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RELATIONSHIP BETWEEN SOIL WEED SEED BANK AND SOIL PROPERTIES IN ARABLE FARMLANDS IN UNIVERSITY OF PORT HARCOURT AND ENVIRONS IN RIVERS STATE-NIGERIA

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ABSTRACT
This paper considered relationship between soil weed seed bank seedlings and soil physicochemical parameters in arable farmlands was sampled in rainy and dry seasons at 3 different depths of 0-5, 5-10 and 10-15cm. Arable farmlands were 22 and 3 controls. Soils were collected at four points randomly with a soil auger, prepared for laboratory analyses and 100g each placed into 225 small bowls replicated 3 times, which were perforated and having tissue papers at base for soils to prevent soil and weed seeds wash off at watering. Emerged weed seedlings were counted, identified weekly for 12 weeks. Soils were allowed to dry and turned over at 4 and 8 weeks, respectively. Unidentified weeds seedlings were transferred into bigger bowls with humus soils, labeled to grow further and then identified. The parameters considered included soil weed seed bank seedlings and soil physicochemical properties. Weed seedlings data and result from physicochemical analysis were subjected to correlation analysis. Result at 5cm depth for rainy season revealed abundance of weed species significant ($p<0.05$) correlated with parameters K and Cu with a correlation coefficient (p-value) of 0.507 (0.016) and 0.611(0.003), respectively. But at 10cm depth it was only correlated with pH with a correlation coefficient (p-value of 0.501 (0.018). However, at 15cm weed species abundance was significant ($p<0.05$) correlated with parameters pH, P, Mg, K and Cu with correlation coefficient (p-value) of 0.488 (0.021), 0.459 (0.032) 0.458 (0.032), 0.445(0.038) and 0.525 (0.012), respectively. The correlation result in dry season revealed that at various depths weed species abundance was not significant ($p<0.05$). Conclusively, soil, water and cultural practices adopted by farmers might have impacted on the macro and micro nutrients availability with pH as master catalyst, while the non mobility of nutrients in dry season also affected non correlation. It can be determined from this study that the relationship between soil seed weed bank and soil properties in arable fields shows differences at the three depths.

Keywords: Depths, Nutrients, Relationship, Soil properties, Weed seed bank.

INTRODUCTION
Food and cash crop production as agricultural business is often faced with lots of barriers which hinders the development, growth and expansion of the sector and these include natural occurrences like climate change for example temperature and rainfall (Ozor, *et al*., 2010; Wreford, *et al*., 2017); human driven activities such like mineral exploration(Ometehinse and Ako, 2019; Ndinwa and Ohwona, 2014); soil degradation, soil erosion and loss of soil fertility (Jellason *et al*., 2021, Kanianska, 2016); lack of irrigation facilities (Mutambara, 2016); low quality farm inputs for example fertilizers (Jack and Tobias, 2017); pests and diseases of which weed account more than others (Boa *et al*., 2015; Oerke, 2006), population dynamics, government policies which determine the final output of crop or animal production (Jellason *et al*., 2021; Kanianska, 2016).

Some of these barriers for example economic development, agricultural project expansion, human population, etc., of course echoes the abuses caused by human beings in the exploitation, mismanagement and lack of respect for our environment (Shende *et al*., 2015). These corresponding impacts of human beings on the environment boost the proliferation of invasive alien and native or indigenous weed species in the agroecosystems (Kumar & Singh, 2020; Howard, 2019; Gentili, 2021). Weed species interferes with crop performances and reduces its quality and yield as observed by (Damalas and Koutroubas, 2022; Chauhan, 2020; Korav *et al*., 2018; Chaudhary *et al*., 2008); hence, there is need for weed control, if not eradicated completely but to the barest minimum for quality, bumper harvest, reduction in cost of production, benefit to man, his animal and the environment (Monteiro and Santos, 2022; Zimdahl, 2018).

According to Bridges (1994), a weed is a plant growing where man wishes other plants, or no plants, to grow and which has some economic, ecological or aesthetic implication for man and/ his activities. Weeds are harbored or anchored by the soil than any other media and would remain so in the future according to Nortcliff *et al*. (2006). The soil is composed of many essential nutrients that are available in varying proportions (Needelman, 2013). Plant growth, development and the ability to produce more or less quantity of fruit/seed, tuber and corm are basically determined by the availability of the required factors which according to Liliane and Charles (2020) were group into three basic categories as technological (agricultural practices, administrative decision etc.) biological (diseases, weeds etc.) and environmental (climatic condition, soil fertility etc.) factors. Consequently, soil weed seed bank is the reservoir of viable weed seed or vegetative propagules present in the soil that are capable to recompose natural vegetation when exposed to optimum conditions through nature or anthropogenic activities in the agroecosystems.

Arable soils contain basic nutrients required by any plant for normal metabolic and cell division processes as macro nutrients-Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus, Potash, Calcium, Magnesium and Sulfur and the micronutrients-Iron, Copper, Zinc, Boron, Molybdenum, Manganese and Chloride (Imran and Gurmani,2011; Kumar *et al*., 2021; (Troeh & Thompson 1993).

Soil with low fertility status would provide less support, which might result to poor growth and development, hence would impact on the seed-bearing ability ((Akinnuoye-Adelabu & Modi, 2018; Yousaf *et al*., 2017). Weed species have the ability to thrive with crops for nutrients, light, and space (Zimdahl, 2018; Lundkvist and Verwijst, 2011) and would eventually convert this modest ability to robust seed production for the next generation and this could be a contributing factor towards the quantity of weed seed added into the soil seed bank at the end of every cropping season.

The objective of the present work was to establish the relationship between soil weed seed bank and physicochemical parameters in the soil across the three sampled soil depths of 0-5cm, 5-10cm and 10-15cm in rainy and dry season in the University of Port Harcourt and environs in Obio-Akpor Local Government Area of Rivers State, Nigeria.

MATERIALS AND METHODS

Study Site

The study site is University of Port Harcourt and environs in Obio/Akpor Local Government Area Council, Rivers State-Nigeria. It is on geographical coordinates: Latitude 4°8729'N and 4°55'N Longitudes 7°0011 and is situated in the Niger Delta wetland of Southern Nigeria. The climatic weather condition of the area is characterized by a tropical monsoon climate with a mean annual temperature of 25 to 28°C and annual rainfall of over

3000 mm. The relative humidity is very high with an annual mean of 85% while the soil is usually sandy or sandy loam underlain by a layer of impervious pan.

Data Collection

The data obtained for this study were from the greenhouse study on the soil weed seed bank samples obtained from four auger samples taken randomly at 3 depths of 0-5, 5-10 and 10-15cm for rainy (June 2020) and dry (January 2021) in each of the 22 arable farmlands and 3 fallow controls, respectively.

Rainy season soil samples were processed and put into small plastic plates sized 6.0 cm high and 10.0cm diameter, perforated and tissue paper placed under to prevent escape of soil/weed seeds and for moisturation that will aid germination of the seeds. Each depth of soil samples was replicated 3 times and to give a total of 225 plastic plates, labeled, watered and arranged in the greenhouse for weekly observation. The same processes were applied to dry season soil samples.

The duration of the observation was for 12 weeks, and the soils in the plastic plates were turned at the end of 4- and 8-weeks intervals after each data collection. On weekly count, weeds were identified, counted and pulled out, and the unidentified weed seedling(s) were transferred into new, bigger and separate plastic plates with humus soil to grow further for identification / confirmation of the weed seedling. All these were carried out with the help of the Curator in the University of Port Harcourt Herbarium.

Data Analyses

SPSS version 22.0 was used for the Correlation Analysis of weed species abundance and soil physicochemical parameters (IBM, 2013).

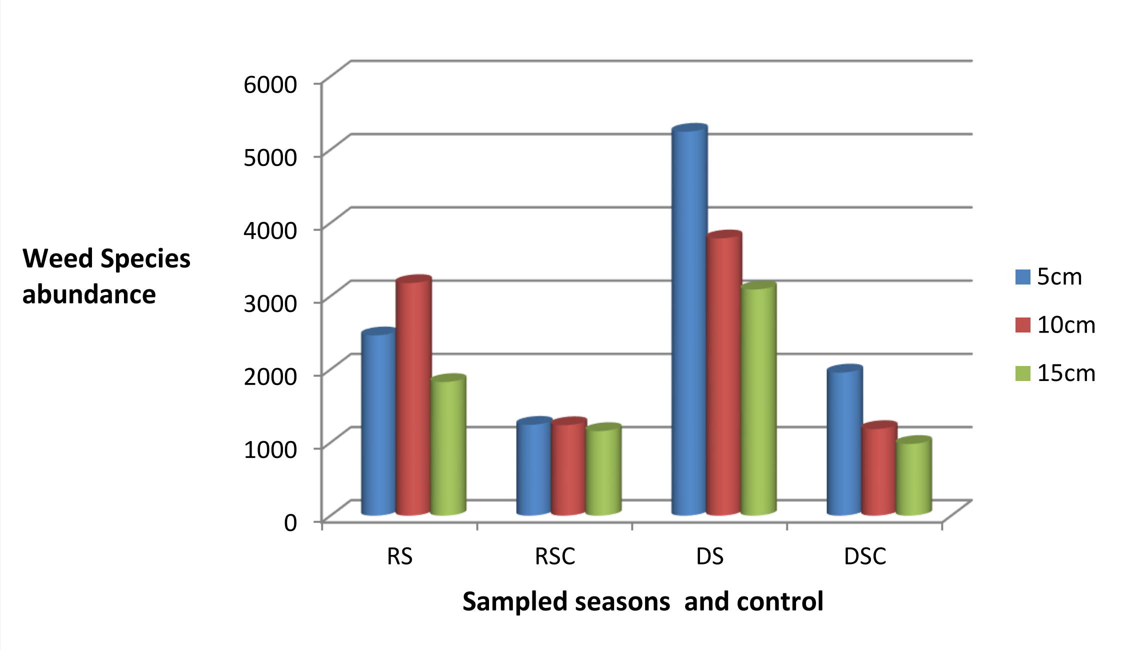
RESULTS AND DISCUSSION

Relationship Between Weed Species Abundance and Soil Physicochemical Parameters Across Depths

The correlation analysis carried out on weed species abundance across the three depths of 0-5, 5-10 and 10-15cm revealed that in rainy season at 5cm depth, abundance of weed species significantly ($p<0.05$) correlated with parameters K and Cu with a correlation coefficient (p-value) of 0.507(0.016) and 0.611(0.003), respectively. At 10cm depth it was only correlated with pH with a correlation coefficient (p-value) of 0.501 (0.018). However, at the depth of 15cm abundance of weed species significant ($p<0.05$) correlated with parameters pH, P, Mg, K and Cu with correlation coefficient (p-value) of 0.488 (0.021), 0.459 (0.032), 0.458 (0.032), 0.445 (0.038) and 0.525 (0.212), respectively, (Tables 1 and Figure 1) and (Table 3).

Table 1: Summary of weed species abundance across depths in rainy and dry seasons and control

Depth(cm)	Rainy Season (weed spp)	Rainy season Control (weed spp)	Dry season (weed spp)	Dry season Control (weed spp.)
5	2465	1243	5245	1958
10	3179	1238	3789	1185
15	1828	1152	3092	981



Legend: RS: Rainy season; RSC: Rainy season control; DS: Dry season; DSC: Dry season control
Figure 1: *Summary of weed species abundance across depths in rainy and dry seasons and control*

Soil Physicochemical Parameters

Every living organism requires good nourishment derivable from food materials consumed from the immediate environment to grow, develop and function optimally. Plant for example; needs about 16 or 17 essential nutrients grouped into macro and micro nutrients for basic physical, chemical and biological processes (Uchida, 2000; Troeh and Thompson, 1993). Each of these macro and micro nutrients play vital role in the functionality of the plant species and in effect influences the growth, development and its ability to bear fruit/seed. Macro and micro nutrients (Carbon, Hydrogen, and Oxygen are derived from the atmosphere and soil water while the remaining 13 or so nutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Zinc, Manganese, Copper, Boron, Molybdenum, and Chlorine) are supplied either from the parent rock materials, organic or inorganic manure (Uchida, 2000; Troeh and Thompson, 1993).

These basic nutrients though are found in the soil, some essential components must be available to stimulate their presence for plant to utilize them for optimal performance and to benefit the agroecosystems. These components are light, heat and water which if amply supplied in the right proportion provides enabling environment for proper utilization and benefit to plant species in the agroecosystems. Hence, internal and external structural growth and development leads to the production of seed/fruit in plant species based on the available nutrients in the soil, while lack of some of these nutrients leads to poor growth and development thus poor seed/fruit production (Major *et al*., 2005; Eizadi-Darbandi and Maghsoudi, 2021). Hence, the result from the sampled soils revealed the composition of the macro and micro nutrients in rainy and dry seasons as impacted on the seed/fruit production of the weed species across the depths in the rainy and dry seasons and controls (Tables 2 and 1).

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Table 2: Result of soil parameters for rainy and dry seasons and controls

Soil Parameters	Rainy season	Rainy control	Dry season	Dry control
H_2O (1:1)	5.88	5.19	5.85	4.98
P (mg/kg)	69.08	41.83	14.30	9.22
%OC	0.83	1.00	1.96	1.70
N (cmol/kg)	0.16	0.14	0.16	0.12
Ca (cmol/kg)	7.94	3.52	5.96	2.76
Mg (cmol/kg)	0.85	0.84	0.68	0.42
K (cmol/kg)	0.11	0.10	0.08	0.05
Na (cmol/kg)	0.23	0.26	0.20	0.19
Acidity (cmol/kg)	0.27	0.40	0.62	1.41
Al (cmol/kg)	0.00	0.00	0.11	0.45
ECEC (cmol/kg)	9.39	5.13	7.55	4.83
Mn (mg/g)	54.11	44.84	40.79	4.83
Fe (mg/g)	55.15	30.82	56.07	41.70
Cu (mg/g)	3.63	2.36	2.44	1.23
Zn (mg/g)	16.30	3.78	19.75	2.75
%Sand	73.47	71.87	86.91	87.93
%Silt	12.13	13.07	10.56	10.07
%Clay	14.13	15.07	2.64	2.00

Correlation Analysis of Weed Species Abundance and Soil Physicochemical Parameters

In the dry season, the correlation result (Table 3) revealed that at depths 0-5, 5-10 and 10-15 cm, respectively, abundance of weed species shows no significant ($p>0.05$) correlation with any parameter. This could be as a result of the impact of dry season on the soil, the weed species and with less farm activities on the arable farmlands. This assertion is in line with a study by Ogazie *et al.* (2022) on the influence of farming systems practices on physicochemical properties of soils in wet and dry season in University of Port Harcourt, Nigeria, which revealed that rainy season with higher mean values impacted more on the soil physicochemical properties than dry season with less mean values. Soils with moisture have the capacity for the mobility of the macro and micro nutrients within and around the soil to the reach of plant species roots for absorption. Water is an essential requirement in agriculture, especially in food crop production; it saturates the soil, unlocks all the vital nutrients in the soil and makes it available for plant use for growth and development leading to seed/fruit production (Mati, 2005; Uchida, 2000).

In the dry season when all farming activities were no longer carried out and also normal biological interfaces and developments that normally take place between the soil microorganisms, insects and animals that live in soil and the environment are also reduced to the lowest level. The weed seedlings abundance across all the three depths revealed no correlation with the soil physicochemical parameters. This might be as result of the dry period away from rainfall which ushered in the dry season, accompanied with elevated temperatures, intense and steady sunshine for example rainy and dry seasons mean values compared across the three depths of 0-5,5-10 and 10-15cm respectively as follows:2465,5245;3179,3789;1828,3092 (Table 1 and Figure 1) which corroborates the findings of Zhang *et al.* (2019) short drought has the potential to impact on soil properties in a work conducted in Loess Plateau region of China.

Furthermore, weed seedlings abundance during the dry season with no relationship to soil physicochemical parameters can be explained, nature of course makes exertions for plant species to have offspring replace itself through seed/fruit or other specialized reproductive organs for continuity. This phenomenon occurs where dews or precipitation settles on the leaf's surfaces of plants, absorb and which encourages the survival of plant species which might lead to fruit/or seed formation before the plant dry out to face severe drought. This corroborates Ye and Peng (2011) and Xie *et al*. (2021) in their findings that dew serves as sources of water for plant species survival in some places of low seasonal rainfall especially in arid and semi-arid environment.

In the greenhouse, abundance of weed species seedlings of 2465 in the rainy season have correlation with K and Cu being macro and micro nutrients which could be as a result of the impact of cultural farming activities carried out before the soils samples were collected. K be it a macro nutrient is required to enhance seed production in plant and of course its presence or absence in the soil could interfere with the ability of plant species seed/fruit production. The result from the soil physicochemical analysis in rainy season revealed K (0.11cmol/kg) with control K (0.10cmol/kg) (Table 2). The increase in K in the rainy season could be as a result of ash from the initial burning of the cut down plant materials and this practice have continued over the last 5 years of cultivating the arable farmlands for crop production in the study area as reported by Ogazie *et al*. (2022).

The available K from the ash in the soil might have encouraged the production of weed seedlings found at 0-5cm (2465) 5-10cm (3179) and 10-15cm (1828) across the soil depths (Table 1 and Figure 1). When a plant seedling gets all the required nutrients and conducive atmosphere needed for growth and development which in turn leads to robust root, stem and leaf development, it translates to good seed/fruit production. According to Morgan and Connolly (2013), Johnson and Mirza (2020); Uchida (2000), the availability of macro and micro nutrients in the right proportion affects the overall wellbeing of plant growth, development, biomass and seed/fruit production. Morgan and Connolly (2013) also noted that the lack of any of the macro and micro nutrients causes stunted growth, death of plant tissue, or yellowing of the leaves caused by a reduced production of chlorophyll, a pigment needed for photosynthesis.

The soil analysis in rainy season with control revealed Cu (3.63 mg/g) and Cu (2.36 mg/g) (Table 2). The importance of Cu in the soil cannot be over emphasized, it is required for enzymatic activities in plants and for chlorophyll, seed production and all other vital functional activities involved in growth and development of the plant (Vatamaniuka, 2022; Erisman *et al*., 2008). Seedling abundance at the depth of 10cm correlated with soil pH, with a correlation coefficient (p-value) of 0.501 (0.018). The soil analysis in the rainy season revealed the mean values of H_2O (1:1) pH 5.88 and control pH 5.19. As presented in Table 3, soil pH is vital and often described as master variable of soil, and it determines the functionality and the availability of all the macro and micro nutrients in soil required by plant for sprouting, growth and development which in effect determines when plant bears seed/fruit and biomass accumulation (Oshunsanya, 2019; Neina, 2019).

Weed species abundance at 15cm depth is significant ($p<0.05$) and correlated with soil parameters of pH, P, Mg, K and Cu. Soil pH, a master catalyst, determines the availability of the various macro and micro nutrients in the soil. The soil pH regulates the increase and decrease of H^+ in the soil which in effect influence the available nutrients reachable to plant for use in terms of growth, development, life cycle and other biological functions. At low pH many nutrients become less available to plant and while some heavy metal may become toxic to plants (Parikh & James, 2012; Oshunsanya, 2019; Neina, 2019). Nevertheless, the mean values of soil pH 5.88 slightly acidic might have encouraged the correlation and also with the presence of soil organic matter and clay in the soils evaluated which buffer soil to maintain a pH range optimal for plant species growth because all these takes place during the rainy season. This assertion was observed by Ogazie *et al*. (2022) in influence of farming systems practices on physicochemical properties of soils in wet and dry seasons in University of Port Harcourt, and Barrow (2017) states that phosphate desorption by soil takes place at lower pH optimum.

Phosphorus (P) an essential nutrient needed by plant in large quantity which promotes root formation, seed formation, stimulates tillering and increase water use efficiency. For P to be available in the soil and stimulate the mentioned activities, the soil pH must be at the optimal level available for plant use to support increase in size and branching ability resulting to more leaves, flowers and in effect highest seeding production capacity, baring non-limiting factors and soil pH neither acidic or alkaline (Barrow, 2017; von Tucher *et al.* (2018).

Magnesium (Mg) needed in large quantity is essential for an array of fundamental physiological and biochemical processes in plant which include chlorophyll synthesis, production, transportation and utilization of photoassimulates, enzyme activities and protein synthesis (Ishfag *et al*., 2022). The availability of Mg depends on local climate, source rock materials, degree of weathering and specific agricultural system and its management practices such as crop type, cropping intensity, rotation and fertilization practices. It is phosphorus carrier in plants and is essential for phosphate metabolism. The deficiency of Mg is not easily noticeable, but more pronounced in highly used or cultivated, leached soil and influenced by soil acidity and cation exchange capacity (CEC) affected by organic matter and percentage clay (Hauer-Jákli and Tränkner, 2019). In deficiency older leaves show interveinal chlorosis, which develop spotted areas of dead tissues and leaf edges curl (Guo *et al*., 2016).

Cu is a micro and an essential nutrient needed in very small quantity for proper growth and development of plants and involved in myriad of morphological, physiological and biochemical processes and acts as a cofactor in enzymatic activities that are essential for photosynthesis, respiration and transport chain according to Mir *et al*. (2021). Macro nutrients are needed in larger quantity while the micro nutrients are needed in small quantity for normal physical, biological and chemical processes from seed germination, growth and development to point of seed/fruit production. The completeness of all these macro and micro nutrients determines the amount of biomass and seed/fruit production from plants which include weed species that impact heavily on our crops planted in our arable farmland for food or cash crop production.

The study area has been continuously cultivated for the last five years, and farmers are known to cultivate the soil every year and planting different crops species amounting to 27 crpo species according to Ogazie *et al*. (2022) on influence of climate change on rural community food crops production pattern in high humid rainforest agroecology in southern part of Nigeria, which cut across both deep and shallow rooted crops, which included cassava, yam, vegetables, legumes fruits and spices. Litters from weeds, dead leaves from crops droppings, crops left over which decays thus contribute to the wellbeing of the soil and made available for crop species planted on the arable farmlands. This is line with the findings of Liu *et al*. (2022) that decomposition of litter has a positive effect on the soil nutrient content, and Hobbie (2015) foliar and soil nutrients across gradients, litter characteristics and root decomposition reinforce positive leaf litter feedback to soil fertility.

These nutrients P, Mg, K and Cu in the soil in which weed species correlated with and with pH as the master catalyst might have impacted on the arable farmlands from which the soils samples were collected for the weed seed bank study in the greenhouse as result of a number of cultural activities that were carried out on arable farmlands for example: bush clearing, bush burning and making of mounds which involves the mixing of all the ashes from the burnt bushes, litters, left over crops species and the upturn of soil from soil surfaces deep into the soil which could be as deep as 15-20cm. This corroborates Sainju and O'Brien (2013) Ogazie *et al.* (2022) that cultural practices to sustain the soil quality and address climate change for continuous increase in crop production and Ogazie *et al*. (2022) slash, burn, continuous tillage, mixed cropping of crops. It also shows that times of the year influence soil physicochemical properties in arable farmland in humid high rain forest (Table 1 and Figure 1), (Table 3).

Table 3: Summary of Correlation analysis of weed species abundance and soil physicochemical Parameters

Depth(cm)	Parameters	Correlation Coefficient	P-value	Decision
5	K(cmol/kg)	0.507	0.016	Significant
5	Cu(mg/g)	0.611	0.003	Significant
	pH			
10	pH	0.501	0.018	Significant
15	pH	0.488	0.021	Significant
15	P(mg/g)	0.459	0.032	Significant
15	Mg(cmol/kg)	0.458	0.032	Significant
15	K(cmol/kg)	0.445	0.038	Significant
15	Cu (mg/g)	0.525	0.012	Significant

CONCLUSION AND RECOMMENDATIONS

The results from soil weed seed bank study and soil physicochemical properties in the rainy and dry seasons are reflection of farming systems practices adopted by the crop growers and the position of the soil fertility. Arable farmlands with the right composition of macro and micro nutrients in the soil under optimal pH will definitely provide robust plant growth and development. This will impact on the root system, stem, branches, biomass, flowering heads and eventual seed/fruit production mostly in the rainy season. Consequently, water availability in the soil determines the mobility of these soil nutrients acting on the soil pH get to the weed seedlings which in turn were positively correlated with those nutrients that were responsible for the proper growth and development for plants to produce seeds found on and within the soil in arable farmlands in the study area. Further work on this relationship will enhance weed control methods in arable farmlands across agro ecological zones.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

REFERENCES

Akinnuoye-Adelabu, D. B. & Modi, A. T. (2018). Effect of soil fertility and maturity stages at harvest on maize yield under rain-fed conditions, *Archives of Agronomy and Soil Science*, **64**:5, 668-681, DOI: 10.1080/03650340.2017.1372572.

Barrow, N. J. (2017). The effects of pH on phosphate uptake from the soil. *Plant Soil* **410**, 401–410 (2017). https://doi.org/10.1007/s11104-016-3008-9

Boa, E., Chernoh, E. and Jackson, G. (2015). *Pest and disease manual*. Africa Soil Health Consortium, Nairobi, August 2015.

Bridges, D.C. (1994). Impact of Weeds on Human Endeavors. *Weed Technology*, **8**(2), 392–395. http://www.jstor.org/stable/3988124.

Chaudhary, S.U., Hussain, M., Ali, M.A. and Iqbal, J. (2008). Effect of wee competition period on yield and yield components of wheat. *J. Agric. Res*. 2008 **46**(1).

Chauhan, B.S. (2020) Grand Challenges in Weed Management. *Front. Agron*. **1**:3. doi: 10.3389/fagro.2019.00003.

Damalas, C.A. and Koutroubas, S.D. (2022). Weed Competition Effects on Growth and Yield of Spring-Sown White Lupine. *Horticulture* 2022, **8**, 430. https://doi.org/10.3390/ horticulturae8050430.

Eizadi-Darbandi, E. & Maghsoudi, A. (2021). Effect of biological and chemical fertilizers and weed control methods on lentil (*Lens culinaris* Medik.) biomass and seed yield. *Iranian Journal Pulses Research*, **12**(1), 144-155. doi: 10.22067/ijpr.v12i1.84970

Erisman, J. W., Sutton, M. A., Galloway, J., Klimont, Z. and Winiwarter, W. (2008). How a century of ammonia synthesis changed the world. *Nature Geoscience*, **1**(10), 636-639.). https://doi.org/10.1038/ngeo325

Gentili, R., Schaffner, U., Martinoli, A. and Citterio, S. (2021). Invasive alien species and biodiversity: impacts and management, *Biodiversity*, **22**:1-2, 1-3, DOI: 10. 1080/1080/14888386.2021.1929484.

Guo, W., Nazim, H., Liang, Z. and Yang, D. (2016). Magnesium deficiency in Plant: An urgent problem. *The Crop Journal*, Vol. **4,** Issue 2, 2016, Pages 83-91, ISSN 2214-5141. Https:doi.org/10.1016/j.cj.2015.11.003.

Hauer-Jákli, M. and Träkner, M. (2019). Critical leaf Magnesium thresholds and the impact of Magnesium on plant growth and photo-oxidative defense: A systematic Review and Meta-analysis from 70 years of research. *Front. Plant Sci*.**10**:766. Doi.10. 3389/ fpls. 2019 .00766.

Hobbie, S. E. (2015). Plant species effects on nutrient cycling: revisiting litter feedbacks, *Trends in Ecology & Evolution*, Volume **30**, Issue 6,2015, Pages 357-363, ISSN 0169-5347.

Howard, P. L. (2019). Human adaptation to invasive species: A conceptual framework based on a case study metasynthesis. *Ambio* **48**, 1401–1430. https://doi.org/10.1007/s13280-019-01297-5https://doi.org/10.1016/j.tree.2015.03.015.

IBM Corp. (2013). IBM SPSS Statistics for Windows, Version 22.0. IBM Corp., Armonk, NY. Retrieved from https://hadoop.apache.org.

Imran, M. & Gurmani, Z. A. (2011). Role of macro and micro nutrients in the plant growth and development. *Science Technology and development*, **30**(3), 36-40.

Ishfag, M., Wang, Y., Yan, M., Wang, Z., Wu, L., Li, C. and Li, X. (2022). Physiological essence of Magnesium in plants and its widespread deficiency in the farming system of China. *Front. Plant Sci*., 25 April 2022. *Sec. Plant Nutrition* Vol. **13**. 2022. Https: //doi. org/10.3389/fpls.2022.802274.

Jack, K. and Tobias, J. (2017). *Seeding success: Increasing agricultural technology adoption through information.* IGC Growth Brief Series 012. London: International Growth Centre.

Jellason, N. P., Robinson, E. J. Z., Chapman, A. S. A., Neina, D., Devenish, A. J. M., Po, J. Y. T. and Adolph, B. A. (2021). Systematic Review of Drivers and Constraints on Agricultural Expansion in Sub-Saharan Africa. *Land* 2021, **10**, 332. https://doi.org/ 10.3390/land1003033.

Johnson, V. J., & Mirza, A. A. (2020). Role of Macro and Micronutrients in the Growth and Development of Plants. *International Journal of Current Microbiology and Applied Sciences, 9***,** 576-587.

Kanianska, R. (2016). *Agriculture and Its Impact on Land-Use, Environment, and Ecosystem Services.* In (Ed.), Landscape Ecology - *The Influences of Land Use and Anthropogenic Impacts of Landscape Creation*. *IntechOpen*. https://doi.org/10.5772/63719.

Korav, S., Dhaka, A.K., Singh, R., Premaradhya, N. and Reddy, G.C. (2018). A study on crop weeds competition in field crops. *Journal of Pharmacognosy and Photochemistry* 2018; **7**(4): 3235-3240.

Kumar Rai, P., & Singh, J. S. (2020). Invasive alien plant species: Their impact on environment, ecosystem services and human health. Ecological indicators, **111**, 106020. https://doi.org/10.1016/j.ecolind.2019.10602.

Kumar S, Kumar S and Mohapatra T (2021) Interaction between Macro- and Micro-Nutrients in Plants. Front. Plant Sci. 12:665583. doi: 10.3389/fpls.2021.66558

Kumar, S., Kumar, S. and Mohapatra, T. (2021) Interaction between Macro- and Micro-Nutrients in Plants. Front. Plant Sci. **12**:665583. doi: 10.3389/fpls.2021.665583

Liliane, T. N. & Charles, M. S. (2020). *Factors Affecting Yield of Crops*. In (Ed.), *Agronomy – Climate Change & Food Security*. *Intech Open*. https:// doi.org/ 10.5772/ intechopen.90672.

Liu, S., Yang, R., Peng, X., Hou, C., Ma, J., Guo, J. (2022). Contributions of Plant Litter Decomposition to Soil Nutrients in Ecological Tea Gardens. *Agriculture* 2022, **12**, 957. https:// doi.org/10.3390/agriculture12070957.

Lundkvist A. and Verwijst T. (2011). *Weed biology and weed management in organic farming*. In: Raumjit Nokkoul eds. *Research in Organic Farming*. *IntechOpen*. 2011; p.157-86.

Major, J., Steiner, C., Ditommaso, A., Falcao, N.P.S. and Lehmann, J. (2005). Weed composition and cover after three years of soil fertility management in the central Brazilian Amazon: Compost, fertilizer, manure and charcoal applications. *Weed Biology and Management* **5,** 69–76. https://doi.org/10.1111/j.1445-6664.2005.00159.x

Mati, B. M. (2005). *Overview of water and soil nutrient management under smallholder rain-fed agriculture in East Africa*. Working Paper 105. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Mir, N.R., Pichtel, J. and Hayat, S. (2021). Copper: Uptake, toxicity and tolerance in plants and management of Cu-contaminated soil. *An international journal on the role of metal ions in Biology, Biochemistry and Medicine*, **34**(4), 737-759. Doi: 10.1007/s10534-021-00306-z.Epub 2021 Apr 28. PMID:33909216.

Monteiro, A. and Santos, S. (2022). Sustainable Approach to Weed Management: The Role of Precision Weed Management. *Agronomy* 2022, **12**, 118. https://doi.org/10.3390/ agronomy 12010118.

Morgan, J.B. and Connolly, E.L. (2013). Plant-Soil Interactions: Nutrient Uptake. *Nature Education Knowledge* **4**(8):2.

Mutambara, S. (2016). Agricultural input supply challenges of smallholder irrigation schemes in Zimbabwe. *Journal of Development and Agricultural Economics*, Vol. **8**(12), pp. 260-271, December, 2016 DOI: 10.5897/JDAE2016-0735 Article Number: 765B2EF62353 ISSN 2006-9774.

Ndinwa, G. C. C. and Ohwona, C. O. (2014). Environmental and health impact of solid mineral exploration and exploitation in South-northern Nigeria: A case study of Igarra in Edo State. *Review of Environment and Earth Sciences* 2014 Vol.**1**, No.1, pp. 24-36 ISSN (e): 2313-8440 ISSN (p): 2409-2150. DOI: 10.18488/journal.80/2014.1.1/80.1.24.36.

Needleman, B.A. (2013). What are soils? *Nature Education Knowledge* **4**(3):2.

Neina, D. (2019). The Role of Soil pH in Plant Nutrition and Soil Remediation. *Hindawi, Applied and Environmental Soil Science* Volume **2019**, Article ID 5794869, 9 pages https:// doi.org/10. 1155 / 2019/5794869.

Nortcliff, S., Hulpke, H., Bannick, C.G., Terytze, K., Knoop, G., Bredemier, M., Schulte-Bisping, H., *et al*., (2006). Soil, Definition, Function and Utilization of soil. In book: Ullmann's Encyclopedia of Industrial Chemistry. Chapter: Land Utilization and soil destruction (Statistics) (2006). DOI: 10.1002/14356007.b07_613.pub2.

Oerke, E. (2006). Crop losses to pests. *The Journal of Agricultural Science*, **144**(1),31-43. Doi: 10.1017/S0021859605005708

Ogazie, C. A., Ochekwu, E. B. and Agbagwa, I. O. (2022). Influence of farming systems practices on physicochemical properties of soils in wet and dry season in University of Port Harcourt, Nigeria. *GSC Advanced Research and Reviews*, 2022, **11**(02), 089–101. https:// doi.org/10.30574/gscarr.2022.11.2.0134.

Omotehinse, A. O. and Ako, B. D. (2019). The environmental implications of the exploration and exploitation of solid minerals in Nigeria with a special focus on Tin in Jos and Coal in Enugu. *Journal of Sustainable Mining*, Volume **18**, Issue 1, 2019, Pages 18-24, ISSN 2300-3960, https://doi.org/10.1016/j.jsm.2018.12.001.

Oshunsanya, A. O. (2019). *Introductory Chapter*: Relevance of Soil pH to Agriculture. Soil PH for Nutrient Availability and Crop Performance. doi: 10.5772/intechopen.82551.

Ozor, N., Madukwe, M.C., Enete A.A., Amaechina, E.C., Onokala, P., Eboh, E.C, Ujah, O. and Garforth C. J. (2010). Barriers to Climate Change Adaptation among Farming Households of Southern Nigeria. *Journal of Agricultural Extension* Vol. **14** (1), June 2010

Parikh, S. J. & James, B. R. (2012) Soil: The Foundation of Agriculture. *Nature Education Knowledge* 3(10):2.

Sainju, U. and O'Brien, D. "Cultural practices to maintain soil quality and address climate change" (2013). *Agricultural Research Magazine*. **65**. https:// digital commons. unl .edu/usdaagresmag/65.

Shende, V. A., Janbandhu, K.S. and Patil, K. G. (2015). Impacts of human beings on environment. *International Journal of Researches in Biosciences*, Agriculture and Technology. Feb. 2015 Special Issue-3, ISSN No. (Online) 2347-517X.

Troeh, F. R. & Thompson, L. M. Soils and Soil Fertility, 5th ed. Oxford University Press, 1993.

Uchida, R. (2000). Essential nutrients for plant growth: nutrient functions and deficiency symptoms. *Plant nutrient management in Hawaii's soils*, **4**, 31-55.

Vatamaniuka, O. K. (2022). Plant movement and LAC of it: How copper facilitates explosive seed dispersal. *PNAS* 2022 Vol. **119** No. 28 e2208331119. https://doi. org/10.1073 /pnas. 2208331119.

von Tucher, S., Hörndl, D. & Schmidhalter, U. (2018). Interaction of soil pH and phosphorus efficacy: Long-term effects of P fertilizer and lime applications on wheat, barley, and sugar beet. *Ambio* **47** (Suppl 1), 41–49 (2018). https://doi.org/10.1007/s13280-017-0970-2.

Wreford, A., Ignaciuk, A and Gruère, G. (2017). "Overcoming barriers to the adoption of climate-friendly practices in agriculture", *OECD Food, Agriculture and Fisheries Papers*, No. **101**, OECD Publishing, Paris. http://dx.doi.org/10.1787/97767de8-en.

Xie, J., Su, D., Lyu, S., Bu, H. and Wo, Q. (2021). Dew formation characteristics of meadow plants canopy at different heights in Hulunbuir grassland, China. *Hydrology Research* (2021) **52**(2): 568-571. https://doi.org/10.2166/nh.2021.168.

Ye, Y. and Peng, S. (2011). Review of dew action effect on plants. *Shengtai Xuebao/Acta Ecological Sinica*, **31**, 3190-3196.

Yousaf, M., Li, J., Lu, J., Ren, T., Cong, R., Fahad, S., Li, X. (2017). Effects of fertilization on crop production and nutrient-supplying capacity under rice-oilseed rape rotation system. *Sci Rep* **7**(1) 1270 (2017). https://doi.org/10.1038/s41598-017-01412-0.

Zhang, Q., Shao, M., Jia, X and Wei, X. (2019). Changes in soil physical and chemical properties after short drought stress in semi-humid forests. *Geoderma* Volume **338**, 15 March 2019, Pages 170-177. Https: //doi.org /10.1016/j. Geoderma. 2018. 11.051.

Zimdahl, R. L. (2018). *Fundamentals of Weed Science*. Fifth Edition. Elsevier Science; 2018.