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A study of soil pH variation on the development of weeds from soil seed banks

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Abstract

This study investigated the influence of soil pH variation on weed development originating from soil seed banks. Soil samples were subjected to distinct pH concentrations of 3, 5, 7, 9, and 11. The objective was to ascertain the effects of varying pH levels on weed species' development and diversity, thereby shedding light on potential implications for crop productivity. The study's significance lies in its exploration of the relationship between pH concentrations and weed diversity, with implications for crop management. If weeds, which possess adaptable traits, are compromised by pH fluctuations, the security of agricultural crops faces a similar threat. The experiment entailed exposing soil samples to diverse pH concentrations, with two sets of replicates and a control group. Initially, the samples were irrigated with a 300 ml solution, followed by subsequent applications of 200 ml every alternate day. Emergent weed counts were documented at four-day intervals over an 8-week period. The findings revealed noteworthy trends. At pH extremes of 3 and 11, reduced diversity was observed due to growth suppression, indicating the susceptibility of weed species to extreme pH conditions. Conversely, pH levels of 5 and 7 fostered greater diversity, suggesting that these moderately acidic to neutral pH ranges are conducive to a wider range of weed species' development. In conclusion, this study underscores the dynamic nature of soil pH and its potential ramifications for both weed diversity and crop health. As human activities continually impact soil pH, it becomes imperative to consider the potential consequences for agriculture. The outcomes stress the need for sustainable soil management practices to safeguard not only weed populations but also the vital agricultural crops that sustain humanity.

Keywords: Soil seed bank, biodiversity, environmental sustainability, soil acidity, soil pH, weed diversity.

Introduction

It has been established that the floristic diversity of any environment is critical in guaranteeing sustainable energy flow within the ecosystem interaction. Therefore, any factor that negativity influences the floristic composition will influence negativity the energy flow within the system. It is evident that a number of factors and human activities such as organic waste disposal, liming, acidic organic matter such as peat moss, land use change, irrigation, land fill, acid rain, agriculture and mining influences floristic diversity. One of which is a change in soil pH due to the role it plays in plants metabolism. A plants cell requires cellular energy of a neutral pH to function effectively but the activities of man alter the pH of the soil, hence the question to what extent would pH influence the diversity of plant in an environment?

Biodiversity is crucial for humanity's well-being. It encompasses a wide range of plants, animals, and microorganisms, all of which interact with each other. Plants, in particular, play a vital role in our lives, providing more than 50% of our diet and serving as the primary source of traditional medicine in rural areas of developing countries like Nigeria. The loss of biodiversity poses a threat to all life on Earth, including humans, as it disrupts the essential processes that support our existence. For instance, pollinators like birds and bees are responsible for a third of global crop production, highlighting their significance in food production

The growth and development of plants are influenced by different conditions, but there is limited information on how pH affects plant growth and seed bank. Fluctuations in environmental or external pH can pose challenges to plants, leading to continuous adjustments in metabolic activities and impacting the diversity of the soil seed bank[1] . Soil pH can be altered through rainwater leaching away basic ions and the decomposition of carbon dioxide and root respiration, resulting in the formation of weak or strong acids[2]. The pH level has a significant influence on the diversity of plant functioning as primary producers, but its extent of impact on the soil seed bank, which is crucial for long-term survival and regeneration of plant assemblages, remains to be fully understood. The soil seed bank serves as a reservoir of viable seeds or vegetative propagates that can contribute to the restoration of natural vegetation[3,4].

The soil seed bank in agro-ecosystems is closely tied to weeds. Understanding its size and species composition can help predict future infestations, develop simulation models for population growth, and guide soil and cultural management programs. This knowledge is crucial for the rational use of herbicides[4].

The germination of mature seeds can be delayed, leading to the formation of a soil seed bank. Soil seed bank studies are crucial for understanding vegetation dynamics and for ecological restoration and management. The seeds in the soil play a vital role in the regeneration of normal vegetation[5].

The seed bank serves as the repository for weed seeds, playing a crucial role in the life cycle of weeds. It is the primary source for future weed populations, encompassing both annual and perennial species that solely reproduce through seeds. Consequently, comprehending the fate of seeds within the seed bank holds significant importance in weed control efforts. Various factors impact the duration for which seeds persist in the seed bank, as they possess the ability to detect and respond to environmental cues, either entering a state of dormancy or initiating germination[6].

Soil and crop management practices play a direct role in influencing the environment of seeds in the soil weed seed bank. This, in turn, can be utilized to effectively manage seed longevity and germination behavior of weed seeds. Seed banks serve as a crucial survival mechanism for many plants and contribute to the long-term stability of ecosystems. Seeds hold significant biological and economic value, as they contain reserves of high protein, starch, and oil that aid in the initial stages of plant growth and development. These reserves make cereals and legumes important food sources for a large portion of the world's population. While soil pH is a key factor in determining grassland plant community composition, its impact on seed persistence remains poorly understood. It is uncertain whether soil pH directly or indirectly affects seed persistence through microbial pathogens. Research conducted by Sun *et al.*[7] highlights the significance of soil pH in shaping grassland plant communities.

This study aimed to investigate the impact of soil pH on seed persistence by examining the soil seed bank across a pH gradient ranging from acidic to alkaline. The effects of pH on seed persistence, whether direct or indirect through microbial pathogens, remain unclear. By analyzing the soil seed bank, this research aimed to shed light on the relationship between pH and seed persistence.

pH, a characteristic that influences the physical, chemical, and biological environment, is of particular concern. It plays a crucial role in cell biology, as the cell environment is always buffered at a pH of 7. pH also affects chemical and biological processes in water, limiting species distribution in aquatic habitats. Furthermore, pH determines enzyme activity and the occurrence of biological reactions. Any significant increase or decrease in pH can result in the denaturizing of biomolecules like proteins, rendering them non-functional and potentially leading to cell death.

A soil's pH is directly linked to its concentration of major nutrients and composition of available microelements for plant uptake. Extreme pH levels can lead to nutrient toxicity or deficiency in plants[8]. Highly acidic or alkaline soil may lack key minerals and trace elements necessary for proper plant growth. pH also affects microbial processes that decompose organic matter and deliver nutrients to the soil. Neutral pH generally provides the best conditions for microbial action, making nitrogen, sulfur, and phosphorus available[9] . pH also impacts the physical environment, as it influences chemical reactions that interact with physical factors. While most plants prefer neutral soils, some species thrive in slightly acidic or alkaline conditions. In other to guarantee the continuous provision of energy provided by the floristic composition of any environment, floral diversity must be guaranteed. A number of factors which influence the environment have been known to also influence floral diversity, one of such is pH. In intact grasslands, soil pH was positively correlated with seed density, as stated by Yang *et al*.[4]

Soil pH plays a vital role in determining soil properties, nutrient availability, microbial activity, and plant growth. It has a direct impact on the chemical and biological processes within the soil. By studying the effect of pH on the seed bank, we can gain valuable knowledge about ecosystem dynamics and the composition of plant communities

This project's findings have practical implications for agricultural practices, habitat restoration, and invasive species management. Understanding the impact of soil pH changes on the seed bank can optimize soil management, promote desired plant species establishment, and inform strategies to control invasive plants. By altering soil pH levels, we hope to understand how this affects the composition, diversity, and germination potential of seeds in the soil. The soil seed bank consists of seeds from previous vegetation or natural dispersal mechanisms. By manipulating soil pH levels, we can simulate changes in soil acidity or alkalinity caused by factors like acid rain, agricultural practices, or pollution.

Materials and Methods

Reconnaissance study: This was a preliminary study aimed at understanding the overall features and qualities of a specific region. The research was conducted on a fallow area on the main campus of the University of Benin, Benin City, Nigeria during the months of January and May, 2023. At the time of the study, this particular area had not been extensively explored or studied before. However, it was evident that the location had experienced some form of disturbance within the past five years, possibly due to agricultural activities or land clearing.

Experimental area: The region described above under "Reconnaissance study" was the initial location where the experiment was initiated before being transferred to the laboratory for further analysis and use. The selection of this area was crucial as it needed to be undisturbed, meaning it had not been altered or affected by human activities such as construction of buildings or any other disturbances at least within 5 years. This was done to ensure that the weeds present in that specific location were naturally occurring and representative of the area's typical weed population. By selecting such an undisturbed area, researchers aimed to maintain the integrity and accuracy of their study by studying the weeds in their natural habitat.

Determination of soil physicochemical characteristics: Soil samples were collected at 3 random areas within pooled random depths (0 – 15 cm) within the area where soil was obtained, just before plant identification and determination for soil seed bank. Pooled soil sample was analyzed for soil physicochemical parameters according to methods described by Hanway and Heidel[10]; Metson[11] ; Nelson and Sommers[12]; APHA[13]. Soil pH was determined using a pH meter (Model 238 PHS-3C); while a hand-held conductivity meter was used to estimate the soil conductivity (HI 70039P, Hanna Instruments). Total organic carbon (TOC) was also determined[12].

Determination of soil seed bank: This study was conducted in an experimental area, where five specific marked out plots (3m x 3m quadrant) were selected based on their coordinates (6.4004664, 5.6259830; 6.4004987, 5.6259948; 6.4004954, 5.6260263; 6.4004317, 5.6260132; and 6.4004580, 5.6260216). The purpose of the study was to determine the taxonomic distribution of plant species within these marked out areas. To achieve this, a nine meter squared quadrant was randomly situated on the ground in the fallow location. This method was employed to ensure a representative sampling of the plants present in each area. The plants found within the quadrants were then identified and counted. The collected data on plant identification and numbers served as the basis for analyzing the soil seed bank in the study. The soil seed bank refers to the collection of dormant seeds present in the soil, which can potentially germinate and contribute to the plant population in the future. Overall, this study aimed to investigate the taxonomic distribution of plants in the specified area by assessing the composition and abundance of plants within the soil seed bank.

Collection of soil: Soil was collected from the experimental area that was marked out for plant identification and soil seed bank (SSB) determination. The objective was to obtain topsoil for the study. The soil was collected from various locations within the cleared area using a hand trowel. After collection, the soil samples from different locations were combined to create a composite sample. This composite sample was then sent to the screen house for further use in the study.

Distribution into bowls: In this scientific experiment, fifteen (15) bowls that were used. These bowls had a height of 17cm and a radius of 25cm. These were filed to the bream to create a total soil surface area of 1963.5cm^2. This totaled approximately 21.6kg sun-dried soil. To conduct the experiment accurately, these bowls were in a screen house. This was necessary to screen out insects, propagules from other plants as well as to ensure watering was strictly by pH-adjusted solution.

Preparation of pH-adjusted solutions: Distilled water was obtained from the Lab., and used for the procedure. Sodium hydroxide and hydrochloric acid were used as template to form the base and acids respectively. One liter (1L) of the distilled water was measured into a conical flask and droplets of hydrochloric acid was applied with a dropper while stirring and checking for the pH with a handheld pH meter until the required pH was attained. For the acidic pH, two levels 3 and 5 were adopted while sodium hydroxide was used to attain the alkaline solution and pH 9 and 11 were adopted. Water from a tap source was taken as the control.

Application of pH treatment: Having filled up the bowls with top soils from the marked out plots, and kept in the well-ventilated screen house, the set up were wetted periodically only by the pH-adjusted solutions until after 10 weeks. Initially, 300 milliliters (ml) of each pH solution was utilized to adequately irrigate the soil on two occasions over the course of one week. Following this, 200 ml of the respective pH solution was applied every alternate day until the completion of the experiment (10 weeks). Although one of the treatments was pH of 7; this did not constitute the control. The control was watered with tap water from the laboratory (pH range 6.85 – 7.1).

Observation and parameter score: In order to conduct this scientific study, the soils were first subjected to different pH solutions. The pH is a measure of the acidity or alkalinity of a substance. The purpose of this experiment was to observe how the different pH levels affected the rate at which plants emerged from the soil. The rate of emergence, which is the time it took for the first sprouts to appear, was carefully recorded and noted over the course of eight weeks. Ten weeks was adopted for this study since reports showed that it took between 2 to 6 weeks for weeds development[14, 15]. The observations were made at regular intervals of four days. The number of plants that emerged in the soil was also counted and recorded at the end of the experiment, also with their height.

Data analysis: To analyze the data, a statistical method called analysis of variance (ANOVA) was used. This method allows the researchers to compare the means of different groups and determine if there are significant differences among them. Software programs such as SPSS® version 23 and PAST® version 2.17c were used for the statistical analyses where necessary. Three replicates measurements were taken and the mean of these measurements were determined and recorded. The experimental design adopted was a complete randomized design, where the allocation of treatments to the experimental units was done randomly. The assumption of the experiment

was that the entire plot was homogeneous, meaning that the different areas within the plot had similar characteristics. The soils used in the study were pooled together before being used.

Results and Discussion

Table-1 presents selected physicochemical characteristics of soil used in the study. Soil pH was 6.31, with a total organic carbon of 1.86%. Whereas total nitrogen was 0.57% available phosphorus was 4.85ppm.

Results showed that before soils were collected for experiment, plant species abundance in soil collection site was determined within 5 randomly sited quadrants. The most abundant plant species was *Cynodon dactylon* with mean abundance of 78, while the least was *Panicum maximum* with a species abundance of 1 (Table-2).

Results showed that the total number of taxa was a mean of 10 and there were a mean 183 individuals. Chao1 is a nonparametric approach used to estimate the number of species in a population. Chao1 is a species richness indicator (the total number of species in a sample). Higher values indicate greater diversity. In this study, Chao-1 was 0.927 (Table-3). A number of plant species were identified in the Herbarium at the Department of Plant Biology and Biotechnology and were given specimen voucher numbers. These species included *Amaranthus viridis, Axonopus compressus, Ageratum houstonianum, Asystasis gangetica, Cynodon dactylon, Ludwigia decurrens, Lindernia crustacean,* and *Oldenlandia corymbosa* (Table-4).

Species abundance and citation index as affected by pH solutions after 8 weeks have been presented on Table-4. With a total of 41 plant species, species abundance was more in the soils at pH 7. This was followed by soils exposed to pH 5 solutions; compared to the control (abundance, 18). With a citation index of 1.000, it meant that *Ageratum houstonianum* was present in all treatments, including control. Being present in 3 out of 6 treatment regimens, *Cynodon dactylon* had a citation index of 0.500. In terms of species abundance, the plant species that was generally the most abundant was *Cynodon dactylon* (abundance, 33).

The link between pH and the life of soil seed banks has received a lot of interest in the field of ecological research. Extensive research has yielded surprising results, demonstrating that a pH range of 5 (slightly acidic) to 7 (neutral) holds the key to optimal growth and variety within these seed banks. This complicated interplay or interaction between pH and seed development inherent in soil seed bank potential emphasizes soil acidity's enormous influence on ecosystem dynamics. The debate that follows delves into the subtle impact of pH on the soil seed bank, looking at the implications for biodiversity, species dispersion, and ecosystem resilience.

The first discovery was based on the varying weed species that grew. These species at the end of the terminated differed from what was gotten during the soil seed bank analysis, which led to the question of why. It was then discovered that we have variation due to factors like natural selection, environmental changes and genetic diversity. Over time, the seed bank may acuminate a range of weed seeds, some of which could have adapted to different conditions or evolved through genetic changes. This can lead to variations in the weed population compared to the original plants in the field which could be due to the effect of pH [16,17]. Plants that grow in a field may differ from what is obtained from its seed soil bank due to several factors. Cross-pollination is one by which if there are other plant species or varieties nearby that can cross-pollinate with the plants in the field, it can result in hybridization. The resulting plants may exhibit different traits than the parent plants. Environmental factor is another factor too, the field's specific environmental conditions, such as sunlight, temperature, soil composition, and moisture levels, can influence the growth and development of plants. These factors may induce variations in the phenotype and characteristics of the plants. Even within a single species, there can be genetic variation among individual plants. This variation arises from natural mutations, genetic recombination, or genetic diversity within the seed soil bank. As a result, the plants that grow in the field may show differences in traits compared to the original seeds. Once plants begin to grow in the field, they are exposed to pressures such as competition for resources, herbivory, diseases, and human intervention. These pressures can influence the survival and reproduction of plants, leading to changes in their gene frequencies and overall composition. Overall, the combination of cross-pollination, environmental factors, genetic variation, and selective pressures can contribute to differences between plants grown in a field and the original seeds from the seed soil bank[3,16,18].

The influence of pH in specie abundance have been demonstrated on Table-5. Studies showed that whereas some plant species were more abundant in soils exposed to more alkaline solutions, they were sparsely present in acid-amended soils. Cynodon was absent in the acidified soils compared to the alkaline ones. Some other plants, including *Cynodon dactylon, Lindernia crustaceae,* and *Panicum laxum* had better abundance at neutral pH.

Species diversity indices as affected by pH solutions after 8 weeks have been indicated on Table-6. There were more taxa in pH 7 and pH 5-exposed soils (taxa, 11-12), compared to the control (taxa, 5). There were more individuals in pH 7 exposed soils compared to the control. Chao-1 index was highest in pH 7, with a value of 22.5, compared to 6.0 in the control. This indicated more diversity at pH 7. However Evenness Index was less at pH 3 (or 0.600) when compared to pH 7. Observable, diversity indices were lower at the extremes of pH at 3 and 11 respectively.

Ludwigia decurrens, in the Control, had a plant height of 6.3cm, compared to *Ageratum conyzoides* (5.3cm) (Figure-1). Under pH 3, the plant maintained similar plant height (Figure-3). Whereas in the control plant, *Sida acuta* had a height of 9.4cm; however soil acidification reduced its height to 4.9cm. *Ageratum houstonianum* at a pH 3 had a plant height of 6.3 cm; it was however higher at pH 5 (11.3cm) and pH 7 (8.4 cm) (Figure-3 and 4). Under pH 3 *Axonopus compressus* presented with the tallest plant (7.8 cm), compared to *S. acuta* (4.5 cm). *Cynodon dactylon* was arguably the tallest plant in all setup.

Total plant biomass within the experimental surface area was determined. All plant species within the experimental bowl were removed, washed to remove soil and debris and dried to constant weight before weighing (Figure-7). Dry weight of sprouted plants in the control was 1.59g, compared to 4.9g in the pH 7 exposed soil, and 2.00g under alkaline conditions.

In a research carried out to check for the influence of land use and abandonment on species composition of vegetation and seed bank in grasslands and oldfields[6], the composition of vegetation and seed bank in an experiment with grassland and oldfield plots in old embanked marshlands. It was concluded that there was a 6% to 72% difference in similarity between the various treatments (controls, disturbed quadrats, and seed bank samples). For each vegetation type, the differences across the controls along with the soil seeds in the bank were quite small, ranging from 22% to 29%. As the succession stage rose (29% in grassland to 22% in oldfield), this resemblance tended to decline. When seed bank samples and disturbed quadrats were analyzed, many similarities were found. In this instance, there were 6% of oldfield and 18% of grassland that were identical. When controls and disturbed quadrats were compared, grassland showed a strong resemblance (58%) whereas oldfield showed a low similarity (8%). Oldfield and grassland seed banks had a significant degree (72%) of similarity. Amiaud et. al[6].

In summary, there were few and not much differences amongst grassland and oldfield in terms of the relationship involving seed bank and unaltered aboveground flora. Very few seedlings appeared within the undisturbed vegetation in both the grassland and the oldfield, which may suggest the significance of gaps for the development of seed banks. The seed bank made a relatively small contribution to the seed flora, and it was obvious that vegetative regrowth predominated in the aftermath of disturbances. Few species that were lost as a result of the transition of grassland to oldfield flora were still found in the seed bank as spores in the soil, but most lost species were not noted there. According to the findings, succession causes a decline in the seed bank's species variety and richness. However, the abundance of buried spores did not considerably decline from grassland to oldfield. This explains the reason why the species found in the undisturbed area where soil was taken from had spores that were originally not found growing there.

Another observation was that at extreme pH there was pure species abundance which could suggest that extreme pH suppressed development of plants as tomato remained the only plants to not exhibit productivity decline at very high solution pH in a study carried out by Islam *et al*.[19]. It suggested that in the pH range of 5.5 to 6.5, all species used for the experiment that included ginger, cassava, maize, wheat, French bean and tomato saw their maximum or nearly maximal growth. The capacity of species to expand outside of this range, however, varied greatly.

Table-1: Physicochemical characteristics of soil used in the study.

Characteristics	Mean±SD (n=3)
pH (H_2O)	6.31±0.56
Organic carbon (%)	1.86±0.52
Total organic matter (%)	3.21±0.93
Total nitrogen (%)	0.57±0.17
Avail. phosphorus (ppm)	4.85±0.98
Potassium (Cmole/kg)	0.56±0.25
Ca (Cmole/kg)	5.32±1.22
Mg (Cmole/kg)	2.75±0.72
Na (Cmole/kg)	0.43±0.08
Exchangeable acidity (Cmole/kg)	0.17±0.03
ECEC (Cmole/kg)	9.14±1.23

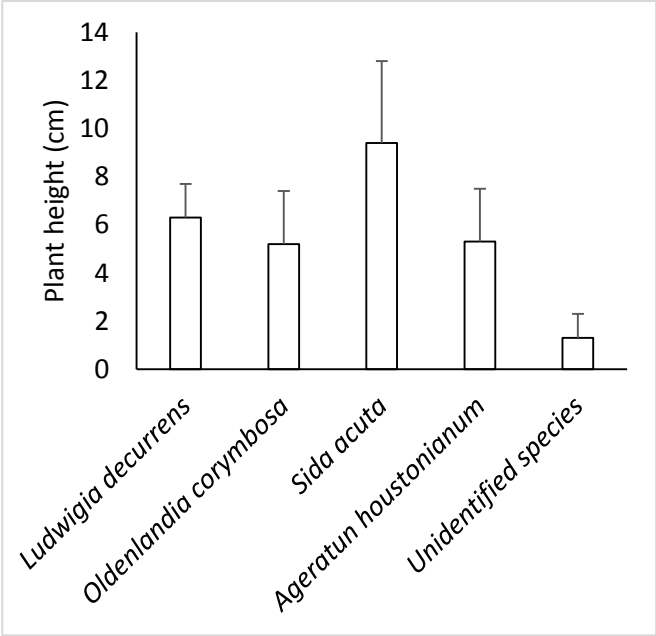

Figure-1: Plant height of weeds affected by soil wetting with water (Control).

Table-2: Plant species abundance at area where plant samples were collected.

Name of weed species	Quadrants					*Mean±SEM
	Q 1	Q 2	Q3	Q 4	Q 5	
Asystasiagangentica	9	0	8	0	2	4±2
Mimosa pudica	10	0	4	0	13	5±3
Sida acuta	6	6	8	13	30	13±5
Croton hitus	60	40	45	0	70	43±12
Paspalumconjugatum	3	0	3	0	40	9±7
Sporoboluspyramidalis	4	9	1	0	3	3±2
Cynodon dactylon	120	30	25	200	15	78±36
Chromolanaeodorata	6	4	4	0	0	3±1
Melociacorchorifolia	5	11	0	3	13	6±2
Desmodium trifolium	12	0	28	1	4	9±5
Panicum maximum	2	2	0	1	0	1±0
Panicumcapilare	3	3	3	0	4	3±1
Richardiascarba	3	0	4	7	4	4±4
Carexleporina	0	1	0	5	8	3±2

*Means have been presented to the nearest integer.

Table-3: Diversity indices of plant species found within soil collection area.

Diversity indices	Quadrant					Mean±SEM
	Q1	Q2	Q3	Q4	Q5	
Taxa_S	13	9	11	7	12	10.400±1.077
Individuals	243	106	133	230	206	183.600±27.171
Dominance_D	0.3128	0.2464	0.2052	0.7609	0.1906	0.343±0.107
Simpson_1-D	0.6872	0.7536	0.7948	0.2391	0.8094	0.657±0.107
Shannon_H	1.628	1.676	1.871	0.5773	1.967	1.544±0.249
Evenness_e^H/S	0.3919	0.5935	0.5904	0.2545	0.596	0.485±0.070
Brillouin	1.539	1.548	1.74	0.537	1.864	1.446±0.235
Menhinick	0.834	0.8742	0.9538	0.4616	0.8361	0.792±0.085
Margalef	2.185	1.715	2.045	1.103	2.065	1.823±0.196
Equitability_J	0.6348	0.7626	0.7803	0.2967	0.7918	0.653±0.093
Fisher_alpha	2.936	2.349	2.845	1.363	2.778	2.454±0.291
Berger-Parker	0.4938	0.3774	0.3383	0.8696	0.3398	0.484±0.101
Chao-1	13	9	11	8	12	10.600±0.927

Table-4: Herbarium specimen number for plants collected and submitted to the University of Benin Herbarium.

Plant name	Specimen voucher number
Amaranthus viridis	UBH-A191
Axonopuscompressus	UBH-A513
Ageratum houstonianum	UBH-A339
Asystasisgangetica	UBH-A460
Cynodon dactylon	UBH-C291
Delonixregia	UBH-D431
Desmodium trifolium	UBH-D654
Diodia sarmentosa	UBH-D518
Ludwigia decurrens	UBH-L656
Lindernia crustacea	UBH-L524
Mimosa pudica	UBH-M426
Oldenlandia corymbosa	UBH-0298
Plastostomaafricanum	UBH-P487
Panicum laxum	UBH- P237
Physalis angulata	UBH-P600
Sida acuta	UBH-S454
Solenostemon monostachyus	UBH-S392
*Solanum*sp.	UBH-S310
Spermaco ceocymoides	UBH-S655

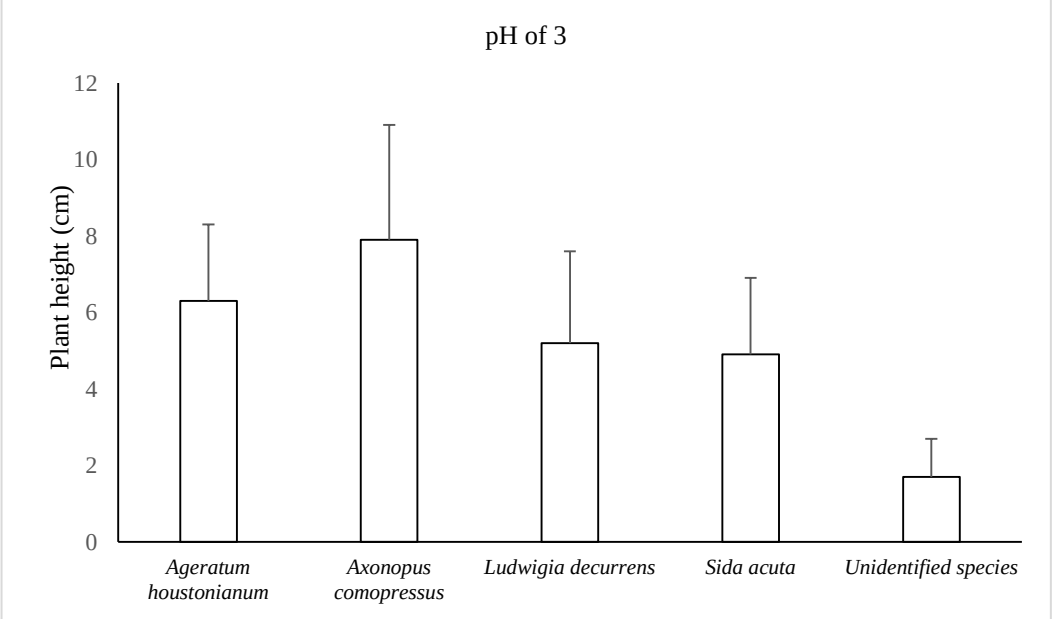

Figure-2: Plant height of weeds affected by soil wetting with water adjusted to pH 3.

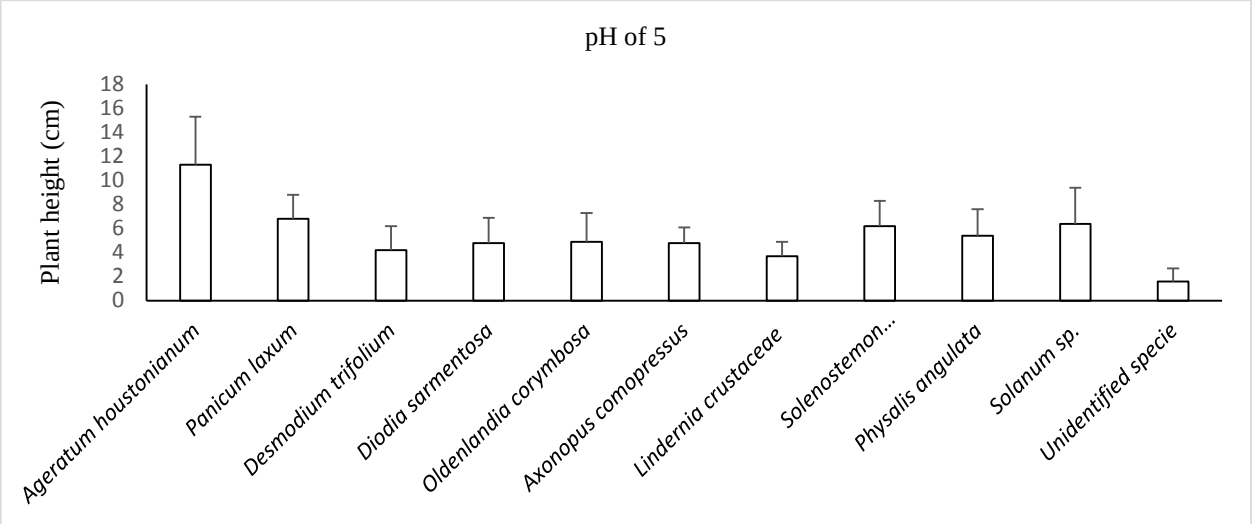

Figure 3: Plant height of weeds affected by soil wetting with water adjusted to pH 5.

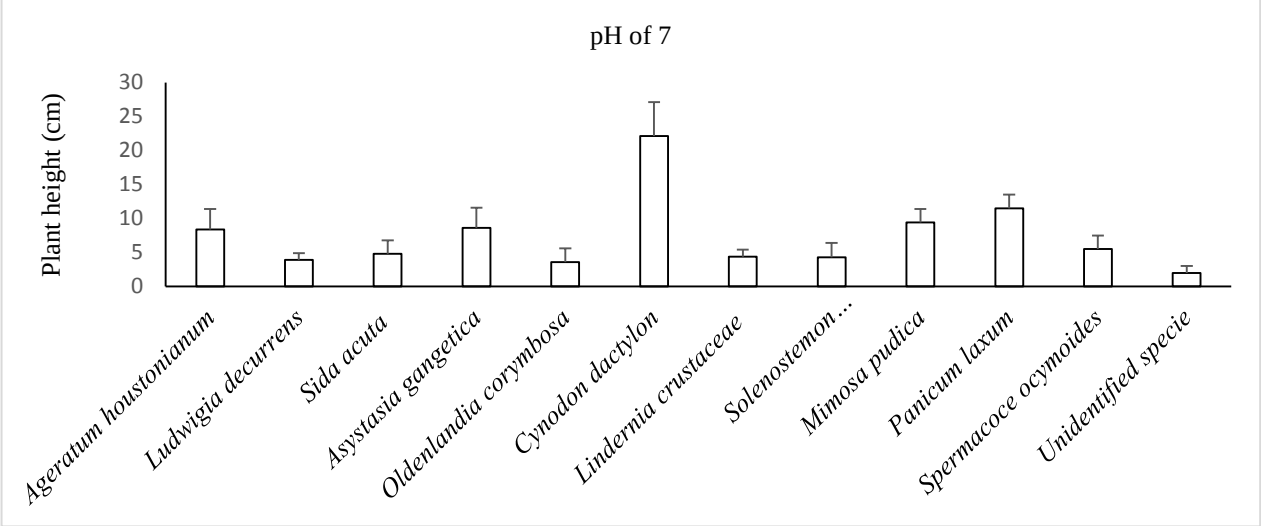

Figure-4: Plant height of weeds affected by soil wetting with water adjusted to pH 7.

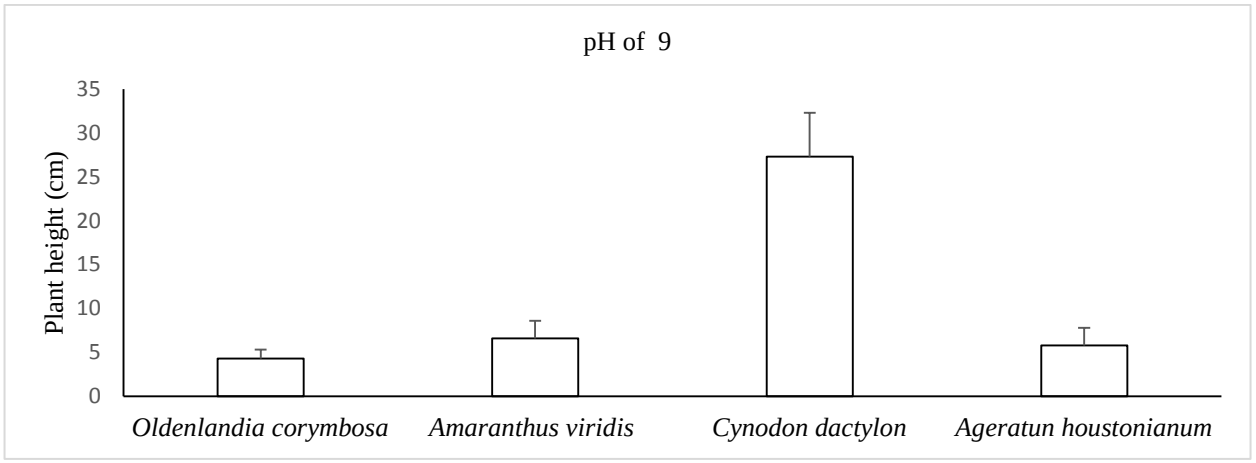

Figure-5: Plant height of weeds affected by soil wetting with water adjusted to pH 9.

Table-5: Species abundance and citation index as affected by pH solutions after 8 weeks.

Plant species	Control	pH3	pH5	pH7	pH9	pH11	Abundance	Citation index
Ageratum houstonianum	1	2	2	5	2	5	17	1.00
Amaranthus viridis	0	0	0	0	2	0	2	0.167
Asystasia gangetica	0	0	0	1	1	0	2	0.333
Axonopus comopressus	0	3	1	0	0	0	4	0.333
Cynodon dactylon	0	0	0	12	9	12	33	0.500
Desmodium trifolium	0	0	2	0	0	0	2	0.167
Diodia sarmentosa	0	0	1	0	0	0	1	0.167
Lindernia crustaceae	0	0	7	11	0	0	18	0.333
Ludwigia decurrens	8	2	0	1	0	1	12	0.667
Mimosa pudica	0	0	0	1	0	0	1	0.167
Oldenlandia corymbosa	5	0	1	1	4	1	12	0.833
Panicum laxum	0	0	8	4	0	0	12	0.333
Physalis angulata	0	0	1	0	0	0	1	0.167
Sida acuta	1	4	0	1	0	1	7	0.667
Solanum sp.	0	0	1	0	0	0	1	0.167
Solenostemon monostachyus	0	0	3	2	0	0	5	0.333
Spermaco ceocymoides	0	0	0	1	0	0	1	0.167
Unidentified species	3	1	4	1	0	0	9	0.667
Abundance	18	12	31	41	18	20	-	-

Table-6: Species diversity indices as affected by pH solutions after 8 weeks.

Parameters	Ctr (Tap water at pH6.8)	pH3	pH5	pH7	pH9	pH11
Taxa_S	5	5	11	12	5	5
Individuals	18	12	31	41	18	20
Dominance_D	0.31	0.24	0.16	0.19	0.33	0.43
Simpson_1-D	0.69	0.76	0.84	0.81	0.67	0.57
Shannon_H	1.34	1.52	2.08	1.98	1.33	1.1
Evenness_e^H/S	0.76	0.91	0.73	0.6	0.76	0.6
Brillouin	1.07	1.14	1.7	1.66	1.06	0.88
Menhinick	1.18	1.44	1.98	1.87	1.18	1.12
Margalef	1.38	1.61	2.91	2.96	1.38	1.34
Equitability_J	0.83	0.94	0.87	0.8	0.83	0.69
Fisher_alpha	2.29	3.22	6.09	5.71	2.29	2.14
Berger-Parker	0.44	0.33	0.26	0.29	0.5	0.6
Chao-1	6	5	14.3	22.5	5	8

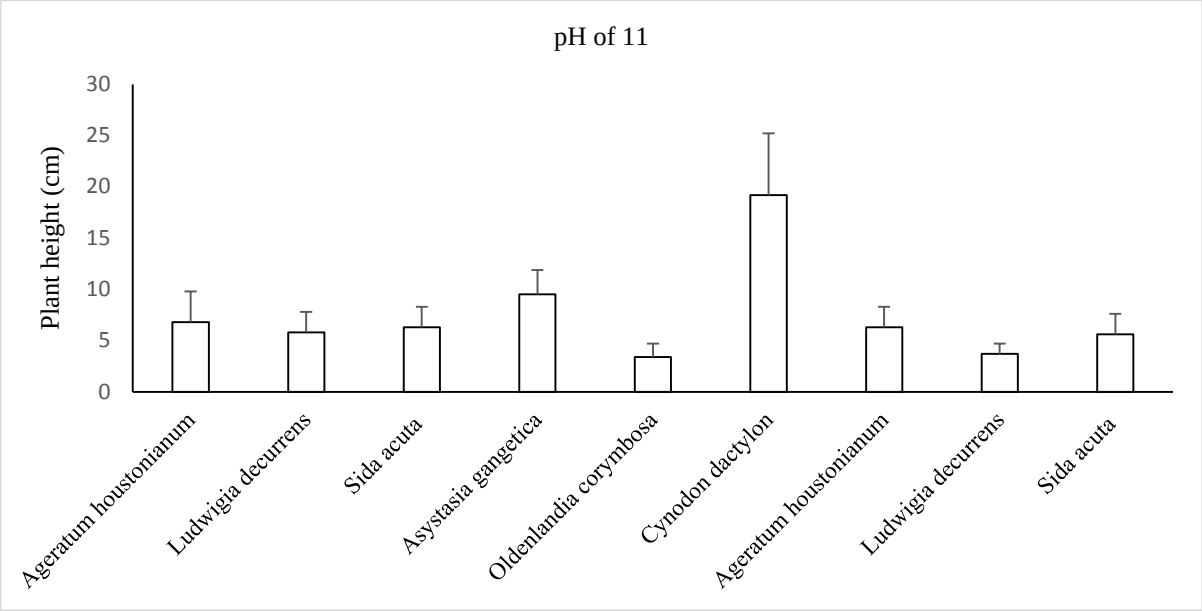

Figure-6: Plant height of weeds affected by soil wetting with water adjusted to pH 11.

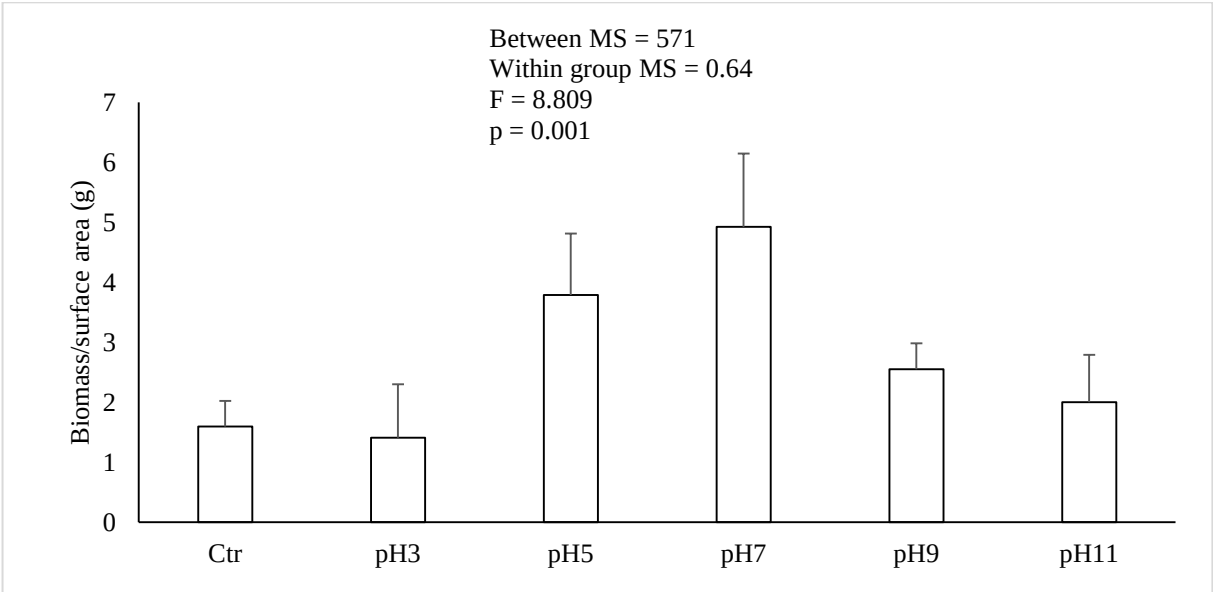

Figure-7: Impact of pH on the total biomass of sprouted plants from soil seed bank after 8 weeks.

Conclusion

Furthermore, the study highlights the importance of considering soil pH in biodiversity conservation efforts. By managing soil pH levels, it is possible to influence weed populations and promote or preserve desired plant diversity. The study on the impact of varying pH on weed growth and development raises important considerations regarding its potential effects on crop plants. If weeds capable of thriving in diverse pH conditions are present, it is likely that they will compete with crop plants for essential resources such as nutrients, water, and sunlight. This competition can lead to reduced crop yield and quality. Additionally, the presence of weeds adapted to extreme pH levels may indicate the presence of soil conditions that are suboptimal for crop growth. In such cases, the crop plants may struggle to establish and grow efficiently, further compromising their productivity. Therefore, it is crucial to carefully manage and control weed populations in agricultural settings to minimize their negative impact on crop plants and maximize overall agricultural productivity. Further research is warranted to explore specific mechanisms by which varying pH affects crop-weed interactions and to develop targeted management strategies to mitigate these effects.

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