EFFECT OF PERIOD OF SUGARCANE CULTIVATION ON THE ABUNDANCE AND DISTRIBUTION OF WEED SEEDS IN THE SOIL PROFILE[1]

Efeito do Período de Cultivo da Cana-de-Açúcar na Abundância e Distribuição das Sementes de Plantas Daninhas no Perfil do Solo

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ABSTRACT - An experiment was laid down in a screen house to determine the distribution of weed seeds at different soil depths and periods of cultivation of sugarcane in Ilorin, Nigeria. Soil samples from different depth levels (0-10 cm, 11-20 cm and 21-30 cm) were collected after harvesting of canes from three different land use fields (continuous sugarcane cultivation for > 20 years, continuous sugarcane cultivation for < 10 years after long fallow period and continuous sugarcane cultivation for < 5 years after long fallow period) in November, 2012. One kilogram of the sieved composite soil samples was arranged in the screen house and watered at alternate days. Germinating weed seedlings were identified, counted and then pulled out for the period of 8 months. Land use and soil depth had a highly significant ($p \leq 0.05$) effect on the total number of weeds that emerged from the soil samples. The 0-10 cm of the soil depth had the highest weed seedlings that emerged. There was an equal weed seed distribution at the 11-20 cm and 21-30 cm depths of the soil. Sugarcane fields which have been continuously cultivated for a long period of time with highly disturbing soil tillage practices tend to have larger seed banks in deeper soil layers (11-20 cm and 21-30 cm) while recently opened fields had significantly larger seed banks at the 0-10 cm soil sampling depth.

Keywords: seedbank, soil depth, weed emergence, screen house, cultivation period.

RESUMO - Um experimento foi instalado em telado para determinar a distribuição de sementes de plantas daninhas em diferentes profundidades de solo e período de cultivo de cana de açúcar em Ilorin, Nigéria. Amostras de solo de diferentes níveis de profundidade (0-10 cm, 11-20 cm e 21-30 cm) foram coletadas após a colheita de cana em três campos diferentes (cultivo contínuo de cana-de-açúcar por> 20 anos, cultivo contínuo de cana-de-açúcar por <10 anos após longo período de pousio e cultivo contínuo de cana-de-açúcar por < 5 anos após longo período de pousio), em novembro de 2012. Um quilograma das amostras de solo compostas foi peneirado e disposto no telado e regado em dias alternados. As mudas de plantas daninhas em germinação foram identificadas, contadas e, em seguida, arrancadas durante um período de 8 meses. Uso do solo e profundidade do solo tiveram efeito altamente significativo ($p \leq 0,05$) no número total de plantas daninhas que emergiram das amostras de solo. Na profundidade do solo de 0-10 cm, houve um maior número de mudas de plantas daninhas que emergiram. Houve uma distribuição igual de sementes de plantas daninhas nas profundidades de 11-20 cm e 21-30 cm no solo. Canaviais cultivados continuamente por um longo período de tempo com um práticas de preparo do solo bastante invasivas tendem a ter um banco de sementes maior em camadas mais profundas do solo (11-20 cm e 21-30 cm), enquanto campos abertos recentemente tiveram bancos de sementes significativamente maiores na profundidade de solo amostrada de 0 -10 cm.

Palavras-chave: banco de sementes, profundidade do solo, emergência de plantas daninhas, telado, período de cultivo.

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INTRODUCTION

Despite advances in weed control technologies, weeds have retained their rank as the most damaging crop pests because weed communities continuously adapt in response to new management measures (Sosnoski & Cardina, 2006). Weed problems begin with weed seeds in the soil and they keep causing problems even though attempts are made to prevent them from going to seedling in the field (Wilson et al., 1985).

Weed flora have changed over the past century, with either increasing or decreasing species abundance depending on management (Marshall et al., 2003). Weed seed banks may reflect the status of weed population in the present and the past, and could be regarded as indicative of the impact of soil and crop management (Buhler et al., 2001). Weed seed bank buffers weed population dynamics against temporal variations in environmental conditions and management practices (Cousens & Mortimer, 1995). Because of the close association between weed seeds and soil in weed seed banks, management practices that affect soil properties have the potential to alter weed seedbank dynamics.

Crop management includes primary agricultural practices that create impact on weed seed banks (Ball, 1992). Land preparation practices are used in order to control weeds, break soil surface hardness, and increase aeration. The type of land preparation influences seed dispersion in the soil profile; management at the same depth favours uniform seed distribution in the soil profile, with lower seed populations being found deeper in the soil (Clement et al., 1996). Thus, knowledge of the total number and type of buried seeds is very useful in predicting which species are likely to emerge in a particular field and makes it possible to develop appropriate approaches and techniques for tillage and long-term weed management. Many researchers reported that the similarity between vegetation and seed bank density decreases with increasing soil core layer depth (Leck & Simpson, 1987; Skoglund, 1990; Zhang & Maun, 1994). However the study of soil seed bank and their distribution with increasing the soil core depth and arranged into dynamics models of plant communities was first time reported in the study area of Pakistan. This work aimed at determining the effect of soil depth and period of cultivation on the distribution of weed seed banks in the soil profile in a sugarcane monoculture in the southern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Three fields with the same weed management practices but different periods of sugarcane cultivation (> 20 years, < 10 years and < 5 years) were selected at the Unilorin Sugar Research Institute (9º29' N, 4º35' E) in Nigeria. A total of 9 randomly selected composite soil samples were collected from 0-10 cm, 11-20 cm and 21-30 cm depth of the soil profile in November, 2012. The soil cores of the same depth were bulked together, air dried and passed through a 2 mm sieve to remove non-reproducing vegetation material and stones. One kilogram of the sieved composite soil samples was used to fill three plastic bowls (13 cm in diameter and 6 cm in depth) which were arranged in the screen house. Each of the bowls had four perforations at the base to facilitate drainage of excess water in the soil samples. The soil samples were watered to field capacity at the beginning of the experiment and on alternate days thereafter, then monitored for weed seedling emergence at four weekly intervals for 8 months. Germinating weed seedlings were enumerated either as broadleaves, grasses or sedges, identified to species level, counted and then pulled out. Identification of weed seedlings was carried out with the aid of the weed identification manual of Akobundu & Agyakwa (1998). Soil samples were stirred after each assessment to stimulate germination by bringing to the surface other weed seeds that might have been deeply buried in them. The experiment was laid out as factorial in a randomized complete block design with three treatments replicated five times. The factors were the depth of soil samples with levels (0-10 cm, 11-20 cm and 21-30 cm) and land use [continuous sugarcane cultivation for > 20 years (F20), continuous sugarcane cultivation for < 10 after long fallow period (F10) and continuous sugarcane cultivation for < 5 after long fallow period (F5)]. An inverse ratio of the volume of soil from an auger sample to the volume of soil per m^2 was 77.50. Total weed emerged per soil samples were then extrapolated to weed density per m^2 by multiplying by 77.50. Data obtained were subjected to analysis of variance (ANOVA) using Gen Stat statistical package.

RESULTS

Twenty-three weed species which included 13 broadleaves, 6 grasses and 4 sedges were enumerated. Depth of soil sample and period of cultivation (landuse) had significant effects on the number of weed seedlings that emerged from the estimated soil samples. There was significant interaction between depth of soil sample and land use (P > 0.05) (Table 1). Highest number of weeds emerged from the 0-10 cm enumerated soil samples that from the F10 field, followed by F5 while F20 had significantly lower emerged weed seedling in the soil layer. The 11-20 cm and 21-30 cm soil depth levels had similar numbers of emerged weeds across the land use intensities and significantly lower than what was obtained in the 0-10 cm depth.

Land use had no effect on emergence of sedges from soil sample while depth of soil sample significantly affected the emergence of *Fuirena umbrellata* and *Mariscus alternifolia* (Figure 1). The 0-10 cm soil depth had a significantly higher number (233 seedlings m^{-2}) of emerged *F. umbrella* and *M. alternifolia* followed by the 21-30 cm soil depth, with a relatively higher density of 138 and 78 seedlings m^{-2}, respectively, compared to the 11-20 cm soil depth. The interaction between land use and depth of sampling significantly influenced the emergence of *Fimbristylis litoralis* and *Cyperus difformis* from the incubated soil samples (Table 2). *F. litoralis* was more abundant in F5 at the 0-10 cm soil depth, which was similar to F10 but significantly higher than F20 at the same soil depth while *C. difformis* was significantly abundant at F10 land use at the 0-10 cm soil depth, F20 and F5 had similar emerged

Table 1 - Interaction effect of soil depth and land use on the number of emerged weed seeds (seedling m^{-2})

Land use	Depth of Soil sample		
	0-10 cm	11-20 cm	21-30 cm
F20	1578 c	1038 d	981 d
F10	3492 a	963 d	503 e
F5	2470 b	730 de	639 d
Sed		213.01	

F20 = Continuous sugarcane cultivation for > 20 years, F10 = Continuous sugarcane cultivation for < 10 after long fallow period, F5 = Continuous sugarcane cultivation for < 5 after long fallow period.

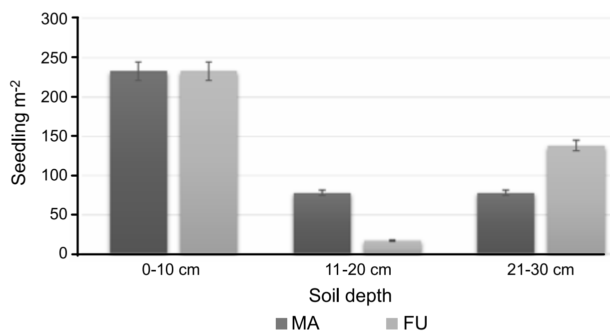

Figure 1 - Effect of soil depth on emergence of sedge weed seedlings (seedling m^{-2}), *Fuirena umbrellata* (FU) and *Mariscus alternifolia* (MA).

Table 2 - Interaction between soil depth and land use on the number of emerged sedge weed seedlings (seedling m^{-2}) from incubated soil samples

Land use	Depth of soil sample (cm)					
	Fimbristylis litoralis			*Cyperus difformis*		
	0-10	11-20	21-30	0-10	11-20	21-30
F20	1150 bc	930 cd	633 cde	1563 b	775 c	749 c
F10	1660 ab	362 de	78 e	3236 a	594 c	129 c
F5	2171 a	413 de	213 e	1583 b	233 c	258 c
Sed		351.62			436.60	

F20 = Continuous sugarcane cultivation for > 20 years, F10 = Continuous sugarcane cultivation for < 10 after long fallow period, F5 = Continuous sugarcane cultivation for < 5 after long fallow period.

population of *C. difformis*. Other soil depths across land use intensities had significantly lower and similar densities to those of *F. litoralis* and *C. difformis*.

Landuse had no effect on emergence of grass weed species from the soil sample. Depth of soil sample significantly ($p \leq 0.05$) affected the emergence of *Digitaria horizontalis* and *Panicum repens* (Figure 2). The 0-10 cm soil depth had a significantly higher number (2155 seedlings m^{-2}) of emerged *D. horizontalis* and 543 seedlings m^{-2} of *P. repens* compared to other soil depths. While the 21-30 cm soil depth had a relatively higher density of *D. horizontalis* compared to the 11-20 cm soil depth, the population of *P. repens* was significantly higher at 11-20 cm than at the 21-30 soil depths.

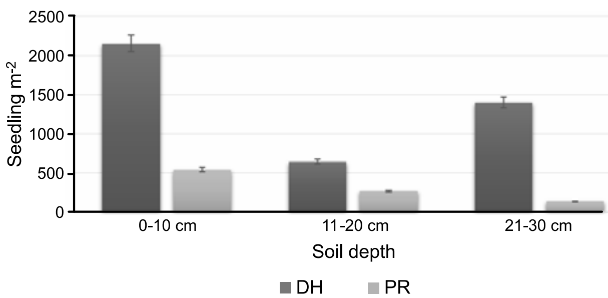

Figure 2 - Effect of soil depth on emergence of grass species (seedling m^{-2}), *Digitaria horizontalis* (DH) and *Panicum repens* (PR).

The interaction between land use and depth of sampling significantly influenced most of the grass weed seedlings emerged from the incubated soil samples (Table 3). The species *Brachiaria* and *Setaria barbata* were more abundant in F10 at the 0-10 cm soil depth while *Paspalum conjugatum* was relatively higher at the 21-30 cm soil depth but similar to the 0-10 cm soil depth except under the F10 field.

Six of the emerged broadleaves were significantly influenced by depth of soil sampling (Figure 3). The first sampling depth (0-10 cm) had a significantly higher number of enumerated broadleaved seedlings while other soil depths had relatively similar population of merged broadleaves except for *Ageratum conyzoides*, which had statistically higher density at 11-20 cm compared to the 21-30 cm soil depth while *Hyptis suaveolens* had an opposite trend to that of the former.

Emergence of *Portulaca oleracea* was significantly affected by land use intensity and soil sampling depth (Figure 4). The density of *P. oleracea* was significantly higher at the F20 field followed by F10, while F5 had the least emerged population of *P. oleracea.* The 0-10 cm

Table 3 - Interaction between soil depth and land use on the number of emerged grass weed seedlings (seedling m^{-2}) from incubated soil samples

Land use	Depth of soil sample (cm)					
	Brachiaria deflexa			*Brachiaria lata*		
	0-10	11-20	21-30	0-10	11-20	21-30
F20	1208	413	252	775	1757	149
F10	2532	336	375	3140	465	181
F5	1021	749	672	1389	310	388
Sed		400.31			489.03	

Land use	Depth of soil sample (cm)					
	Paspalum conjugatum			*Seteria barbata*		
	0-10	11-20	21-30	0-10	11-20	21-30
F20	336	129	388	368	336	284
F10	207	26	26	2578	1757	853
F5	310	78	388	2048	388	226
Sed		72.32			61.03	

F20 = Continuous sugarcane cultivation for > 20 years, F10 = Continuous sugarcane cultivation for < 10 after long fallow period, F5 = Continuous sugarcane cultivation for < 5 after long fallow period.

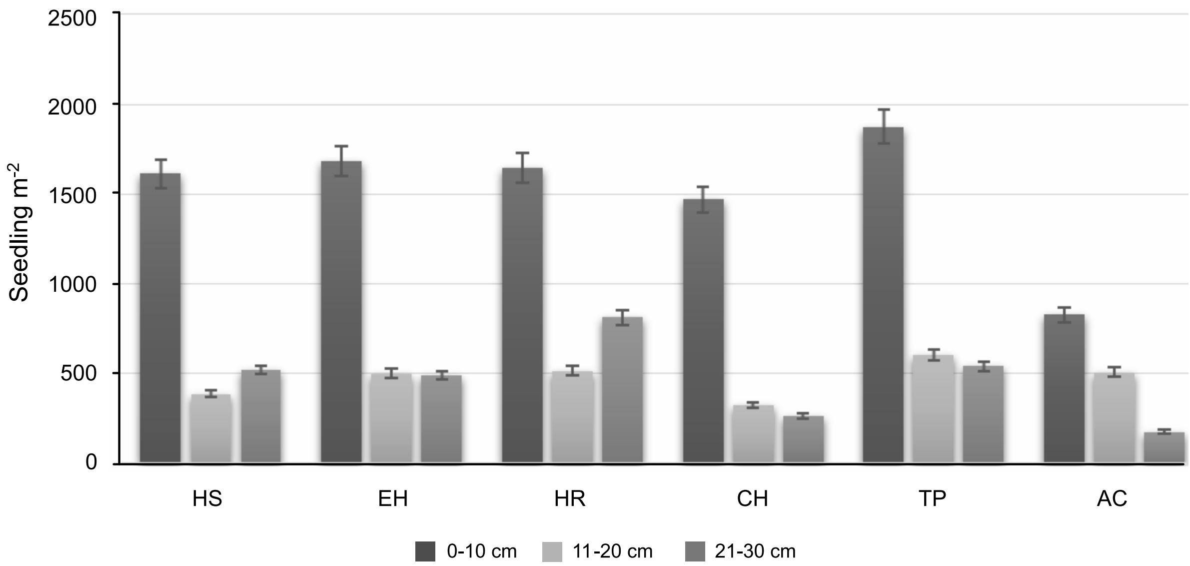

Figure 3 - Effect of soil depth on the number of some broadleaf weed seedlings (seedling m^{-2}) *Hyptis suaveolens* (HS), *Euphorbia hyssopifolia* (EH), *Euphorbia hirta* (HR), *Chromolena odorata* (CH), *Tridax procumbens* (TP) and *Ageratum conyzoides* (AC).

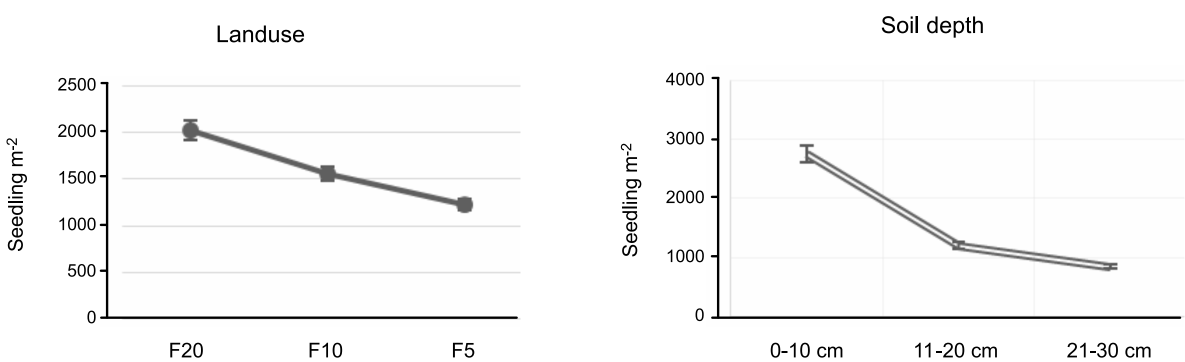

Figure 4 - Effect of landuse and soil depth on emergence of *Portulaca oleracea* (seedling m^{-2}).

Table 4 - Interaction between soil depth and land use on the number of emerged broadleaf weed seedlings (seedling m^{-2}) from incubated soil samples

Land use	Depth of soil sample (cm)								
	Spigellia anthelmia			*Tephrosia bracteolata*			*Croton lobatus*		
	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
F20	620	310	388	103	0	52	795	336	407
F10	1731	568	233	982	129	103	1987	439	304
F5	1757	388	103	775	1137	517	1725	543	310
Sed		278.11			187.73			230.01	
Land use	Depth of soil sample (cm)								
	Euphorbia heterophylla			*Oldelandia corymbosa*			*Phyllantus amarus*		
	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
F20	394	465	775	620	517	775	336	930	1214
F10	2306	620	355	2842	827	413	1932	698	233
F5	891	388	640	1473	413	439	1105	465	284
Sed		331.84			503.12			219.72	

soil depth had a significantly higher number of *P. oleracea* compared to other soil sampling depths, which had similar emerged population rates to those of the weed.

DISCUSSION

Soil seed bank density decreased with increases in soil depth. The pattern of depth distribution of seed banks is similar for all the weed species. In the three fields, all the weed species encountered were concentrated at the upper 0-10 cm of the soil. In Ohio, Cardina et al. (1991) studied three soils with different cropping history and reported that the top 0-5 cm of the soil had the highest numbers of the total weed seeds. Zhang et al. (1998) observed that weed seedling emergence and seedbank depletion are greater from seeds near the soil surface than from those more deeply buried because more seeds encounter favourable conditions for germination. Rahman et al. (2000), who studied four cultivation treatments on the distribution of weed seeds in the soil profile at the Waikato Orchard near Hamilton, found that larger seedbank and more weed seedlings were at the upper 5 cm of the soil profile and there was no difference in seed numbers between 0-5 and 5-10 cm depths while in the Zambezi valley, Mavungahidze et al. (2009) found the highest weed seedling emergence at the 0-10 cm soil depth. This phenomenon might be partly attributed to the fact that it takes some time for seeds produced by the weed species to penetrate the lower soil layer, and this agrees with the findings of Wagner et al. (2003). This large surface seed stock could also be due to the considerable seed rain and lack or inadequate weed control at the end of the cropping season because most farmers tend not to weed late weeds.

An equal distribution of weed seeds at the 11-20 cm and 21-30 cm soil depths were also observed and this supports research work done previously by Yenish et al. (1992) and Mavungahidze et al. (2009). Different types of cultivation also influence seed distribution among soil aggregates and in the soil profile. Studies of the horizontal movement of weed seeds following cultivation with different implements have shown that most seeds moved < 1 m from their source (Rew & Cussans, 1997). The vertical seed movement is of greater consequence as different types of cultivation move seeds to different depths in the soil (Dessaint et al., 1996).

The period of sugarcane cultivation affected weed distribution in the fields. The continuously cultivated field had more weed seeds in the deeper soil layers while fields once under fallow had significantly larger weed seed banks at the 0-10 cm soil depth. This might be attributed to differences in edaphic characteristics, past land preparation methods and weed control practices. The cultivation activities in the fallow fields might have disrupted weed seed dormancy induced by the long fallow period, and this could be the reason for increased weed seedling population in such fields.

The 0-10 cm soil depth contains higher amount of weed seeds than the 11-20 and 21-30 cm soil depth levels. Sugarcane fields which have been continuously cultivated for a long period of time, tend to be have larger seed banks in deeper soil layers (11-20 cm and 21-30 cm) while recently opened fields had significantly larger seed banks at the 0-10 cm soil sampling depth.

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