Plant Archives Vol. 24, No. 2, 2024 pp. 2345-2350 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.335

ASSESSING THE VERTICAL WEED SEED BANK DISTRIBUTION IN DIFFERENT SOILS AT DIFFERENT DEPTHS IN POLLACHI REGION OF INDIA

K. Kiruthika [1]*, P. Nivethadevi [1], R. Muthukrishnan [2], M.R. Nandhakumar [1] and C. Tamilarasan[3]

[1] Department of Agronomy, Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi- 642 103, (Tamil Nadu Agricultural University) Tamilnadu, India.

[2]Department of Soil Science & Agricultural Chemistry, Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi- 642 103, (Tamil Nadu Agricultural University) Tamilnadu, India.

[3]Department of Seed Science & Technology, Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi- 642 103, (Tamil Nadu Agricultural University) Tamilnadu, India.

*Corresponding author E-mail: kiruthikaagri98@gmail.com

(Date of Receiving- 08-03-2024; Date of Acceptance-26-05-2024)

ABSTRACT

An experiment was conducted at Vanavarayar Institute of Agriculture, Manakkadavu, Pollachi, to investigate the vertical distribution of weed seed bank in the Anaimalai Block of Pollachi during the summer 2023. The distribution of weed seed bank was assessed through germination studies in a pot culture experiment. Various types of soil were collected at different depths from different villages in the Anaimalai region. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) and was replicated thrice. The experiment consisted of two factors with twelve treatments: Factor 1 comprised of different types of soils *viz.*, black soil, red soil, Red Calcareous and Red Laterite soils, and Factor 2 with different soil depths *viz.*, 0-15 cm, 15-30 cm and 30-45 cm depths. The results indicated a higher number of weed seed germination in soil samples collected from the top 0-15 cm depth, whereas lower germination was observed in samples from 30-45 cm depth. Among soil types, red soils exhibited a higher number of grasses and sedges followed by red laterite soil, while fewer species were observed in black soil. Conversely, broadleaved weeds were abundant in black soil followed by red calcareous soil. This study sheds light on how soil type and depth affect the distribution of weed seed banks in Pollachi's Anaimalai region.

***Key words*:** weed seed bank, soil, depth, weed flora and weed density

Introduction

Weeds are unwanted and undesired plants that interfere with land and water resources. 45% of the annual losses in agricultural produce are caused by weeds alone and the yield loss is comparatively higher in the tropics. The key biological features of weeds that enable their survival are their high rate of seed multiplication, greater potential for vegetative propagation, the ability for rapid growth, as well as the capability to adapt to adverse ecological conditions. Crop production is impacted financially by yield and quality losses resulting from weed interference, as well as the expense of weed control (Maqsood *et al.*, 2020). If weeds are left uncontrolled, complete crop failure can occur. Seeds are the principal means by which weeds spread and invade new areas. A single weed plant commonly produces a vast number of seeds, which easily escape detection when scattered on or in the soil, making their presence known only as they germinate and become plants (Bhatt and Singh, 2007). The accumulation of these seeds in the soil, known as the weed seed bank, acts as a reservoir of viable weed seeds distributed throughout the soil profile, exerting pressure on future crops by serving as a potential source of weed populations of both annuals and perennials. (Schwartz-Lazaro, L.M. and Copes, J.T, 2019). The persistence of weeds in agricultural farms is primarily contributed by weed seed banks (Menalled, 2008). The number of seeds in the seed bank differs between soil types and the concentration of seeds varies with different depths and it was not consistent among soil types (Cardina *et al*., 1991).

When weed seeds reach the seed bank, several factors such as soil temperature, moisture, and light influence the period for which seeds endure, as well as the changing of the soil's microclimate determines the weed population and infestations. (Knezevic *et al*., 2002). In virgin soils, the density of weed seed banks can be zero, while in cultivated soils, it can range from hundreds of thousands (4100-137700 m^{-2}) (Lee and Thierfelder, 2017). The mechanical dispersal of seeds by wind, water, animals, or cultivation equipment all helps to maintain weed seed banks on a regular basis. Weed seeds, once dispersed, can have varied outcomes: some germinate and thrive, while others perish, decay, or get eaten. Many weeds have evolved dormancy mechanisms, delaying germination until conditions are favorable. This allows them to survive in harsh environments (Menalled and Schonbeck, 2011). Seeds in the seed bank could sense their surroundings and use these stimuli to either become dormant or to germinate. Apart from that, the seeds buried deeper are exposed to toxic and germination-inhibiting gases, thus reducing germination.

Since the seed bank serves a physical history of cropping systems, success or failure, understanding its occurrence could be necessary for overall weed management (Hossain and Begum, 2015). It may help producers in identifying and alleviating the effects of crop-weed competition on crop yield and quality. Effective weed management strategies include reducing the number of viable seeds in the soil seed bank thus reducing the weed population. The soil and crop management practices can directly impact the environmental conditions within the weed seed bank in soil, influencing the duration of weed seed viability and their germination tendencies. Keeping these aspects in view, this study was prioritized to experiment with weed seed banks and weed populations in various soils at different depths.

Materials and Methods

The pot study was conducted at Vanavarayar Institute of Agriculture (VIA), Department of Agronomy, Pollachi, Tamil Nadu, India during summer 2023; to assess the vertical weed seed bank distribution in Anaimalai block. Geographically, the experimental site was located in the western zone of Tamil Nadu at 10°39' N latitude and 77°0' E longitude at an altitude of 287.6 m above mean sea level. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) and it was replicated thrice. The treatments comprised of four types of soil as factor 1 *viz.*, black soil, red soil, red Calcareous and red laterite soils and three levels of soil depth as factor 2 *viz.*, 0-15 cm, 15-30 cm and 30-45 cm depth. Soil samples were collected from both the southern and northern farms of the VIA Campus, as well as from various villages in the Anaimalai block including Periyapodhu, Ramanimuthaliputhur and Anaimalai. The seedling emergence method was used to study soil seed banks. The physicochemical characteristics of the collected soil samples were analyzed and interpretations of various weed parameters, such as the weed flora of different soils, absolute weed density, relative weed density and weed dry matter production were observed in different soils at different depths during the study. Weed count was noted as per the category of grasses, sedges and broadleaved weeds and expressed in numbers. Absolute Weed density, relative weed density and dry weight of grasses, sedges and broadleaved weeds were recorded at 15, 30, 45, and 60 days after soil sample collection. The relative weed density of category-wise weeds (sedges, grasses and broad-leaved weeds) was calculated using the formula suggested by Kim and Moody (1980).

$$\text{Relative weed density} = \frac{\text{Number of weeds in each category}}{\text{Total number of weeds}} \times 100$$

The emerged weed plants were collected and separated into sedges, grasses and broadleaved weeds. They were shade-dried and then oven-dried at 65°C for 72 hours until a constant weight is reached. Weed dry matter of sedges, grasses and broadleaved weeds was expressed as g pot^{-1}.

Result and Discussion

Weed flora

During this study, fourteen weeds were predominantly observed. Of these eleven were broad-leaved weeds, three were grasses and two were sedges. Broad-leaved weeds include *Alternanthera bettzickiana, Amaranthus blitum, Cleome gynandra, Galinsoga parviflora, Hyptis suaveolens, Mimosa pudica, Mollugo disticha, Oldenlandia corymbosa, Phyllanthus niruri, Starchyterpheta jamaicensis, Trianthema portulocastrum.* Among these, *Alternanthera bettzickiana* and *Trianthema portulacastrum* were particularly abundant. In case of grasses *Cynodon dactylon and Digitaria longiflora* were noted, while, *Cyperus iria and Cyperus rotundus* were observed among the sedges. Most of the weeds were annual, followed by some perennials such as sedges

Table 1: Absolute weed density of grasses (No. of seedlings emerged per pot).

Soil types /soil depth	45 DAYS				60 DAYS				
	D1	D2	D3	Mean		D1	D2	D3	Mean
S1	1.96	0.84	0.84	**1.17**	S1	2.23	0.71	0.71	**1.18**
S2	**3.07**	2.92	2.29	**2.76**	S2	2.86	2.50	2.14	**2.50**
S3	2.05	1.13	1.01	**1.40**	S3	1.72	1.00	0.88	**1.20**
S4	2.99	1.55	1.24	**1.93**	S4	**2.91**	1.72	1.00	**1.88**
Mean	**2.52**	**1.61**	**1.35**		**Mean**	**2.43**	**1.48**	**1.18**	
	S	**D**	**S at D**			**S**	**D**	**S at D**	
S.Ed	0.18	0.14	0.39		**S.Ed**	0.24	0.18	0.50	
CD (p=0.05)	0.57*	0.50*	1.00*		**CD (p=0.05)**	0.73*	0.63*	1.27*	

S1 – Red soil, S-2 – Black soil, S3 – Red laterite soil, S4 – Red non-calcareous soil; D1 – 15 cm depth, D2 – 30 cm depth and D3 – 45 cm depth

belonging to the Cyperaceae family. A few species which were not observed generally in the field were identified in the weed seed bank. This might be due to prolonged seed dormancy or allelopathic effect of some species or unsuitable field conditions for ideal germination of weed species. These findings align with similar observations reported by Ranjit *et al*., in 2007.

Absolute weed density

Densely populated weeds in a specific region play a crucial role in ensuring survival, disrupting native species' access to essential resources, and influencing the prospects for future generations. The absolute weed density of grasses did not show significance for up to 15 days across the treatments. However, significant differences were found between the treatments from 30 days onwards.

Regarding soil type, the maximum weed density of grasses (2.50) was observed in red soil (S_2) at 60 days of observation followed by (1.88) in red laterite soil (S_4). Conversely, the minimum weed density (1.18) was recorded in black soil (S_1) (Table 1). Similarly, in the case of sedges and broadleaved weeds, the highest weed density (1.95 & 2.44) was noted in red soil. While the lowest weed density (1.18 &1.68) was observed in black soil. The maximum preference of weed growth in red soil over the other types might be due to its porous nature with good drainage capacity which can stimulate germination and facilitate the growth of weeds. As a result, indicated, the maximum density of weed species is generally more in arable soils as mentioned by Konstantinovic, B. *et al*., (2014). In the case of soil depth, the absolute weed density of grasses (2.43) was highest at 15 cm depth (D_1), followed by the 30 cm depth (1.48) (Table 1). The lowest weed density (1.18) was recorded at 45 cm depth (D_3) at 30, 45, and 60 days, indicating a significant decrease in the density of grass species and the germinability of weed seeds with increasing depth. Similar trends were observed for sedges (Table 2) and broadleaved weeds (Table 3) as reported by Shiferaw, Demissew, & Bekele, 2018.

The interaction effect was significant with varying soils at different depths. A greater number of grasses (2.91) was observed in red laterite soil at 15 cm (S_4D_1) followed by (S_2D_1) red soil at 15 cm depth (2.86). In contrast, a lower weed density of 0.71 was recorded in black soil at depths of 30 and 45 cm (D_2 & D_3) (Table 1). Regarding Sedges, abundant density (2.85) was noticed in red soil at 15 cm depth and was minimum (0.71) in black soil at depths of 30 and 45 cm (Table 2). A similar trend was observed for broadleaved weeds also. These findings are consistent with Tóth *et al.*, (2022) where the germination and emergence rate were absent or low beyond 15 cm.

Table 2: Absolute weed density of sedges (No of seedlings emerged per pot).

Soil types /soil depth	45 DAYS				60 DAYS				
	D1	D2	D3	Mean		D1	D2	D3	Mean
S1	1.94	0.84	0.84	**1.21**	S1	2.12	0.71	0.71	**1.18**
S2	**2.79**	1.87	1.42	**2.03**	S2	**2.85**	1.84	1.17	**1.95**
S3	1.75	1.37	1.76	**1.63**	S3	1.49	1.10	1.57	**1.39**
S4	1.51	1.66	1.01	**1.39**	S4	1.62	2.46	1.00	**1.69**
Mean	**2.00**	**1.44**	**1.26**		**Mean**	**2.02**	**1.53**	**1.11**	
	S	**D**	**S at D**			**S**	**D**	**S at D**	
S.Ed	0.22	0.17	0.47		**S.Ed**	0.25	0.20	0.54	
CD (p=0.05)	0.68*	0.59*	1.19*		**CD (p=0.05)**	0.78*	0.68*	1.36*	

S1 – Red soil, S-2 – Black soil, S3 – Red laterite soil, S4 – Red non-calcareous soil; D1 – 15 cm depth, D2 – 30 cm depth and D3 – 45 cm depth

Relative weed density

Relative density refers to the measurement of the numerical strength of a species relative to the total number of individuals across all species within a particular area or ecosystem. Among the various soil types, the relative weed density of grasses was found to be highest (42.04%) in red soil (S_2), followed by (28.53%) by red laterite soil (S_4), while the lowest percentage (7.83%) was observed in black soil (S_1) (Fig. 1). It might be due to soil texture which plays a significant role in the emergence of weed seeds. Smaller soil particles can limit the availability of oxygen to buried seeds and facilitate the release of toxic

Table 3: Absolute weed density of broad leaves (No of seedlings emerged per pot).

Soil types /soil depth	45 DAYS				60 DAYS				
	D1	D2	D3	Mean		D1	D2	D3	Mean
S1	2.98	1.00	0.71	**1.56**	S1	2.98	1.17	0.88	**1.68**
S2	2.96	2.18	1.79	**2.31**	S2	3.12	2.34	1.87	**2.44**
S3	2.31	1.57	0.88	**1.59**	S3	2.31	1.57	1.10	**1.66**
S4	2.18	1.83	1.84	**1.95**	S4	2.49	1.91	1.84	**2.08**
Mean	**2.84**	**1.81**	**1.43**		**Mean**	**2.73**	**1.75**	**1.42**	
	S	**D**	**S at D**			**S**	**D**	**S at D**	
S.Ed	0.24	0.18	0.50		**S.Ed**	0.23	0.18	0.49	
C D (p=0.05)	0.73*	0.64*	1.28*		**CD (p=0.05)**	0.72*	0.62*	1.25*	

S1 – Red soil, S-2 – Black soil, S3 – Red laterite soil, S4 – Red non-calcareous soil; D1 – 15 cm depth, D2 – 30 cm depth and D3 – 45 cm depth

In terms of soil depth, the maximum relative density of grasses was noted at 15 cm depth followed by 30 cm. Minimum weed density of approximately 17.8 % was observed at a depth of 45 cm at 60 days. The reason for the higher density of weed species at shallow layers may be attributed to several factors. Firstly, most of the weed species in the soil were distributed at depths of 15 and 30 cm. Additionally, tillage practices like mouldboard ploughing and disc ploughing result in a uniform distribution of weed seed bank at the plough layer (Swanton Clarence *et al.*, 2000). These tillage practices effectively bring the buried weed seed bank to the upper layers of the soil, which could be a reason for higher population density in topsoil (Feledyn-Szewczyk *et al.*, 2020). Regarding Sedges, relative weed density was higher (22.8 %) at 30 cm followed by 15 cm depth and lower weed density (21.9 %) was recorded at 45 cm depth. The relative density of Broad-leaved weeds (60.3 %) was higher at 45 cm depth (D_3) followed by 30 cm (D_2), which was 56.5% (Fig. 1). The lowest relative weed density of broad-leaved weeds (44 %) was recorded at a depth of 15 cm (D_2) at 60 days.

metabolites under hypoxial conditions leading to decreased rates of germination and emergence, particularly in black soil (Benvenuti and Mazzoncini, 2021). In case of sedges, the highest density (36.23 %) was observed in red calcareous soil (S_3), followed by (25.82 %) by red laterite soil (S_4). The lowest relative weed density (7.17 %) was observed in black soil (S_1) (Fig. 1). When it comes to broadleaved weeds, the highest relative weed density (85.0%) was perceived in black soil (S_1) followed by red calcareous soils (45.64%). This strong presence of broad-leaved weeds may be attributed to resilience as reported by Ranjit *et al.*, (2007) that broadleaved weeds were unaffected by conventional or reduced tillage or other environmental conditions and they also observed the seeds of this category remained viable for several years or decades. Notably, a minimum weed density of 37.32 % was observed in red soil (S_2) indicating the persistent nature of these weeds across different soil types.

Significant interactions were perceived between the treatments. Maximum relative weed density of grasses (51.87%) was observed in red laterite soil at 15 cm depth (S_4D_1) followed by red soil at 30 cm depth (S_2D_2). In case of sedges, the highest relative weed density (63.88 %) was recorded in red calcareous soil at a depth of 45 cm (S_3D_3) followed by (48.46 %) in red laterite soil at 30 cm depth, at 60 days (Fig. 1). Sedges were almost distributed across all depths of soil, except in black soil at

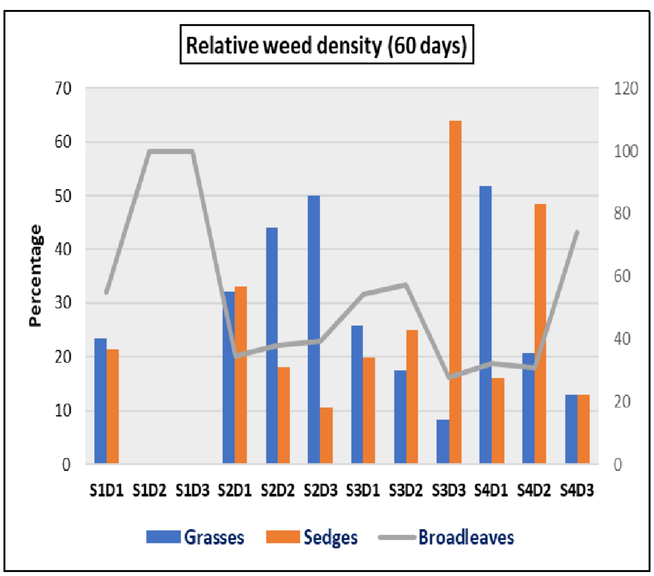

Fig. 1: Relative weed density (%) of grasses, sedges and broadleaves at 60 days.

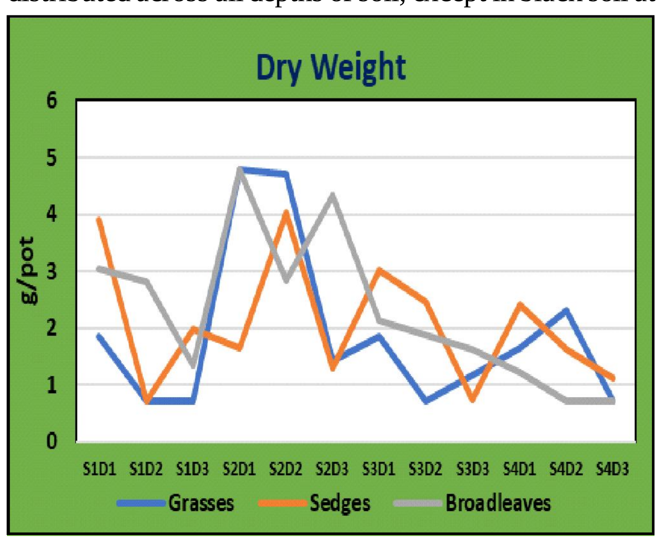

Fig. 2: Dry matter production (g pot^{-1}) of grasses, sedges and broadleaves at 60 days.

depths of 30 cm (S_1D_2) and 45 cm (S_1D_3). Weed seeds were predominantly distributed in red soil and red laterite soil might be due to which serves as a bank, especially for grasses and sedges. Negligible weed density of zero was observed at 30, 45, and 60 days in black soil at depths of 30 cm (S_1D_2) and 45 cm (S_1D_3), respectively. This could be due to weed seeds may undergo dormancy in deeper soil layers due to compaction and hypoxia conditions, which might hinder germination and also due to higher clay content in black soil which significantly inhibits the germination of weeds.

Dry Matter Production (g pot^{-1})

Considering soil types, dry matter production in grasses (3.64 g) was highest in red soil, followed by red laterite soil (1.55 g), Lowest dry matter (1.09 g) was noticed in black soil. In sedges, the highest weed dry matter production was noted in red soil (2.32 g), followed by black soil (2.20 g), and the lowest dry matter (1.72 g) (Fig. 2) was observed in red laterite soil. The same trend was noted in broadleaved weeds. The maximum dry weight of grasses, sedges, and broadleaf weeds was recorded at 15 cm depth followed by 35 cm and 45 cm depths. All groups including grasses, sedges and broadleaves showed a significant decline with increased soil penetration resistance (Tóth *et al*., 2022).

Among the interactions, the maximum weed dry weight of grasses (4.79 g) was recorded under red soil at a depth of 15 cm and the minimum (0.71 g) was observed in black soil at depths of 30 and 45 cm respectively. Weed dry matter production (4.02 g), was highest in red soil (S_2D_1) at a depth of 30 cm in case of sedges followed by (3.91 g) in black soil at 15 cm depth (S_1D_1) (Fig. 2). The lowest dry weight of sedges (0.71 g) was observed in the black soil at a depth of 30 cm. Regarding broad-leaved weeds, weeds present in red soil at 15 cm depth (S_2D_1) produced the highest dry matter of 4.78 g followed by red soil at a depth of 45 cm, which was 4.33 g. The lowest dry matter (0.71g) was recorded in red laterite soil at depths of 30 and 45 cm respectively (Fig. 2). The capacity of soil to retain water and its compactness can affect the flow of oxygen in the soil which may negatively impact the viability and germination of seeds. Seeds may exhaust their energy reserves prematurely if they sprout from too great a depth before reaching the sunlight. Furthermore, studies have shown that weed seed decay also accounts for up to 80% of seed loss. (Sias Cynthia, *et al.*, 2021).

Conclusion

Our study revealed that the majority of weed species are predominantly found in topsoil (0 -15 cm depth) across all the soil types, with red and red laterite soils showing higher weed density. The duration of viability for seeds within the soil seed bank is influenced by agricultural methods and environmental variables. It is evident that effective management practices are necessary to reduce the weed seed bank in the soil. Our findings imply that the frequency and depth of tillage play a crucial role in regulating weed seed emergence. Therefore, adopting appropriate tillage techniques, along with considering soil type variations, can significantly contribute to weed control efforts and promote sustainable agricultural practices. Moving forward, our focus will be on investigating the presence of weed seed banks in deeper layers of diverse soil types and their persistence under different management practices. We emphasize that comparable research in various habitats is necessary to test whether the presence of weed seed bank is attributed to multiple factors.

Acknowledgment

We extend our sincere gratitude to the Vanavarayar Institute of Agriculture for generously providing the essential resources needed to carry out our research.

References

Benvenuti, S. and Mazzoncini M. (2021). “Active” weed seed bank: Soil texture and seed weight as key factors of burial-depth inhibition. *Agronomy,* **11(2)**, 210.

Bhatt, M. and Singh S. (2007). Soil seed bank dynamics of weed flora in upland and lowland paddy cultivation areas of far western Nepal. *Scientific World,* **5(5)**, 54-59.

Cardina, J., Regnier E. and Harrison K. (1991). Long-term tillage effects on seed banks in three Ohio soils. *Weed Science,* **39(2)**, 186-194.

Feledyn-Szewczyk, B., Smagacz J., Kwiatkowski C.A., Harasim E. and WoŸniak A. (2020). Weed flora and soil seed bank composition as affected by tillage system in three-year crop rotation. *Agriculture*, **10(5)**, 186.

Gao, P., Zhang Z., Shen J., Mao Y., Wei S., Wei J. and Qiang S. (2020). Weed seed bank dynamics responses to long term chemical control in a rice–wheat cropping system. *Pest management science*, **76(6)**, 1993-2003.

Hossain, M. and Begum M. (2015). Soil weed seed bank: Importance and management for sustainable crop production-A Review. *Journal of the Bangladesh Agricultural University,* **13(2)**, 221-228.

Kim, S.C. and Moody K. (1980). “Reduced plant spacing for weed suppression in transplanted rice.” Proceedings of the 1980 British Crop Protection ConferenceWeeds, 17-20 Nov 1980, Brighton.

Konstantinovic, B., Blagojevic M., Samardzic N. and Pejic B. (2014). Vertical distribution of weed seed banks in extensive and intensive methods of grapevine cultivation. *Bulgarian Journal Of Agricultural Science*, **20(4)**, 860-867.

Maqsood, Q., N. Abbas R., A. Iqbal M., A. Serap K., Iqbal A. and Sabagh A.E. (2020). Overviewing of weed management practices to reduce weed seed bank and to increase maize yield. *Planta Daninha*, **38**, e020199716.

Menalled, Fabian (2008). Weed Seedbank Dynamics and Integrated Management of Agricultural Weed. Agriculture and Natural Resources (Weeds), 200-708SA

Menalled, F. and Schonbeck M. (2011). Manage the weed seed bank: minimize "Deposits" and maximize "Withdrawals". *margins,* **1(8)**.

Ranjit, J.D., Suwanketnikom R., Chinawong S., Suprakarn S., Sooksathan I. and Juntakool S. (2007). Weed seed bank response to soil depth, tillage and weed management in the mid hill ecology. *Kasetsart J.,* **41**, 17-33.

Schwartz-Lazaro, L.M. and Copes J.T. (2019). A review of the soil seedbank from a weed scientists perspective. *Agronomy,* **9(7)**, 369.

Shiferaw, W., Demissew S. and Bekele T. (2018). Ecology of soil seed banks: Implications for conservation and restoration of natural vegetation: A review. *International Journal of Biodiversity and Conservation*, **10(10)**, 380-393.

Sias, C., Wolters B.R., Reiter M.S. and Flessner M.L. (2021). Cover crops as a weed seed bank management tool: A soil down review. *Italian Journal of Agronomy,* **16(4)**.

Swanton, C.J., Shrestha A., Knezevic S.Z., Roy R.C. and Ball-Coelho B.R. (2000). Influence of tillage type on vertical weed seedbank distribution in a sandy soil. *Canadian Journal of Plant Science,* **80(2)**, 455-457.

Tóth, Á., Deák B., Tóth K., Kiss R., Lukács K., Rádai Z. and Miglécz T. (2022). Vertical distribution of soil seed bank and the ecological importance of deeply buried seeds in alkaline grasslands. *Peer. J.,* **10**, e13226.