, Eleusine indica, Mollugo verticillata, Physalis angulata, Richárdia brasiliensis, Solanum americanum, Sorghum arundinaceum*	*15*	Euphorbiaceae (1), Amarantaceae (2), Poaceae (3), Commelinaceae (1), Cyperaceae (1), Solanaceae (3), Asteraceae (1), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Scrophularaceae (1)	*11*
(1) 10-15cm	*Phyllanthus tenellus, Mollugo verticillata, Eleusine indica, Richárdia brasiliensis, Solanum americanum, Sorghum arundinaceum, Stemódia trifoliata*	*7*	Poaceae (2), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Solanaceae (1), Scrophularaceae (1)	*6*
(2) 0-5 cm	*Mollugo verticillata, Stemodia trifoliata, Cyperus rotundus, Acalypha communis, Amaranthus hybridus, Chamaesyce hyssopifolia, Digitária horizontalis, Echinochloa colonum, Eclipta alba, Eleusine indica, Lepidium virginicum, Phyllanthus tenellus, Portulaca oleracea, Richardia brasiliensis, Solanum americanum, Sorghum arundinaceum*	*16*	Euphorbiaceae (2), Amarantaceae (1) Cyperaceae (1), Poaceae (3), Asteraceae (1), Brassicaceae (1), Molluginaceae (1), Phyllantaceae (1), Potulaceae (1), Rubiaceae (1), Solanaceae (2), Scrophularaceae (1)	*12*
(2) 5-10 cm	*Mollugo verticillata, Stemodia trifoliata, Acalypha communis, Amaranthus hybridus, Chamaesyce hyssopifolia, Cyperus rotundus, Datura stramonium, Echinochloa colonum, Eleusine indica, Phyllanthus tenellus, Portulaca oleracea, Solanum americanum*	*12*	Euphorbiaceae (2), Amarantaceae (1), Cyperaceae (1), Solanaceae (2), Poaceae (2), Molluginaceae (1), Phyllantaceae (1), Potulaceae (1), Scrophularaceae (1)	*9*
(2) 10-15cm	*Mollugo verticillata, Phyllanthus tenellus, Chamaesyce hyssopifólia, Commelina benghalensis, Datura stramonium, Echinochloa colonum, Eleusine indica, Portulaca oleracea, Richárdia brasiliensis, Solanum americanum,*	*11*	Euphorbiaceae (1), Commelinaceae (1), Solanaceae (2), Poaceae (2), Molluginaceae (1), Phyllantaceae (1), Potulaceae (1), Rubiaceae (1), Scrophularaceae (1)	*9*
(3) 0-5 cm	*Cyperus rotundus, Datura stramonium, Sorghum arundinaceum, Amaranthus hybridus, Chamaesyce hyssopifolia, Commelina benghalensis, Eclipta Alba, Eleusine indica, Melampodium paniculatum, Mollugo verticillata, Phyllanthus tenellus, Richardia brasiliensis, Solanum americanum, Solanum sisymbrifolium, Stemódia trifoliata*	*15*	Euphorbiaceae (1), Amarantaceae (1), Cyperaceae (1), Commelinaceae (1), Solanaceae (3), Asteraceae (2), Poaceae (2), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Scrophularaceae (1)	*11*
(3) 5-10 cm	*Acalypha communis, Cyperus rotundus, Amaranthus deflexus, Amaranthus hybridus, Chamaesyce hyssopifólia, Croton lobatus, Datura stramonium, Digitaria horizontalis, Eleusine indica, Mollugo verticillata, Phyllanthus tenellus, Richardia brasiliensis, Sorghum arundinaceum*	*13*	Euphorbiaceae (3), Amarantaceae (2), Cyperaceae (1), Solanaceae (1), Poaceae (3), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1)	*8*
(3) 10-15cm	*Cyperus rotundus, Mollugo verticillata, Acalypha communis, Amaranthus hybridus, Eclipta alba, Eleusine indica, Phyllanthus tenellus, Richárdia brasiliensis*	*8*	Euphorbiaceae (1), Amarantaceae (1), Cyperaceae (1), Solanaceae (1), Poaceae (1), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1)	
(4) 0-5 cm	*Acalypha communis, Amaranthus deflexus, Amaranthus hybridus, Boerhavia diffusa, Brachiaria decumbens,*	*21*	Euphorbiaceae (3), Amarantaceae (2), Nictaginaceae (1), Poaceae (3),	*12*

	Chamaesyce hyssopifólia, Commelina benghalensis, Croton lobatus, Cyperus rotundus, Digitária horizontalis, Eclipta alba, Eleusine indica, Emilia sonchifolia, Galinsoga paviflora, Melampodium perfoliatum, Mollugo verticillata, Phyllanthus tenellus, Portulaca falsa, Portulaca oleracea, Richárdia brasiliensis, Sorghum arundinaceum		Commelinaceae (1), Cyperaceae (1), Asteraceae (4), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Solanaceae (1), Portulaceae (1)	
(4) 5-10 cm	*Melampodium paniculatum, Digitária horizontalis, Acalypha communis, Amaranthus deflexus, Amaranthus hybridus, Boerhavia diffusa, Chamaesyce hyssopifolia, Commelina benghalensis, Croton lobatus, Cyperus rotundus, Eclipta alba, Eleusine indica, Emilia sonchifolia, Galinsoga paviflora, Mollugo verticillata, Phyllanthus tenellus, Portulaca falsa, Portulaca oleracea, Richardia brasiliensis*	*19*	Euphorbiaceae (3), Amarantaceae (2), Nictaginaceae (1), Poaceae (2), Commelinaceae (1), Cyperaceae (1), Asteraceae (4), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Portulaceae (1)	*11*
(4) 10-15cm	*Eleusine indica, Acalypha communis, Amaranthus deflexus, Amaranthus hybridus, Cyperus rotundus, Datura stramonium, Galinsoga paviflora, Mollugo verticillata, Phyllanthus tenellus, Portulaca falsa, Portulaca oleracea, Richardia brasiliensis*	*11*	Euphorbiaceae (1), Amarantaceae (2), Poaceae (1), Cyperaceae (1), Asteraceae (1), Molluginaceae (1), Phyllantaceae (1), Rubiaceae (1), Portulaceae (2), Solanaceae (1)	*10*
TOTAL	32 species		13 families	

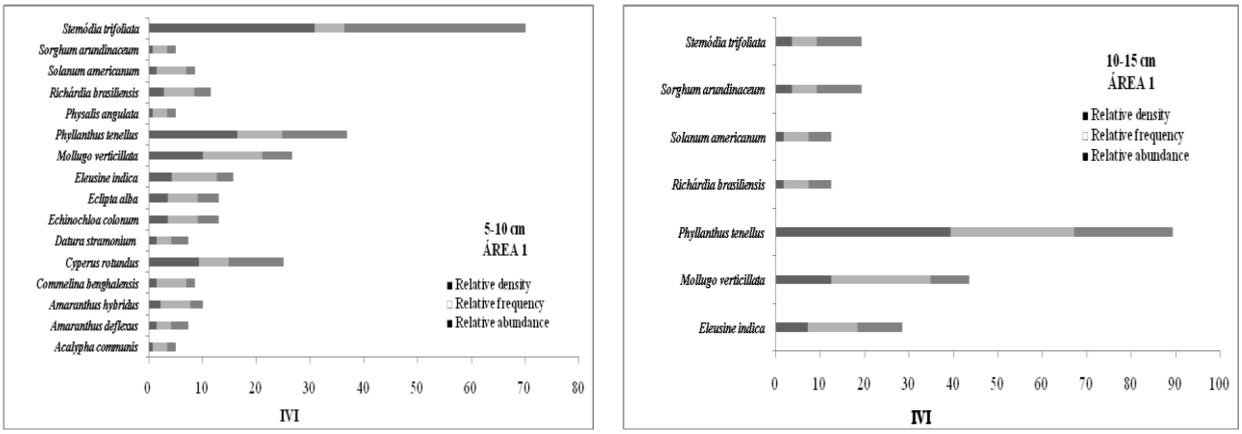

Fig 1. Relative density, relative frequency, relative abundance and importance value index of the three depths in Area 1 (Intercropped brachiaria with coconut (*Cocus nucifera*), grazed)

in the first 12 months and 80 % in the second year (Marchezan et al., 2003).

In area 3, prevalence of *Cyperus rotundus* with high levels of relative importance (RI), (over 90 %) was observed. This was also verified by Kuva et al. (2007) studying weed communities in machine-harvested sugarcane fields without previous straw burning. These results also corroborate with those found by Oliveira and Freitas, (2008), who found that *C. rotundus* showed the highest importance value in sugarcane areas.

According to Godoy et al. (1995), *C. rotundus* appears commonly in soil under conventional tillage system, which favors its spread and establishment due to dormancy overcoming caused by the division of tubers and elimination of apical dominance exerted by the distal tubercle. As a result, for the other species, low population densities can be attributed to interspecific competition exerted by *C. rotundus*. The amount of straw present in the area (13.22 t ha^{-1}; Table 3) may explain the interception of herbicides, which remain deposited on becoming more vulnerable to volatilization and/ or photodecomposition before reaching the soil (Negrisoli et al., 2009, Taylor et al., 2009). This amount of straw also has an important role in suppressing weeds emergence.

Correia and Durigan (2004), studied the effects of mulching on the emergence of *Brachiaria decumbens*, *Digitaria horizontalis*, *Sida spinosa*, *Ipomoea grandifolia*, *I. hederifolia* and *I. quamoclit*. They found that sugarcane straw mulching at 5, 10 and 15 t ha^{-1} caused an inhibitory effect on seedling emergence of *B. decumbens* and *S. spinosa*. They noticed the same for *D. horizontalis* under 10 and 15 t ha^{-1} of straw. However, for *I. grandifolia* and *I. hederifolia*, the number of emerged seedlings was similar between amounts of straw. Moreover, Silva et al. (2003) found that amounts of straw up to 8 t ha^{-1} did not reduce the emission of epigeous events of *C. rotundus*, although delaying these events.

At the area 4, the highest number of species was observed, probably due to the intense soil disturbance and constant addition of fertilizer for annual crops (Table 1). However, the number of species also decreased in the deeper depths, probably due to the inversion of soil layers during the process of plowing, which results in better distribution and burial of large amounts of seeds in the soil profile.

Refsell and Hartzler, (2009) claim that common waterhemp (*Amaranthus rudis*) seeds were concentrated near the soil surface in no-till plots, whereas seed in the chisel-till plots

Table 2. Similarity index at three depths among four areas under different land use managements.

Depth (cm)	Similarity index (%)					
	-------------------------------Evaluated areas*----------------------------------					
	1 X 2	1 X 3	1 X 4	2 X 3	2 X 4	3 X 4
0-5	82,05	81,08	69,77	77,78	66,67	60,00
5-10	75,00	68,75	57,89	64,29	52,94	70,59
10-15	70,00	55,56	47,62	54,55	56,00	78,26

*/ Brachiaria with coconut (*Cocus nucifera*) intercropped, grazed (1) and ungrazed (2), sugarcane cultivation (3) and conventional tillage soil, with plowing and harrowing (4).

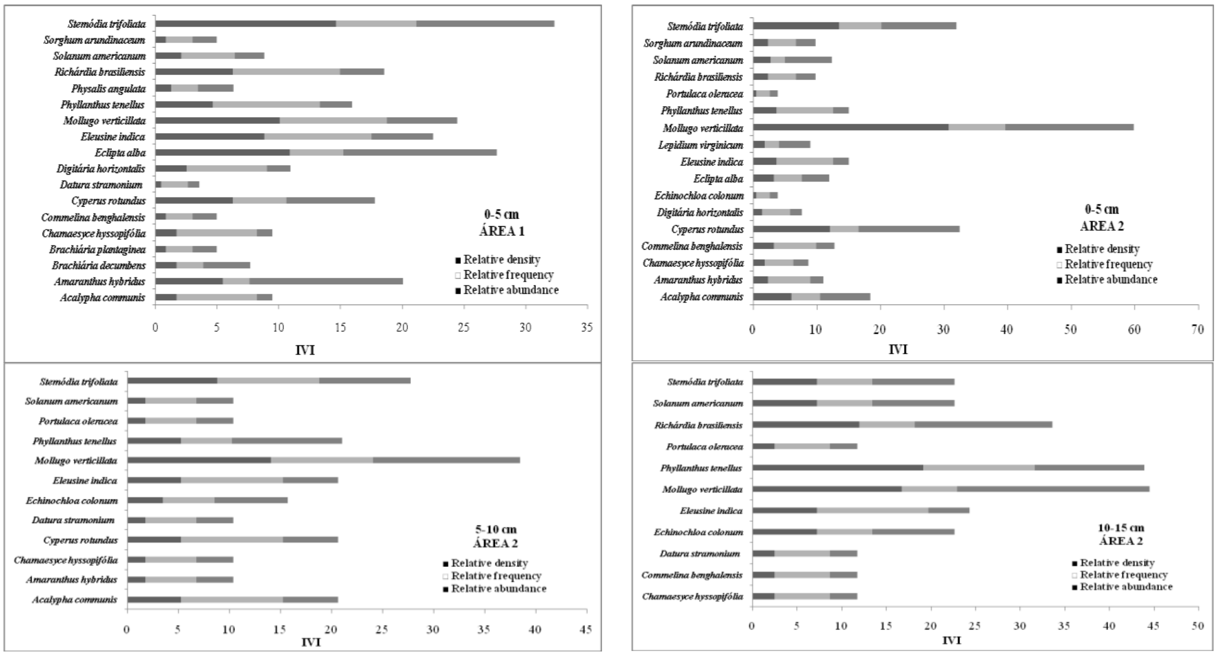

Fig 2. Relative density, relative frequency, relative abundance and importance value index of the three depths in Area 2 (Intercropped brachiaria with coconut (*Cocus nucifera*), ungrazed).

were mostly found in the 9 - 15 cm soil layer. The influence of depth and seed distribution in soil on weeds germination is a factor with vast available literature. Machado Neto and Pitelli (1988) found that germination of *Euphorbia heterophylla* seeds was similar at depths of 20-10 cm (80 %), being higher than those observed on the soil surface (21.3 %). When assessing the similarity index (SI%), by comparing depths two by two, a higher SI% was found in areas 1, 2 and 4 between depths 0-5 x 5-10 cm, while in the area 3 higher SI % was observed between the 5-10 x 10-15 cm depths (Table 3). Distinct results for the third area indicate a residual effect of herbicides used in the sugarcane crop, which leads to a decrease in seed bank at the shallow soil layer (0-5 cm).

The same index, comparing the areas two by two at each depth, showed greater similarity in the upper layer (0-5) between areas 1 and 2 and areas 1 and 3, 82.1 % and 81.1 %, respectively (Table 3), probably due to the fact that there is no soil tillage in these areas. The largest discrepancy (heterogeneity of species) was observed between areas 1 and 4 at higher depth (10-15 cm). For areas with lower machine traffic and/or trampling by animals, the greatest similarity of plant species was observed in the upper layers, indicating either a decrease in number of seeds or increase in seed dormancy as depth increased – or both of them.

Materials and Methods

Description of the evaluated areas

The trial was carried out with soil samples collected from four agricultural areas at the Campus II of the Universidade Vale do Rio Doce, in Governador Valadares city, Minas Gerais state, Brazil, in May, 2007. All areas have the similar climatic conditions and soil texture, differentiated only by the management adopted for more than five years as described below:

Area 1 (18°49'25.09"S; 41°54'0.80"W) – Silvopastoral system composed by coconut (*Cocus nucifera*) trees with *Brachiaria decumbens* submitted to grazing below the trees (grazed *Brachiaria*/coconut);

Area 2 (18°49'23.58"S; 41°54'0.81"W) – Silvopastoral system composed by coconut (*C. nucifera*) trees with *Brachiaria decumbens*, not subjected to grazing below the trees (not grazed *Brachiaria*/coconut). These areas are part of a project aimed to evaluate economic and ecological viability of that intercropping. The coconut crop was established in 1998, with seedlings being planted in triangular arrangement with equal spacing of 7.5 m both between plants and rows.

Table 3. Similarity index at three depths, compared in pairs, within each area with different management systems.

Evaluated area*	Similarity index (%)		
	---------------------------------Depths (cm)*---------------------------		
	0-5 cm x 5-10 cm	0-5 cm x 10-15 cm	5-10 cm x 10-15 cm
1	84,21	64,28	61,53
2	78,78	70,96	76,92
3	64,53	66,67	75,00
4	88,38	66,67	72,72

*/ Brachiaria with coconut (*Cocus nucifera*) intercropped, grazed (1) and ungrazed (2), sugarcane cultivation (3) and conventional tillage soil, with plowing and harrowing (4).

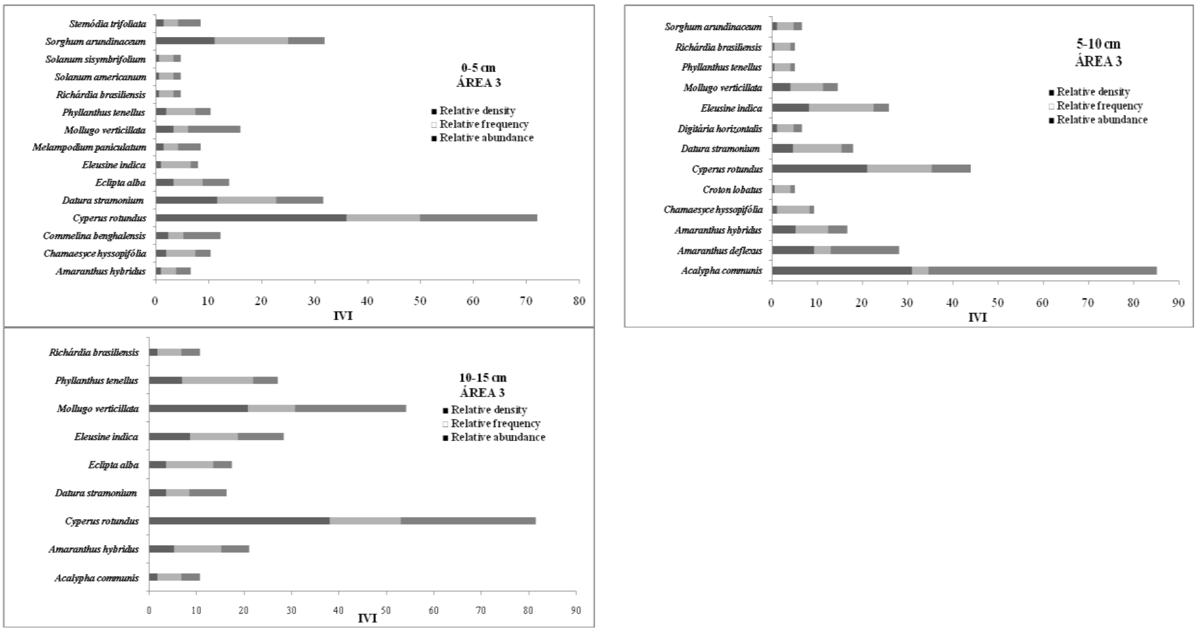

Fig 3. Relative density, relative frequency, relative abundance and importance value index of the three depths in Area 3 (sugarcane cultivation).

Table 4. Analytical results of the four assessed areas: brachiaria with coconut (*Cocus nucifera*) intercropped, grazed (1) and ungrazed (2), sugarcane cultivation (3) and conventional tillage soil, with plowing and harrowing (4).

	Chemical characteristics							
Area	pH	P	K	Ca^{2+}		Mg^{2+}	Al^{3+}	H+Al
		----mg/dm^3----		---------------------cmolc/dm^3---------------------				
1	5.70	22.00	207.45	1.68		0.90	0.18	1.30
2	6.20	4.90	79.80	2.02		1.00	0.18	1.30
3	5.50	3.40	81.10	2.02		0.89	0.18	1.90
4	5.70	63.00	460.15	2.02		0.67	0.18	1.50
	M.O.		P-rem.	S	T	T	V	m
	-dag/kg-	% C	-mg/L-	-----------cmolc/dm^3----------			---------%----------	
1	1.18	0.69	39.00	3.11	4.41	3.29	70.52	5.47
2	1.52	0.88	35.00	3.22	4.52	3.40	71.24	5.29
3	1.40	0.81	35.00	3.12	5.02	3.30	62.15	5.45
4	1.75	1.02	39.00	3.87	5.37	4.05	72.07	4.44

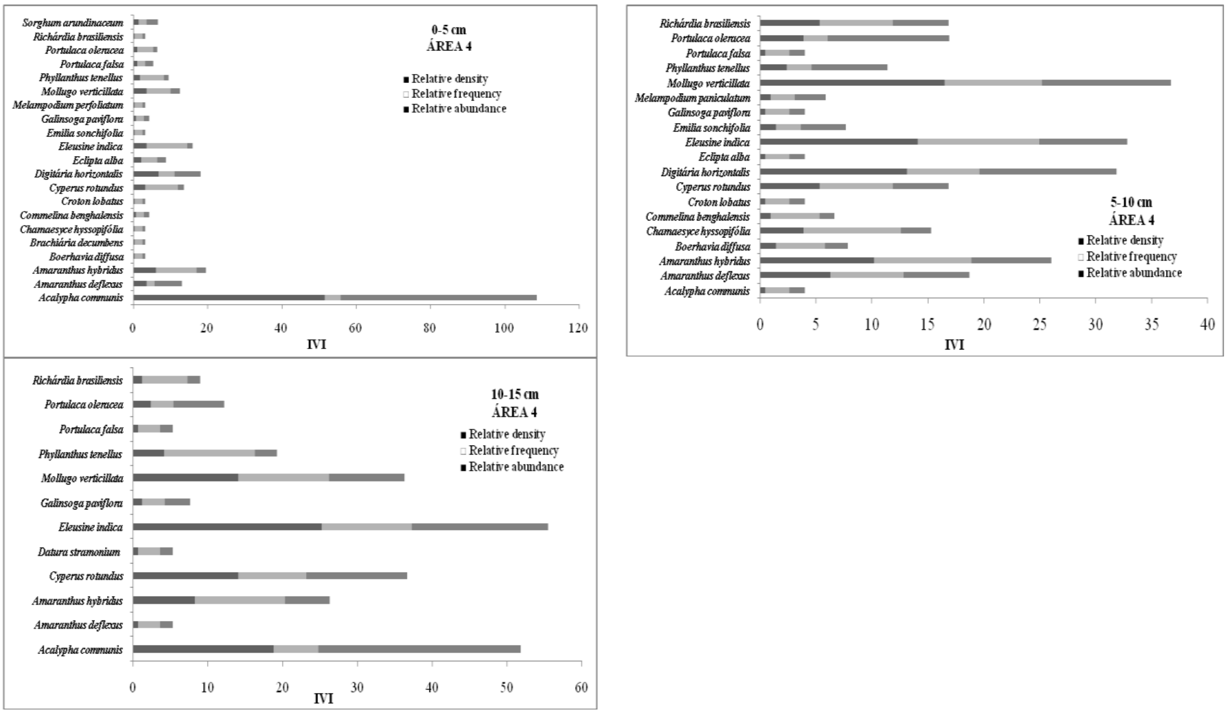

Fig 4. Relative density, relative frequency, relative abundance and importance value index of the three depths in Area 4 (conventional tillage soil, with plowing and harrowing).

Brachiaria was introduced in 2003, forming a canopy between the existing coconut plants. The total area of intercropping was 3 ha, split in two plots of 1.5 ha each.
Area 3 (18°50'7.12"S; 41°54'7.05"W) - Sugarcane crop, planted in an area of 2.5 ha in 1998 with the objective of supplementary feeding for dairy farming of the University. Sugarcane was cut manually every 12 months without residue burning, in the system known as green sugarcane.
After sugarcane cutting, a chemical weed control with the herbicide Fortex® (diuron + MSMA) at a dose of 4 L ha^{-1} with no adjuvant addition was applied.
Area 4 - Area of approximately 1 ha, which has been under conventional tillage system for nine years, with plowing followed by harrowing for planting of annual crops. Sorghum (*Sorghum bicolor*), alfalfa (*Medicago sativa*), beans (*Phaseolus vulgaris*) and, more recently, corn (*Zea mays*), are among the crops grown in this area. At the initial area preparation, a desiccation with glyphosate was done for weed control. In the last crop (corn) harvest, desiccation was also done with glyphosate.

Phytosociological evaluations

Phytosociological characterization of weed species, emerged from soil seed bank, was carried out at the soil depths of 0-5, 5-10 and 10-15 cm, in each area. In each area, five 484 cm^2 samples for each depth were collected. Then, samples were subjected to soil moisture determination, and corrected to 70 % of field capacity then placed in 2 L volume PVC pots. These pots were identified and distributed on benches in a greenhouse as a completely randomized design with five replications. Every 20 days after installation of the trial, all the emerged seedlings were identified and collected. Four collections were done, being the last one 80 days after assembly. After each count, the soil of the containers was revolved, so that the seed bank could express its potential.
For each present species, estimations of relative frequency (RRF), relative density (RSD) and relative abundance (ABR) were conducted. These phytosiociological variables describe the relationship of each species with the others in the same area, as well as importance value index (IVI) that describes which species are most important within the studied area (Mueller-Dombois and Ellenberg, 1974).
The following formulas, proposed by Mueller-Dombois and Ellenberg (1974), were used to estimate these characteristics:

$$FRR = \frac{frequency\ of\ species\ (RES)}{Total\ frequency\ of\ all\ species}\ x\ 100$$

$$DER = \frac{density\ of\ species\ (DEN)}{Total\ density\ of\ species}\ x\ 100$$

$$ABR = \frac{abundance\ of\ species\ (ABN)}{Total\ abundance\ of\ species}\ x\ 100$$

$$IVI = FRR + DER + ABR$$

A comparison between sites by means of the similarity index (SI) was determined. To assess similarity between botanical populations in the two studied areas, the SI - Sørensen Similarity Index (1972) was calculated, using the formula:

$$IS\ (\%) = \left(\frac{2a}{b+c}\right)\ x\ 100$$

Where; a = number of species common to both areas, and c = total number of species in the two compared areas. The IS varies from 0 to 100, with a maximum when all species are common to both areas and minimum when there are no species in common.

Conclusions

According to our results, there are remarkable differences regarding the emergence from the seed bank between areas, management conditions and evaluated depths. Generally, seed germination tends to decrease as the soil depth increases, whereas the number of germinated species in the deepest layer was lower in all evaluated tillage systems.

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