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SPECIES DIVERSITY AND DYNAMICS IN THE SOIL SEED BANK OF A YAM FIELD AND A FALLOW FIELD

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ABSTRACT

Soil seed bank is a natural storage for seeds deposited at various soil depths. In this study, the soil seed bank of a yam field and fallow field within the University of Port Harcourt were examined using seedling emergence method to identify and record the floristic composition of both fields through their emergent seedlings. Soil samples from eight points for each field totaling sixteen points were collected and at three soil depths (0-5cm, 5-10cm, and 10-15cm). The soil samples were transferred to Centre for Ecological Studies, University of Port Harcourt for preparation and monitored for four weeks. Statistical analysis was done for the data generated using one-way ANOVA in addition to their graphical representation. From the result, the fallow field showed higher species abundance (emergence seedlings) but was not significantly different at a 5% level of probability from the yam field at all depths. Species diversity index revealed high diversity at 10cm depth for yam field and 5cm depth for the fallow field while the lowest was at 15cm depth for the fallow field. Agricultural tillage of the yam field led to lower species density, abundance, and composition due to seed destruction and deepening of seeds down the soil depths. Soil seed bank provided the vegetation history of the fields and information necessary for weed management.

Keywords: Fallow Field, Floristic Composition, Soil Seed Bank, Tillage, Weed Management, Yam Field

Introduction

Soil seed bank is the natural storage for seeds (both viable and non-viable) and is usually present at various soil depths. Zhoa et al. (2016) opined that soil seed bank consists of an assemblage of viable seeds from different plants. These seeds are often dormant within the soil of most ecosystems (Lu et al., 2010) but can maintain the genetic variations of the above-ground population (Honnay et al., 2008). Information on the regenerative potential of soil seed bank of an ecosystem after a disturbance has been documented (Baker, 1989; Coffin and Lauenroth, 1989; Thompson et al., 1993; Kellerman and Van Rooyen, 2007; Li et al., 2009). The presence of more seeds in soil seed bank has enabled plant species to survive extreme climatic conditions (Gonzalez-Alday et al., 2009) and is key to the flexibility of biological communities (Wang et al., 2013). This feat can be achieved when seeds are exposed to favorable environmental conditions.

The dynamics of community succession are initiated by pioneer species invasion and soil seed bank is utilized to forecast the dispersion of new species enrolment (Elizabeth, 2006). Hence it is an ecological component shaping the dynamics of ecosystem. According to Santos et al. (2013) and Silva et al. (2013), accumulation of seeds in the seed bank depends on seed dispersal, germination, and death of the seeds. The period of seed storage in the soil otherwise known as latent stage reflects the history and current situation of the community (Thompson, 2000; Kalamees et al., 2012). Within the soil, a bank of vegetative propagules like tubers, rhizomes, and stolons could cause persistence in perennials (Fernandez-Quintanilla et al., 1991) which could be of regenerative potential for an environment.

Soil seed banks are characterized based on resilience and persistence of the seeds (Freitas, 1990) or longevity of the seeds present (Garwood, 1989; Ken-Thompson et al., 1997). Within the soil seed bank, several factors influence the duration of seed dormancy due to seed sensitivity to their environment (Hossain and Begum, 2015). In an agro-system, agricultural soil can contain a huge number of weed seeds (Menalled, 2013) which is vital in weed management. Soil seed bank renews plant population and restructures the species richness and diversity of plant communities (Santos et al., 2013; Silva et al., 2013). Saatkamp et al. (2014) reported important interaction between relevant biophysical processes and agricultural practices to soil seed bank. Following these events, soil seed bank is considered an essential component of plant communities (Song et al., 2017). Therefore, to determine the species diversity of an ecosystem particularly after a disturbance, the seed location in the soil profile is an important feature because only seeds situated on or close to the surface can germinate (Benvenuti, 2007). This explains why various soil depths and locations are considered in studies of species density.

The seed bank constitutes a potential threat to agricultural production because it is the primary source of future weed infestation in fields (Cavers and Benoit, 1989). Consequential to this, extensive studies have been carried out on soil seed banks

(Begum et al., 2006; Singh et al., 2012; Saatkamp et al., 2014) because of their economic impacts, rapid regeneration, and potential for weed management. Therefore, this study aims at evaluating the species diversity, richness, evenness, and floristic composition of the soil seed bank in a yam field and fallow field within the agric. farm at the University of Port Harcourt.

Materials and Methods

Study area

The study evaluated the soil seed bank of two locations namely; a cultivated yam field and a fallow field, within the agricultural research farm at the University of Port Harcourt, Rivers State. The agriculture research farm is known for its yearly agricultural produce, operations, practices, and weed growth. The geographical location and coordinates of the study area were obtained using a GPS (Global Positioning System) device (Table1).

Table 1: GPS of the study area.

Study area	Latitude	Longitude
Yam field	4.9081089	6.9171436
Fallow field	4.9059826	6.9143729

GPS Device: Garmin GPSMAP 64S

Data collection

Soil samples were collected randomly using a soil auger within the study locations. Eight points from each location (yam field and fallow field) were selected and totaling sixteen (16) points. At the point of collection, three depth levels were taken for evaluation (0-5cm, 5-10cm, and 10-15cm). The fallow field was used as the control. The collected soil samples were put into well-labeled polythene bags and taken to the Centre for Ecological Studies at the University of Port Harcourt for seedling emergent studies. A total of forty-eight (48) samples were collected (three depths for each point). Replication of the 48 samples twice to derive a total of ninety-six (96) samples. The samples were sieved, 100g weighed, and poured into labeled and perforated plastic plates with tissue paper placed at the base to control the moisture content of the soil and regulate moisture escape through the perforated holes. Daily water sprinkling and exposure to adequate sunlight were done for the duration of the study - four weeks (Anyanwu et al., 2019) with modifications on the duration.

Seedling emergence methods were adopted for the study to determine species density, viability, and composition across the two locations at various depths. Seedlings started to emerge within the first week of study. The emerging seedlings were identified using Akobundu et al. (2016), counted, and discarded weekly using forceps. After the weekly record, each soil sample was stirred and watered to give equal germination opportunity to all available seeds (INFI, 2001).

Data analysis and research design

The data collected were analyzed using one-way analysis of variance (ANOVA) to ascertain the significant difference within factors at a 5% level of probability. Multiple comparisons using Least Significant Difference (LSD) to determine significant differences between paired factors, descriptive statistics (mean and standard deviation), differences between depths and nature of fields were additionally utilized. The experimental design used was Randomized Complete Block Design (RCBD).

Results

Species composition per soil seed bank location

This study demonstrated that a total of seven hundred and seventy-four (774) seedlings emerged from the two locations with the yam field having two hundred and eighty-six (286) species while the fallow field had four hundred and eighty-eight (488) species. A total of twenty-four (24) plant species germinated which are classified into seventeen (17) families.

By distribution, Poaceae had four (4) species; Rubiaceae, Asteraceae, Solanaceae, and Fabaceae had two (2) species each, while other families; Cyperaceae, Linderaceae, Lamiaceae, Phyllantaceae, Melastomaceae, Amaranthaceae, Portulacaceae, Convulucaceae, Euphorbiaceae, Cleomaceae, Onagraceae, and Malvaceae all had one (1) species each (Table 2).

Table 2: Summary of the total number individual number of species observed across various location depths.

			Yam Field			Fallow Field		
	Species	**Families**	**5cm**	**10cm**	**15cm**	**5cm**	**10cm**	**15cm**
1.	*Oldenlandia corymbosa* L.	Rubiaceae	48	54	55	126	63	40
2.	Sedges	Cyperaceae	7	21	31	66	49	21
3.	*Lindernia spp.*	Linderaceae	4	4	3	22	3	6
4.	*Solenstemon monostachyus* (P. Beauv.) Brig.	Lamiaceae	1	2	1	0	0	0
5.	*Ageratum conyzoides* L.	Asteraceae	1	2	1	10	4	1
6.	*Physalis spp.*	Solanaceae	1	2	2	0	0	1
7.	*Synedrella nodiflora* Gaertn.	Asteraceae	0	1	1	2	2	0
8.	*Phyllanthus spp.*	Phyllantaceae	0	2	1	3	28	6
9.	*Eleusine indica* (L.) Gaertn.	Poaceae	1	4	1	2	0	2
10.	*Spermacoce ocymoides* Burm.f.	Rubiaceae	2	1	2	3	1	1
11.	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae	0	0	0	1	0	2
12.	*Mimosa pudica* L.	Fabaceae	0	1	0	0	1	0
13.	*Dissotis floribundus*	Melastomaceae	0	0	2	3	2	0
14.	*Digitaria horizontalis* Willd.	Poaceae	7	1	2	2	3	0
15.	*Cynodon dactylon* (L.) Pers.	Poaceae	0	0	4	1	1	0
16.	*Cyathula prostrata* (L.) Blume	Amaranthaceae	4	2	0	0	2	0
17.	*Solanum spp.*	Solanaceae	0	0	0	1	0	0
18.	*Indigofera spp.*	Fabaceae	1	1	0	1	2	0
19.	*Talinum triangulare* (Jacq.) Willd.	Portulaceae	1	1	0	0	0	0
20.	*Ipomoea involucrata* P. Beauv.	Convulucaceae	0	1	0	0	0	0
21.	*Acalypha spp.*	Euphorbiceae	0	0	1	0	1	0
22.	*Cleome spp.*	Cleomaceae	0	0	0	0	0	1
23.	*Ludwigia spp.*	Onagraceae	0	0	0	1	0	0
24.	*Triumfetta spp.*	Malvaceae	1	0	0	1	0	0
	Total number of individual species		13	16	14	16	14	10
	Total number of plant species		79	100	107	245	162	81

Number of species in the Yam field

At depths 5cm, 10cm, and 15cm, nine (9) species were consistent across the depths with *Oldenlandia corymbosa*, sedges, *Lindernia sp.*, and *Digitaria horizontalis* as the abundant species. The least represented species are *Triumfetta* sp., *Acalypha* sp., *Ipomoea involucrata*, and *Mimosa pudica* with one (1) record across the three depths (Fig. 1).

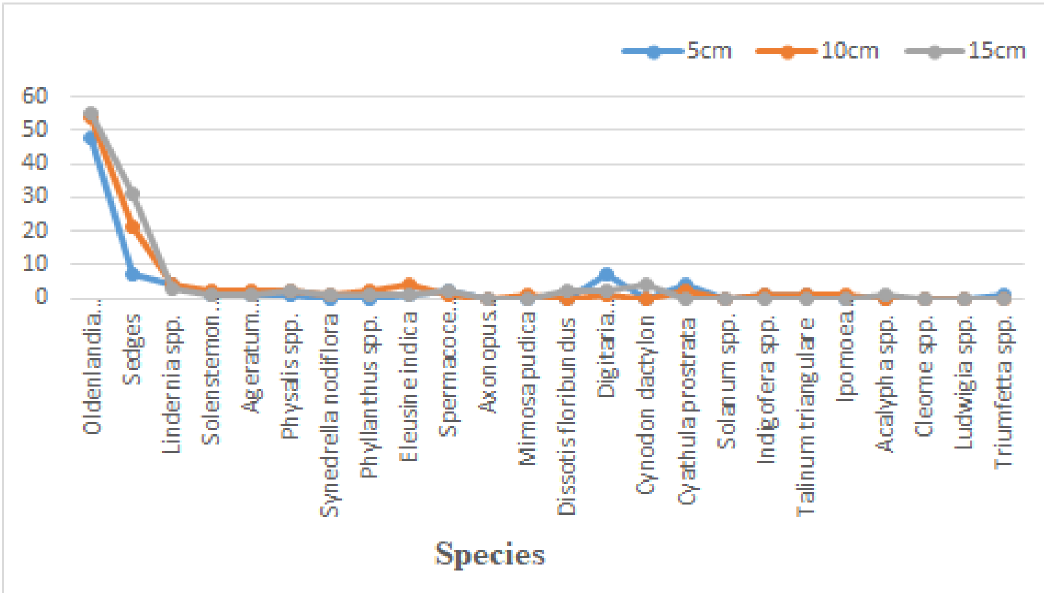

Fig 1: Number of Species in Yam Field. P.S.Y-axis represent number of species identified and counted. X-axis represent the species identified.

Number of species in the fallow field

Across the soil depths (5cm, 10cm, and 15cm), *Oldenlandiacorymbosa,* sedges, *Lindernia sp., Ageratum conyzoides*, *Phyllanthus* sp. and *Spermacoce ocymoides* are the most abundant and consistent species across the three depths. There was a significant decrease in species abundance down the soil depths (Table 2). The least represented species are *Acalypha* sp., *Cleome* sp., *Ludwigia* sp., *Triumfetta* sp., *Solanum* sp., *Physalis* sp., and *Mimosa pudica* (Fig. 2).

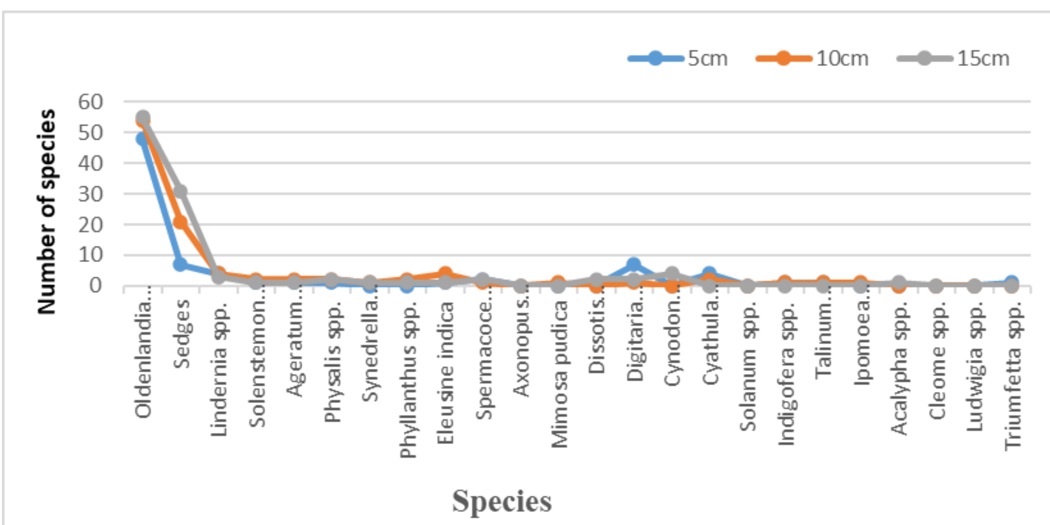

Fig. 2: Number of Species in Fallow Field.

Difference between the study fields at each depth

There is no significant difference (p>0.05) between number of species in the yam field and the fallow field across the soil depths (5cm, 10cm, and 15cm). The fallow field had the highest species at 5cm and 10cm depths compared to the yam field with the lowest at both levels. On the contrary, the yam field had a higher species abundance at 15cm compared to the fallow field (Table 3).

Based on the progression in number of species at the yam field across the soil depths downwards, there was no significant difference at a 5% significant level between the depths. In the fallow field, the decrease in number of species down the soil depths had no significant difference at a 5% significant level (Table 4).

Table 3: Difference between the study locations at each depth of the mean number of individuals

	5cm	10cm	15cm
Yam Field	3.29	4.17	4.46
Fallow Field	10.21	6.75	3.38
T-Test (p-value)	0.263	0.528	0.731

Table 4: Difference between depths across location of study for the number of individuals

	Yam field	Fallow Field
5cm	3.29	10.21
10cm	4.17	6.75
15cm	4.46	3.38
ANOVA (p-value)	0.933	0.484

Species Diversity

In this study, *Oldenlandia corymbosa* had the highest species dominance followed by Sedges and *Lindernia* sp. at both locations across the soil depths. For the yam field, species richness and diversity was highest at 10cm depth followed by 15cm and 5cm while species evenness was highest at 15cm depth followed by 10cm and 5cm. In the fallow field, species diversity, richness, and evenness was highest at 5cm depth followed by 10cm and 15cm (Tables 5, 6 and 7).

Table 5: Species diversity index for yam field and fallow field at the various depths.

	Yam Field			Fallow Field		
	5cm	**10cm**	**15cm**	**5cm**	**10cm**	**15cm**
Taxa_S	13	16	14	16	14	10
Individuals	79	100	107	245	162	81
Dominance_D	0.3918	0.3416	0.3523	0.3475	0.2747	0.3239
Simpson_1-D	0.6082	0.6584	0.6477	0.6525	0.7253	0.6761
Shannon_H	1.515	1.632	1.484	1.457	1.614	1.484
Evenness_e^H/S	0.3498	0.3195	0.3149	0.2682	0.3588	0.441
Margalef	2.746	3.257	2.782	2.727	2.555	2.048

P.S. Taxa_S: number of species; Individuals and Dominance_D: number of individuals; Shannon and Evenness: species evenness; Marglef: richness.

Table 6:Summary of species diversity for the yam field

	5cm	Lower	Upper	10cm	Lower	Upper	15cm	Lower	Upper
Taxa_S	13	10	13	16	11	16	14	11	14
Individuals	79	79	79	100	100	100	107	107	107
Dominance_D	0.3918	0.2844	0.5296	0.3416	0.266	0.4402	0.3523	0.2878	0.4335
Simpson_1-D	0.6082	0.4701	0.7156	0.6584	0.5598	0.734	0.6477	0.5663	0.7122
Shannon_H	1.515	1.182	1.771	1.632	1.289	1.838	1.484	1.202	1.7
Evenness_e^H/S	0.3498	0.2867	0.4783	0.3195	0.2825	0.4314	0.3149	0.2674	0.3939
Brillouin	1.323	1.025	1.568	1.442	1.153	1.642	1.328	1.082	1.53
Menhinick	1.463	1.125	1.463	1.6	1.1	1.6	1.353	1.063	1.353
Margalef	2.746	2.06	2.746	3.257	2.171	3.257	2.782	2.14	2.782
Equitability_J	0.5905	0.4899	0.704	0.5885	0.5149	0.6808	0.5622	0.4876	0.6451
Fisher_alpha	4.428	3.032	4.428	5.378	3.154	5.378	4.304	3.074	4.304
Berger-Parker	0.6076	0.4937	0.7215	0.54	0.44	0.64	0.514	0.4206	0.6075
Chao-1	23.5	11.2	28	19.5	12	33	17	13	35

P.S. Taxa_S: number of species; Individuals and Dominance_D: number of individuals; Shannon and Evenness: species evenness; Marglef: richness; Berger-parker: most abundant species; Equitability: measure variation.

Table 7:Summary of species diversity for the fallow field

	5cm	Lower	Upper	10cm	Lower	Upper	15cm	Lower	Upper
Taxa_S	16	11	16	14	11	14	10	7	10
Individuals	245	245	245	162	162	162	81	81	81
Dominance_D	0.3475	0.306	0.3993	0.2747	0.2413	0.3194	0.3239	0.2568	0.4172
Simpson_1-D	0.6525	0.6006	0.694	0.7253	0.6805	0.7586	0.6761	0.5828	0.7432
Shannon_H	1.457	1.271	1.584	1.614	1.419	1.753	1.484	1.207	1.676
Evenness_e^H/S	0.2682	0.2532	0.3593	0.3588	0.3242	0.4367	0.441	0.3805	0.5655
Brillouin	1.368	1.203	1.493	1.498	1.324	1.63	1.331	1.09	1.511
Menhinick	1.022	0.7028	1.022	1.1	0.8642	1.1	1.111	0.7778	1.111
Margalef	2.727	1.818	2.727	2.555	1.966	2.555	2.048	1.365	2.048
Equitability_J	0.5253	0.4934	0.5937	0.6116	0.5655	0.672	0.6444	0.5683	0.7371
Fisher_alpha	3.834	2.366	3.834	3.676	2.668	3.676	3.001	1.838	3.001
Berger-Parker	0.5143	0.4531	0.5755	0.3889	0.3333	0.463	0.4938	0.3827	0.6049
Chao-1	19.75	12	30	15.2	11.33	28	12	7.5	20

P.S. Taxa_S: number of species; Individuals and Dominance_D: number of individuals; Shannon and Evenness: species evenness; Marglef: richness; Berger-parker: most abundant species; Equitability: measure variation.

DISCUSSION

This study shows that soil seed banks are natural repositories for seeds. A total of seven hundred and seventy-four (774) seedlings emerged from the two locations. The yam field and fallow field had two hundred and eighty-six (286) species and four hundred and eighty-eight (488) species respectively. In addition, twenty-four (24) plant species belonging to seventeen (17) families germinated and were identified.

Several agricultural practices have negative effects on species diversity thereby leading to loss of seeds and adult plant species. In this study, soil tillage practices had negative impacts on the species density, abundance, and composition hence leading to the destruction of seeds (species) in the yam field as compared to the fallow field. This is in per with the review of Shiferaw et al. (2018). It resulted in a difference in the species abundance and diversity between the yam field and the fallow field as higher species abundance was recorded in the fallow field compared to the yam field. The plant species present in the yam field gives a clue on the future weed infestations and possible management practices. From an agricultural perspective, studies on soil seed banks are useful tools in providing information necessary for weed management strategy. This concurs with the findings of Begum et al. (2006) and Singh et al. (2012) but on rice fields and rice-wheat farming respectively. Within the yam field, a variety of seeds were stored in the soil seed bank which varied from the fallow field and vice versa. *Solenstemon monostachyus* and *Ipomoea involucrata* were only present in the yam field but absent in the fallow field while *Axonopus compressus, Solanum* spp., *Cleome* spp., and *Ludwigia* spp. were only present in the fallow field.

The use of species diversity index to calculate species composition of different ecosystems has been widely adopted for a variety of studies (Anyanwu et al., 2019; Adesegun et al., 2020; Archy *et al*., 2020). Similarly, this approach proved useful in distinguishing the two locations at various depths (5cm, 10cm, and 15cm). The fallow field had higher species abundance, but lower species diversity compared to the yam field across all soil depths. There is a decrease in species abundance and diversity down the soil depths of the fallow field. Contrary to this, the yam field showed an increase in species abundance down the soil depths. This phenomenal decrease in the soil depths of the fallow field affirms the findings of Shiferaw et al. (2018).

Studies on the various soil depths across different communities are necessary to know the species diversity and regenerative potential of an ecosystem (Dalling et al., 1989; Fisher et al., 2009). At 5cm soil depth, the fallow field had more species diversity and abundance compared to the yam field. At 10cm, the fallow field had more species abundance, but lower species diversity compared to the yam field. At 15cm soil depth, the yam field showed more species abundance and species diversity. This further proves that soil tillage of the yam field destroyed some seeds and led to the deepening of seeds at 10cm and 15cm. *Oldenlandia corymbosa*, had the highest population density followed by sedges and *Lindernia* spp. whereas *Talinum triangulare, Ipomoea involucrata, Acalypha* spp., *Cleome* spp., *Ludwigia* spp., and *Triumfetta* spp. are the least represented species in both locations. The level of species diversity was calculated using Taxa_S and margalef diversity index which proved that the highest diversity is at 10cm depth for the yam field and 5cm depth for the fallow field. Dominance_D and Individual species diversity index showed that the highest number of species abundance was at 15cm for the yam field and 5cm for the fallow field. The number of seed species in the yam field and fallow field is not significantly different ($p>0.05$). Also, there is not much variation in species

richness, evenness, and diversity between both communities at the various depths.
Both communities are rich in species but there is a relative abundance in the distribution of individual species per community. Species dominance of a particular environment (ecosystem) could be significant in identifying that community and are referred to as keystone species for such communities.
It is worthy to note that although tillage practices at the yam field had negative impacts on the species abundance and diversity at the soil depths, the presence of some species at the seed bank can maintain the genetic variations of the above-ground population. Ecologically, this implies that the species present in the soil seed bank possess a regenerative potential for the disturbed ecosystem and provides the history for the plant species in that community. Contrary to this, in an agricultural system, studies on the soil seed bank help to forecast the possible weed infestation of the farm thereby creating awareness on the best weed management approach needed. The ability of fallow fields to house large varieties of plant species and aid in the storage of dormant seeds was reported by Major and Dessiant (1998) which is in per to this study. Fallow periods in agriculture allow the soil to regain its nutrients, maintain moisture contents (Traba and Morales, 2019), and help to build up the vegetation of a disturbed habitat.

CONCLUSION

The study showed that soil seed bank is important in revealing the possible weed infestation of a cultivated field and highlighting the species richness and diversity of an environment. It also maintains the ecosystem dynamics, vegetation, succession and conservation of genetic variability.

Both communities are rich in species but different in their species abundance and distribution across the soil depths. In addition, information on the regeneration potential, structure, and historical view of the vegetation cover of an environment could be assessed through the soil seed bank. Tillage practices affect the species density, abundance, and composition of the yam field but provide a means to manage the possible weed infestation.

CONFLICTS OF INTEREST

The authors hereby declare that there is no conflict of interest.

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