Revista Brasileira de Ciências Agrárias
ISSN: 1981-1160
agrarias.prppg@ufrpe.br
Universidade Federal Rural de Pernambuco
Brasil

Ribeiro Mesquita, Mário Luiz; Alves Andrade, Leonaldo; Esfrain Pereira, Walter
Germination, floristic composition and phytosociology of the weed seed bank in rice interropped with corn fields
Revista Brasileira de Ciências Agrárias, vol. 11, núm. 1, 2016, pp. 14-20
Universidade Federal Rural de Pernambuco
Pernambuco, Brasil

Agrária - Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.11, n.1, p.14-20, 2016
Recife, PE, UFRPE. www.agraria.ufrpe.br
DOI:10.5039/agraria.v11i1a5359
Protocolo 5359 - 18/10/2015 • Aprovado em 14/03/2016

Germination, floristic composition and phytosociology of the weed seed bank in rice interropped with corn fields

Mário Luiz Ribeiro Mesquita[1], Leonaldo Alves Andrade[2], Walter Esfrain Pereira[2]

[1] Universidade Estadual do Maranhão, Centro de Estudos Superiores de Bacabal, Rua Dias Carneiro, 155, CEP 65700-000, Bacabal-MA, Brasil. E-mail: mario-mesquita51@hotmail.com
[2] Universidade Federal da Paraíba, Centro de Ciências Agrárias - Campus III, Campus Universitário, Cidade Universitária, CEP 58397-000, Areia-PB, Brasil. E-mail: landrade@cca.ufpb.br; wep@cca.ufpb.br

ABSTRACT

Germination, floristic composition and phytosociology in the soil weed seed bank are important to know the weed flora and to predict weed infestations. The objective of this research was to assess and to compare germination, the weed flora and phytosociology of the soil weed seed bank in rice intercropped with corn fields in Maranhão State, northeastern Brazil by the germination method in the greenhouse and by weed sampling in the field. Phytosociological parameters computed were frequency, density, abundance and the importance value of each species. Diversity was assessed by the Shannon's Diversity Index. We recorded a total of 1,998 individuals from 40 species, 31 genera and 16 families from which 1,339 individuals germinated in the greenhouse and 659 in the field. Weed density was higher in the greenhouse (878 plants m^{-2}) than in the field (261 plants m^{-2}). The Cyperaceae family had the highest floristic richness with 12 species. The dominant species based on the importance value were *Scleria lithosperma* (IV = 37.0%) in the greenhouse and *Lindernia crustacea* (IV = 27.7%) in the field. Floristic diversity was higher in the greenhouse with H' = 2.66. These results could help to predict weed infestation potential and could lead to improved weed management practices in rice intercropped with corn fields in Maranhão State.

Key words: competition, Cyperaceae, importance value, intercropping

Germinação, composição florística e fitossociologia no banco de sementes de plantas invasoras em áreas de arroz consorciado com milho

RESUMO

Germinação, composição florística e fitossociologia de espécies presentes no banco de sementes no solo são importantes para conhecer a flora e prever infestações de plantas invasoras. Objetivou-se avaliar e comparar a germinação, a flora invasora e a fitossociologia no banco de sementes do solo em áreas de arroz consorciado com milho no Estado do Maranhão, pelo método de germinação em bandejas, em casa de vegetação e no campo, pelo método de amostragem de plantas. Os parâmetros fitossociológicos calculados foram frequência, densidade, abundância e o valor de importância para cada espécie. A diversidade foi calculada pelo Índice de Diversidade de Shannon. Registrou-se o total de 1.998 indivíduos de 40 espécies, 31 gêneros e 16 famílias, dos quais 1.339 individuos de 29 espécies germinaram na casa de vegetação e 639 indivíduos de 29 espécies, no campo. A densidade foi maior na casa de vegetação com 878 plantas m^{-2}. A família Cyperaceae teve a maior riqueza florística com 12 espécies. As espécies dominantes foram *Scleria lithosperma* (VI = 37.0%) na casa de vegetação e *Lindernia crustacea* (VI = 27.7%) no campo. A diversidade florística foi maior na casa de vegetação com H' = 2.66. Estes resultados podem contribuir para a previsão de infestações e para subsidiar práticas de manejo de plantas invasoras em áreas de cultivo de arroz consorciado com milho no Maranhão.

Palavras-chave: competição, Cyperaceae, consorciação de culturas, valor de importância

Introduction

Weeds are a major biological constraint for rice intercropped with corn farmers because they interfere with crop growth and development by means of competition for light, space, water and nutrients. Moreover, many weed species possess allelopathy mechanisms that hinder or even prevent the growth of other species associated with them, including rice and corn, resulting in decreased yield by up to 96% (Chauhan & Johnson, 2011).

Many weed species can produce a huge number of small seeds and vegetative propagules as a strategy to survive stresses imposed by control methods (Leck & Schütz, 2005; Libertino, 2015; Munhoz & Felfili, 2006). After dispersal, seeds may remain on the soil surface or be buried by means of biotic and abiotic agents thus forming a seed bank which becomes the main source of weeds in cropping fields.

The weed seed bank in the soil is a dynamic system with inputs and outputs. The inputs occur via seed rain as a result of efficient dispersion mechanisms and the outputs by means of germination, predation (Chauhan et al., 2010; Hesse et al., 2007; Rodriguez & Garcia, 2009), and decay or seed death (Mohler et al., 2012).

Numerous factors affect weed seed germination including variations in soil temperature and moisture (Begum et al., 2006; Hérault & Hiernaux, 2004; Maia et al., 2004), light intensity (Vivian et al., 2008; Batlla & Benech-Arnold, 2014) and physiological aspects of the seeds particularly seed dormancy (Baskin & Baskin, 2006). When favorable environmental conditions occur and physiological constraints are overcome, seeds germinate; weeds grow and produce new propagules enriching the soil seed bank.

Research on identification and quantification of weed species germinated in the soil seed bank from cropping fields were carried out by numerous authors (Andrade et al., 2009; Begum et al., 2006; Costa et al., 2009; Gasparino et al., 2006; Ikeda et al., 2008; Isaac & Guimarães, 2008; Kamoshita et al., 2010; Lacerda et al., 2005; Lopes et al., 2006; Mesquita et al., 2014). However, greenhouse or field weed seed bank assessments in rice intercropped with corn fields have not been documented previously. Additionally, most of the reported research was directed to agribusiness with no concern for generating useful knowledge for smallholders.

Therefore, there is a need to carry on research to identify the species present and to determine the size of the weed seed bank. Studies on soil weed seed bank ecology in this region are crucial for improving weed control practices.

Field and greenhouse studies are needed in order to understand the soil weed seed bank germination dynamics and its relationship with the weed flora on rice intercropped with corn fields. These studies can contribute to predict infestations and could lead to improved management practices to decrease the negative effects of weed interference with crop growth and yield.

The objective of this research was to compare greenhouse and field germination, and to assess floristic composition, phytosociological parameters and species diversity of the weed seed bank in rice intercropped with corn field in Maranhão State, northeastern Brazil.

Material and Methods

This research was carried out in a cropping field of six hectares, located in São Luis Gonzaga municipality (4°23'19''S and 44°39'96''W) in the central portion of Maranhão State, northeastern Brazil.

Climate in the region is of the Aw type, according to Köppen's classification, tropical hot and humid with a rainy season, from January to June and a dry season, from July to December. Average temperture is 25 ^{o}C and mean rainfall is around 1,800 mm year^{-1}. Latosols are the prevalent soils, acording to Empresa Brasileira de Pesquisa Agropecuária (2008).

The chemical and physical attributes of the soil at 0 – 20 cm depth were as follows: organic matter (g dm^{-3}) = 26; pH (in $CaCl_2$) = 5.7; P - Melich = 4 (mg dm^{-3}); K^+ (mmol$_c$ dm^{-3}) = 4.5; Ca^+ (mmol$_c$ dm^{-3}) = 74; Mg^{2+} (mmol$_c$ dm^{-3}) = 36; $H+Al^3$ (mmol$_c$ dm^{-3}) = 19; Na^+ (mmol$_c$ dm^{-3}) = 7.7; Al^{3+} (mmol$_c$ dm^{-3}) = 0; sand = 39%; silt = 53% and clay = 8%. (M. L. R. Mesquita, unpublished data).

Rice intercropped with corn was grown in slash and burn agriculture system according to local farmer practices. Land preparation consisted of slashing secondary forest associated with shrub vegetation in September of 2008 and burning the dry biomass in November. Rice variety Bonança was planted with a dibbling stick in hills spaced 0.40 m x 0.40 m and corn variety BR – 106 was planted in rows opened with a hand hoe spaced 3.0 m x 0.10 m. Both crops were planted at the same time in the beginning of January of 2009.

Fifteen pairs of plots of 25 m^2 were established in the field. In half of these plots six soil samples per plot were taken with an open metal rectangle 25 cm long, 16 cm wide and 3 cm deep, keeping a minimum distance of 1.0 m from the plot border. The rectangle was introduced three cm deep into the soil and all material enclosed by the internal perimeter was withdrawn. In total, 90 soil samples were taken. This procedure was carried out in the end of the dry season, in November 2008 one month before the rice intercropped with corn planting by farmers.

Soil samples were transported to a greenhouse covered with plastic and with the lateral walls covered by 50% black shade cloths to protect from predators, located at the Farm School of the Agrarian Sciences Center of the Maranhão State University at São Luís where they were left to germinate in aluminum trays 25 long, 16 wide and 5 cm deep, in January, 2009 and irrigated daily.

Three aluminum trays with washed sand were added as controls because of the possibility of eventual contamination by seed rain of local weed species. During the experiment, no contamination was observed.

The identification, counting and removal of weed seedlings from the trays were performed every 15 days over a period of 130 days, from January through May 2009. At 60 days after the start of the experiment, irrigation was suspended for two weeks and soil was turned over to facilitate germination of seeds located in the lower portion of the trays. Seven assessments were made, four before and three after water restriction.

In the other plots half, six weed samples were taken per plot in the rainy season, 2009 with the same metal rectangle used to collect soil samples. Weeds were cut at the ground level, identified by species and counted. Samplings were performed one day before both the first and the second weedings of the rice intercropped with corn; there were three in January and three in February 2009, totalling 90 weed samples.

Botanical identification was performed by analyzing the external morphological characteristics of vegetative and reproductive parts and according to specialized literature, by comparison with other species and also by consulting experts. The species that could not be identified at the sampling time were transplanted into plastic containers and cultivated until they reached the flowering stage. The floristic list was organized according to the classification system of the Angiosperm Phylogeny Group III (APG III, 2009).

Phytosociological parameters computed were the absolute and relative values of frequency, density, abundance and the importance value of each species according to the following equations (Muller-Dombois & Ellemberg, 1974).

$$\text{Absolute Frequency} = \frac{\text{NSi}}{\text{TNS}}$$

where:

NSi - number of samples with the presence of the species i

TNS - total number of samples

$$\text{Relative Frequency} = \frac{\text{AFi}}{\sum \text{AF}} \times 100$$

where:

AFi - absolute frequency of the species i

$\sum$ AF - sum of all absolute frequencies

$$\text{Absolute Density} = \frac{\text{TNi}}{\text{A}}$$

where:

TNi - total number of individuals of the species i

A - area sampled in hectares

$$\text{Relative Density} = \frac{\text{ADi}}{\sum \text{AD}} \times 100$$

where:

ADi - absolute density of the species i

$\sum$ AD - sum of all absolute densities

$$\text{Absolute Abundance} = \frac{\text{TNi}}{\text{TNSi}}$$

where:

TNi - total number of individuals of the species i

TNSi - total number of samples with the presence of the species i

$$\text{Relative Abundance} = \frac{\text{AAi}}{\sum \text{AA}} \times 100$$

where:

AAi - absolute abundance of the species i

$\sum$ AA - sum of all absolute abundances

$$\text{Importance Value} = \text{RF} + \text{RD} + \text{RA}$$

where:

RF - relative frequency

RD - relative density

RA - relative abundance

Floristic diversity was assessed by the Shannon's Diversity Index (*H'*) based on natural logarithm which considers equal weight among rare and abundant species. It is considered that the higher the value of *H'* the greater the floristic diversity (Shannon & Weaver, 1949). The Shannon's Diversity Index was computed by the equation:

$$H = -\sum_{I=1}^{S} \text{pi} \ln \text{pi}$$

Where ln is the natural logarithm; pi = ni/N; ni is the number of sampled individuals of the species i; and N is the total number of sampled individuals. The result is expressed in natural digits (nats) per individual, because the formula uses a log base e. It varies from 1.5 to 3.5 and hardly exceeds 4.0 (Kwak & Peterson, 2007)

Results and Discussion

A total of 4,099 indivíduals from 55 species, 40 genera and 20 families germinated from the weed seed bank in the soil. Specifically, 3,160 individuals from 41 species were recorded in the greenhouse and 939 individuals from 30 species, in the field (Table 1).

The families with the highest species richness both in the greenhouse and in the field were Cyperaceae with 12; Poaceae with eight; and Fabaceae and Malvaceae, with six species each. These families contributed with 47.3% of the species total. In contrast, 11 families had only one species each, which corresponds to 55% of the total of all recorded families.

The number of families, genera and species was higher in the greenhouse than in the field (Figure 1).

The species richness of the Cyperaceae family observed in this study indicates that the formation of significant seed bank is an important regeneration component for many species of this family (Leck & Schütz, 2005). Moreover, the ability of vegetative propagation by means of a complex underground system consisting of rhizomes and tubers with many species having underground stolons is a competitive advantage of many species of Cyperaceae (Munhoz & Felfili, 2006).

Similar results were reported by Kamoshita et al. (2010) who observed that 86% of the species present in the seed bank of 22 rice fields from smallholder rice farmers in Cambodian were from the Cyperaceae family.

On the other hand, the way most species of the Poaceae family grow with dense clumps or the presence of rhizomatous

Table 1. List of species, families and number of individuals recorded in the weed seed bank in the field and in the greenhouse at a rice intercropped with corn field in Maranhão state, northeastern Brazil

Species	Family	Number of individuals	
		in the field	in the greenhouse
Alternathera tenella Colla	Amaranthaceae	4	1
Emilia coccinea (Sims) G. Don	Asteraceae	-	53
Erechtites hieracifolius (L). Raf. ex DC.	Asteraceae	-	10
Galinsoga parviflora Cav.	Asteraceae	1	-
Commelina diffusa Burm. f.	Commelinaceae	-	24
Murdannia nudiflora (L.) Brennan	Commelinaceae	-	3
Ipomoea triloba L.	Convolvulaceae	-	3
Cyperus difformis L.	Cyperaceae	17	-
Cyperus diffusus L.	Cyperaceae	-	204
Cyperus distans L. f.	Cyperaceae	72	-
Cyperus iria L.	Cyperaceae	171	165
Cyperus luzulae (L.) Rottb. ex Retz.	Cyperaceae	35	-
Cyperus meyenianus Kunth	Cyperaceae	-	77
Cyperus rotundus L.	Cyperaceae	22	347
Fimbristylis dichotoma (L.) Vahl	Cyperaceae	175	-
Fimbristylis miliacea (L.) Vahl	Cyperaceae	165	-
Pycreus lanceolatus (Poir.) C. B. Clarke	Cyperaceae	-	240
Schoenoplectus juncoides (Roxb.) Palla	Cyperaceae	-	116
Scleria lithosperma (L.) Sw.	Cyperaceae		268
Chamaesyce hirta (L.) Millsp.	Euphorbiaceae	1	4
Calopogonium mucunoides Desv.	Fabaceae	15	14
Chamaecrista flexuosa (L.) Greene	Fabaceae	1	-
Crotalaria retusa (L.)	Fabaceae	1	-
Crotalaria spectabilis Roth	Fabaceae	-	24
Desmodium adscendens (Sw.) DC.	Fabaceae	-	21
Mimosa pudica L.	Fabaceae	3	-
Hyptis suaveolens (L.) Poit.	Lamiaceae	-	1
Sida cordifolia L.	Malvaceae	33	-
Sida glaziovii K. Chun	Malvaceae	1	-
Sida rhombifolia L.	Malvaceae	17	42
Sida santaremensis H. Monteiro	Malvaceae	7	2
Sida urens L.	Malvaceae	1	-
Urena lobata L.	Malvaceae	8	2
Boerhavia erecta L.	Nyctaginaceae	-	677
Ludwigia leptocarpa (Nutt.) H. Hara	Onagraceae	-	7
Ludwigia octovalvis (Jacq.) P. H. Raven	Onagraceae	-	26
Phyllanthus niruri L	Phyllanthaceae	1	17
Phyllanthus orbicularis Kunth	Phyllanthaceae	-	3
Lindernia crustacea (L.) F. Muell	Plantaginaceae	10	498
Scoparia dulcis L.	Plantaginaceae	-	3
Brachiaria decumbens Stapf	Poaceae	8	14
Cenchrus echinatus L.	Poaceae	-	14
Digitaria ciliaris (Retz.) Koeler	Poaceae	-	67
Echinochloa colona (L). Link	Poaceae	99	16
Eleusine indica (L.) Gaertn.	Poaceae	29	7
Eragrostis ciliaris (Retz.) Koeler	Poaceae	-	21
Panicum maximum Jacq.	Poaceae	25	50
Panicum trichoides Sw.	Poaceae	-	20
Talinum paniculatum (Jacq.) Willd.	Portulacaceae	-	69
Pteridium aquilinum (L.) Kuhn	Pteridaceae	3	-
Oldenlandia corymbosa L.	Rubiaceae	2	15
Spermacoce verticilata L.	Rubiaceae	-	5
Physalis angulata L.	Solanaceae	6	1
Thelypteris dentata (Forssk.) E. P. St. John	Thelypteridaceae	6	-
Turnera subulata Sm.	Turneraceae	-	9

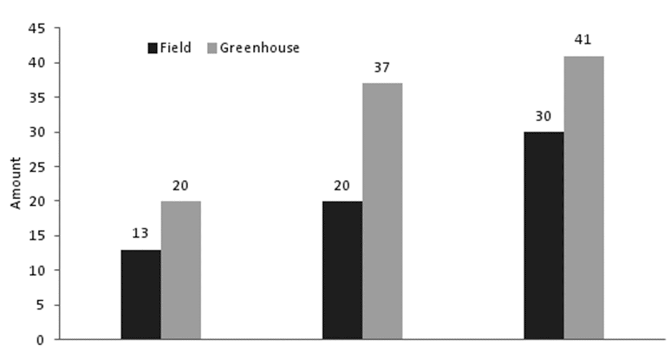

Figure 1. Number of families, genera and species in the weed seed bank at a rice intercropped with corn field in Maranhão State, northeastern Brazil, assessed in the field and in the greenhouse

and stoloniferous individuals widely scattered in the weed community is a major feature of the dominance of this family in many rice cropping fields. Furthermore, seeds of many species of the Malvaceae and Fabaceae have long persistence in the soil because of their tegument impermeability to water and gases (Baskin & Baskin, 2006)

The dominance of Cyperaceae and Poaceae families was also observed in floristic surveys in rice in Formoso do Araguaia, Tocantins State (Erasmo et al., 2004).

Soil samplings for the greenhouse study were taken at the end of November, 2008 and weed samplings in the field were carried out in January and February, 2009. Thus there was an interval of two months between these procedures.

The greatest weed germination density in this study was observed in the greenhouse with 878 plants m^{-2} exceeding in more than three times the density in the field (261 plants m^{-2}).

The lowest density in the field may be due to seed and seedling losses due to detrimental effect of fungi and insect predators as observed by Hesse et al., (2006), Mohler et al. (2012) and Rodriguez & Garcia, (2009). In post-dispersal weed seed studies carried out in rice fields in the Philippines, Chauhan et al. (2010) observed that in a period of only 14 days, the fire ants (*Solenopsis geminata*) were the main predators and responsible for removal of 98%, 88% and 75% of *D. ciliaris*, *E. indica* and *E. colona* seeds respectively, previously placed on soil surface.

Furthermore, the lowest density recorded in the field was also due to intra and interspecific competition as observed by Hérault & Hiernaux (2004) in weed seed and population dynamic studies carried out in Africa, and also by Isaac & Guimarães (2008), in research carried out on weed seed bank and emergent flora in cropping fields of the Mato Grosso State, Midwestern Brazil.

Conversely, when this study was carried out in the greenhouse, seeds were protected from predators by the plastic cover and lateral walls covered with black shade cloths and sistematically irrigated. Maia et al. (2004), studying weed seed bank in natural fields observed that soil moisture content was the most imporant abiotic factor affecting patterns of vegetation variation. Other authors also consider soil water content as a determinant factor affecting weed seed bank germination (Munhoz & Felfili, 2006; Vivian et al., 2008). Moreover, withdrawal of weed seedlings from trays after assessments carried out in the greenhouse decreased the effect of competition which is generally lower at the weed seedling phase.

Twenty five species were found only in the greenhouse: *E. coccinea*, *E. hieracifolius*, *C. diffusa*, *M. nudiflora*, *I. triloba*, *C. diffusus*, *C. meyenianus*, *P. lanceolatus*, *S. juncoides*, *S. lithosperma*, *C. spectabilis*, *D. adscendens*, *H. suaveolens*, *B. erecta*, *L. leptocarpa*, *L. octovalvis*, *P. orbicularis*, *S. dulcis*, *C. echinatus*, *D. ciliaris*, *E. ciliaris*, *P. trichoides*, *T. paniculatum*, *S. verticilata* and *T. subulata*. In contrast, 14 species were found only in the field: *G. parviflora*, *C. difformis*, *C. distans, C. luzulae*, *F. dichotoma*, *F. miliacea*, *C. flexuosa, C. retusa*, *M. pudica*, *S. cordifolia*, *S. glazioii*, *S. urens, P. aquilinum* and *T. dentata.*

The species that were found only in the field probably have seeds that are more light sensitive to germinate than the other species found only in the greenhouse.

On the other hand, 16 species were common both in in the greenhouse and in the field: *A. tenella*, *C. iria*, *C. rotundus*, *C. hirta*, *C. mucunoides*, *S. rhombifolia*, *S. santaremensis*, *U. lobata*, *P. niruri*, *L. crustacea*, *B. decumbens*, *E. colona*, *E. indica*, *P. maximum*, *O. corymbosa* and *P. angulata*.

The species that were common in the field and in the greenhouse demonstrated to possess great plasticity, that is, the capacity to adapt to different sites besides tolerance to anthtropic activities and to the stress imposed by environmental factors in the agroecosystem studied.

The most important species based on the Importance Value (IV) were *F. dichotoma* (IV=42.5%) in the field with greater contribution from Relative Frequency (RF), Relative Density (RD) and Relative Abundance (RA); and *B. erecta* (IV=40.4%) in the greenhouse, with greater contribution from RF and RD (Table 2).

The species dominance in the weed seed bank is related not only to farmer cultural practices and of the site cropping history but also to the species breeding capacity. All seeds cited in this study propagate by seeds being that *F. dichotoma* besides seeds also propagate by rhizomes (Lorenzi, 2008).

Floristic diversity was greater in the greenhouse (*H'*=2.65 natural digits per individual) than in the field (*H'*=2.47). The highest number of individuals and species found in the greenhouse contributed for this result. Mesquita et al. (2014) reported a similar floristic diversity (*H'*= 2.66) in greenhouse weed seed bank study carried out in Bacabal municipality, in the same region.

Table 2. Phytosociologial parameters of the predominant species in the weed seed bank in the field and in the greenhouse from a rice intercropped with corn field in Maranhão State, northeastern Brazil

Species	RF	RD	RA	IV%
In the field				
F. dichotoma	12.0	21.8	8.7	42.5
F. miliacea	11.2	19.0	8.2	38.4
C. iria	10.8	12.8	5.7	29.3
E. colona	11.6	10.3	4.2	26.1
C. distans	9.6	8.3	4.2	22.1
S. cordifolia	5.6	3.8	3.3	12.7
E. indica	3.2	3.3	5.1	11.6
P. maximum	6.4	2.9	2.2	11.5
C. difformis	1.2	2.0	7.8	11.0
C. rotundus	2.8	2.5	4.4	9.7
In the greenhouse				
B. erecta	13.1	21.4	5.9	40.4
L. crustacea	13.1	15.8	4.3	33.2
C. sphacelatus	6.1	11.0	6.5	23.6
P. lanceolatus	2.0	7.6	13.5	23.1
S. lithosperma	8.5	8.5	3.6	20.6
C. diffusus	8.5	6.5	2.7	17.7
C. iria	5.2	5.2	3.6	14.0
S. juncoides	2.3	3.7	5.7	11.7
C. meyenianus	1.7	2.4	5.1	9.2
D. ciliaris	5.6	2.1	1.4	9.1

RF = Relative Frequency, RD = Relative Density, RA = Relative Abundance, IV = Importance Value.

Conclusions

The weed seed bank of rice intercropped with corn fields in Maranhão State is largely dominated by species of the families Cyperaceae, Poaceae, Fabaceae and Malvaceae.

Germination, weed density of the weed seed bank of rice intercropped with corn fields in Maranhão State, are higher in the the greenhouse than in the field.

The number of families, genera and species is higher when the seed bank is assessed in the greenhouse than in the field.

The dominant species in the the weed seed bank assessed field and in the greenhouse are *Fimbristylis dichotoma* and *Boerhavia erecta*, respectively.

Floristic diversity of the weed seed bank in the soil is higher when it is assessed in the greenhouse than in the field.

Acknowledgements

This research was supported by CAPES (Coordination for the Improvement of Higher Level Personnel, Brazil).

Literature Cited

Andrade, M.V.M. de; Andrade, A.P. de; Silva, D.S. da; Bruno, R.L.A.; Guedes, D.S.A. Levantamento florístico e estrutura fitossociológica do estrato herbáceo e subarbustivo em áreas de caatinga no Cariri paraibano. Revista Caatinga, v.22, n.1, p.229-237, 2009. <http://periodicos.ufersa.edu.br/revistas/index.php/sistema/article/view/1059/554>. 23 Jul. 2015.

Angiosperm Phylogeny Group - APG. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. APG III. Botanical Journal of the Linnean Society, v.161, n.2, p.105-121, 2009. <http://dx.doi.org/10.1111/j.1095-8339.2009.00996.x>.

Baskin, C.C.; Baskin, J.M. The natural history of soil seed banks of arable land. Weed Science, v.4, n.3, p.549-557, 2006. <http://dx.doi.org/10.1614/WS-05-034R.1>.

Batlla, D.; Benech-Arnold, R.L. Weed seed germination and the light environment: implications for weed management. Weed Biology and Management. v.14, n.2, p.77-87, 2014. <http://dx.doi.org/10.1111/wbm.12039>.

Begum, M.; Juraimi, A. S.; Rastan, S.O.B.S.; Amartalingam, R. Man, A. B. Seed bank and seedling emergence characteristics of weeds in ricefield soils of the muda granary area in north-west peninsular Malaysia. Biotropia, v.13, n.1, p.11-21, 2006. <http://journal.biotrop.org/index.php/biotropia/article/view/215/184>. 28 Jul. 2015.

Chauhan, B.S.; Johnson, D.E. Row spacing and weed control timing affect yield of aerobic rice. Field Crops Research, v.121, n.2, p.226-231, 2011. <http://dx.doi.org/10.1111/j.1365-3180.2010.00807.x>.

Chauhan, B.S.; Migo, T.; Westerman, P.R.; Johnson, D.E. Post dispersal of weed seeds in rice fields. Weed Research**,** v.50, n.6, p.553-560, 2010. <http://dx.doi.org/10.1111/j.1365-3180.2010.00807.x>.

Costa, J.R.; Mitja, D.; Fontes, J.R. Bancos de sementes de plantas invasoras em cultivos de mandioca na Amazônia central. Planta Daninha, v.27, n.4, p.665-671, 2009. <http://dx.doi.org/10.1590/S0100-83582009000400004>.

Empresa Brasileira de Pesquisa Agropecuária. Sistema brasileiro de classificação de solos. 2.ed. Rio de Janeiro: Embrapa, 2008. 306 p.

Erasmo, E.R.L.; Pinheiro, L.L.A.; Costa N.V. Levantamento fitossociológico de plantas infestantes em áreas de produção de arroz irrigado cultivado sob diferentes sistemas de manejo. Planta Daninha, v.22, n.2, p.195-201, 2004. <http://dx.doi.org/10.1590/s0100-83582004000200004>.

Gasparino, D.; Malavasi, U.C.; Malavasi, M.M.; Sousa, I. Quantificação do banco de sementes sob diferentes usos do solo em área de domínio ciliar. Revista Árvore, v.30, n.1, p.1-9, 2006. <http://dx.doi.org/10.1590/s0100-67622006000100001>.

Hérault, B.; Hiernaux, P. Soil seed bank vegetation dynamics in Sahelian fallows; the impact of past cropping and current grazing treatments. Journal of Tropical Ecology, v.20, n.6, p.683-691, 2004. <http://dx.doi.org/10.1017/s0266467404001786>.

Hesse, E.; Rees, M.; Müller-Schärer, H. Seed bank persistence of clonal weeds in contrasting habitats: implications for control. Plant Ecology, v.190, n.2, p.233-243, 2007. <http://dx.doi.org/10.1007/s11258-006-9203-7>.

Ikeda, F.S.; Mitja, D.; Vilela, L.; Silva, J.C.S. Banco de sementes em cerrado *sensu stricto* sob queimada e sistemas de cultivo. Pesquisa Agropecuária Brasileira, v.43, n.6, p.667-673, 2008. <http://dx.doi.org/10.1590/s0100-204x2008000600001>.

Isaac, R.A.; Guimarães, S.C. 2008. Banco de sementes e flora emergente de plantas daninhas. Planta Daninha, v.26, n.3, p.521-530, 2008. <http://dx.doi.org/10.1590/s0100-83582008000300007>.

Kamoshita, A.; Ikeda, H.; Yamagishi, J.; Ouk, M. Ecophysiological study on weed seed bank and weeds in Cambodian paddy fields with contrasting water avaliability. Weed Biology and Management, v.10, n.4, p.261-272, 2010. <http://dx.doi.org/10.1111/j.1445-6664.2010.00393.x>.

Kwak, T.J.; Peterson J.T. Community indices, parameters, and comparisons. In: Guy; C. S.; Brown, M. L. (Eds.). Analysis and interpretation of freshwater fisheries data. Bethesda: American Fisheries Society, 2007. p.677-763

Lacerda, A.L.S.; Victoria Filho, R.; Mendonça, C. G. Levantamento do banco de sementes em dois sistemas de manejo do solo irrigados por pivô central. Planta Daninha, v.23, n.1, p.1-7, 2005. <http://dx.doi.org/10.1590/s0100-83582005000100001>.

Leck, M.A.; Schütz, W. Regeneration of Cyperaceae, with particular reference to seed ecology and seed banks. Perspectives in Plant Ecology, Evolution and Systematics, v.7, n.2, p.95-133, 2005. <http://dx.doi.org/10.1016/j.ppees.2005.05.001>.

Libertino, G.V. Biology of *Boerhavia erecta* L. <http://agris.fao.org/agris-search/search.do?recordID=PH8510816.>. 25 Jan. 2015.

Lopes, K.P.; Sousa, V.C.; Andrade, L.A.; Dornelas, V.G.; Bruno, R.L.A. Estudo de bancos de sementes em povoamentos florestais puros e em uma capoeira de floresta ombrófila aberta, no município de Areia, PB, Brasil. Acta Botanica Brasilica, v.20, n.1, p.105-113, 2006. < http://dx.doi.org/10.1590/S0102-33062006000100010>.

Lorenzi, H. Plantas invasoras do Brasil: terrestres aquáticas, parasitas e tóxicas. 4.ed. Nova Odessa: Instituto Plantarum, 2008. 640 p.

Maia, F.C.; Medeiros, R.B.; Pillar, V.P.; Focht, T. Soil seed bank variation patterns according to environmental factors in a natural grassland. Revista Brasileira de Sementes, v.26, n.2, p.126-137, 2004. <http://dx.doi.org/10.1590/S0101-31222004000200018>.

Mesquita, M.L.R; Andrade, L.A.; Rodriges, W.E. Banco de sementes do solo em áreas de cultivo de subsistência na floresta ombrófila aberta com babaçu (*Orbygnia phalerata* Mart.) no Maranhão. Revista Árvore, v.38, n.4, p.677-688, 2014. <http://dx.doi.org/10.1590/S0100-67622014000400011>.

Mohler, C.L.; Dykeman, C.; Nelson E.B.; Ditommaso, A. Reduction in weed seedling emergence by pathogens following the incorporarion of green crop residue. Weed Research, v.52, n.5, p.467-477, 2012. <http://dx.doi.org/10.1111/j.1365-3180.2012.00940.x>

Muller-Dombois, D.; Ellemberg, H. Aims and methods of vegetation ecology, New York: John Wiley & Sons, 1974. 547p.

Munhoz, C.B.R.; Felfili, J.M. Fitossociologia do estrato herbáceo-subarbustivo de uma área de campo sujo no Distrito Federal, Brasil. Acta Botanica Brasilica, v.20, n.3, p. 671-685. 2006. <http://dx.doi.org/10.1590/S0102-33062006000300017>.

Rodriguez, C.; Garcia, M.A. Seed-bank dynamics of the tropical weed *Sida rhombifolia* (*Malvaceae*): incidence of seedling emergence, predators and pathogens. Seed Science Research. v.9, n.4, p.241-248, 2009. <http://dx.doi.org/10.1017/S0960258509990146>.

Shannon, C.E.; Weaver, W. The mathematical theory of communication. Urbana: University of Illinois Press. 1949. 144p.

Vivian, R.; Gomes Junior, F.G.; Chamma, H.M.C.P.; Silva, A.A.; Fagan, E.B.; Ruiz, S.T. Efeito da luz e da temperatura na germinação de *Alternathera tenella, Conyza bonariensis* e *Digitaria ciliaris*. Planta Daninha, v.26, n.3, p.507-513. 2008. <http://dx.doi.org/10.1590/S0100-83582008000300005>.