A STUDY OF SOIL pH VARIATION ON THE DEVELOPMENT OF WEEDS FROM SOIL SEED BANKS

By

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SR/2043/RPR/22/130

UNIVERSITY OF BENIN

BENIN CITY.

AUGUST, 2023.

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A Project Report submitted to the Department of Plant Biology and Biotechnology, Faculty Of Life Sciences in Partial Fulfillment of the Requirements for the Award of Bachelor of Science (Honours) Degree (B.Sc.) in Plant Biology and Biotechnology

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CERTIFICATION

We certify that this research work was carried out by Precious OSAGIE of the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Benin City, Nigeria.

_____ _____

Prof. B. IKHAJIAGBE **Date**
Project Supervisor

_____ _____

Prof. E. D. Vwioko **Date**
Head of Department

DEDICATION

To God Almighty

To my family

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATE

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.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The natural environment provides invaluable services that are challenging to quantify monetarily. It plays a crucial role in purifying our air, ensuring clean water, cultivating food and medicine, mitigating noise pollution, and maintaining a clean environment.

The natural environment offers several benefits to mankind. Naturally, it serves as a source of food and habitat for various wildlife species such as lizards, fishes, frogs, and birds. Additionally, smaller organisms like worms, crayfish, aquatic insects, and bacteria play a crucial role in breaking down dead organisms, producing nutrients that support the survival and growth of wildlife. It then plays a vital role in improving water health. Weeds, plants, and algae act as natural filters, removing toxins, chemicals, harmful bacteria, and sediments from drains and waterways. Furthermore, small animals and microorganisms in the silt contribute to the breakdown of these pollutants, ensuring that clean water is returned to rivers, creeks, and waterways. The environment is also essential for our overall well-being. It provides us with food, medicine, and materials. In urban areas, green spaces in the environment offer a valuable opportunity to connect with nature and enjoy its benefits. Moreover, the environment holds significant cultural importance for aboriginal people and various other cultures.

The environment plays a regulatory role which is enhancing a better climate that is beneficial to all (Lamichhane *et al.,* 2018). The atmosphere moderates Earth's temperature through heat-trapping greenhouse gases, mainly carbon dioxide (CO2). But the ocean is also crucial to climate. It acts as a control knob, absorbing or releasing carbon and heat in response to changes in the atmosphere. A more stable climate is achieved when the environment effectively breaks

down and stores carbon within plants and soil, preventing it from being released as carbon pollution into the atmosphere.

Additionally, the environment plays a crucial role in flood control by absorbing excess water from heavy rainfall and gradually releasing it back into the environment. This processed helps stabilize creeks and river banks, while mangroves and salt marshes provide further protection against erosion caused by floods and storm surges along shorelines and river banks.

Man's impact on the environment is undeniable. While man needs the environment to survive, the environment does not need man. In fact, man poses a threat to the survival of the environment. The damages inflicted on the environment can always be traced back to man. This negative impact is evident in the physical, chemical, and biological aspects of the environment (Pietri and Brookes, 2008). Overpopulation, pollution, burning of fossil fuels and deforestation are just a few ways in which humans impact the environment. These changes have led to climate change, soil erosion, poor air quality, and unfavorable growing conditions for primary producers which may range from acidification to an alteration in the pH inherent in the soil.

1.2 Research Problem

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 (Zebarth *et al.,* 2015). 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 (Wolfgang and Conrad, 2018). 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.

Humans have a role to play in influencing soil pH some of which are by pollution, industrial discharge and the use of fertilizers, which is a threat to diversity.

1.3 Literature Review

1.3.1 Biodiversity

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. Invertebrates play a crucial role in maintaining soil health for agriculture by liberating essential nutrients for plant growth. Additionally, marine life serves as a vital source of animal protein for many people. Trees, bushes, and wild grasslands help prevent flooding by slowing down water flow and aiding in soil absorption, while also purifying the air we breathe. Furthermore, many of our medicines originate from plants, underscoring their importance in healthcare. Overall, every aspect of biodiversity is valuable, and its preservation is essential for our well-being.

Biological diversity ensures the survival of life by providing a range of species with different adaptations. For example, if there are two communities, Community A with 500 men that can survive temperatures up to 20ºC, and Community B with 20 men that can survive a wider temperature range, an unpredictable climate change could wipe out the entire Community A while only affecting a few individuals in Community B. It is crucial to fully embrace the variability that drives natural selection in order to maintain biological diversity.

1.3.2 Levels of Biological Diversity

According to Ashok (2016), biodiversity refers to the variety of life on earth, including plants, animals, microorganisms, and their genes. It encompasses a wide range of plants in their natural ecosystems. Biodiversity is typically described at three levels: genetic diversity, species diversity, and ecosystem diversity. These levels of biodiversity hold significant value. Genetic diversity refers to the variation in genes within a species, and it is a fundamental source of biodiversity. This diversity increases with environmental variability.

Species refers to the variability of species within a region, encompassing the variability within a population or between different species in a community. It serves as the fundamental unit for classifying organisms and is commonly used to describe biodiversity. Ecosystem, on the other hand, is a complex system comprised of biotic components interacting with each other, as well as with the non-living elements or abiotic components of the environment.

The biotic component of an ecosystem consists of microorganisms, animals and plants. Plants, as primary producers, play a crucial role in sustaining the ecosystem. They release oxygen as a byproduct of photosynthesis and serve as the foundation of every food web. Occupying the first trophic level, plants provide sustenance for herbivores and animals in the second trophic level. Often referred to as power plants, they capture solar energy and convert it into organic molecules, which fuel all other living organisms. Additionally, plants contribute to maintaining the atmosphere by producing oxygen and absorbing carbon dioxide. This oxygen is vital for cellular respiration in aerobic organisms and helps maintain the ozone layer, protecting life on Earth from harmful ultraviolet radiation. Furthermore, plants aid in reducing the greenhouse effect and global warming by removing carbon dioxide from the atmosphere. They also play a crucial role in the biogeochemical cycle by recycling matter. For instance, through transpiration, plants move significant amounts of water from the soil to the atmosphere. Some plants even host nitrogen-fixing bacteria, making nitrogen available to other plants and ultimately to humans. Moreover, plants provide us with various useful products such as firewood, timber, fiber, medicine, dye, pesticide, oils, and rubber.

A single tree can provide food and shelter for various species, including insects, worms, small mammals, birds and reptiles. 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. This

study aims to investigate the impact of pH on the soil seed bank of plants. Environmental pH plays a crucial role in numerous chemical reactions. The perception of external pH has been extensively studied in microorganisms. Soil pH is influenced by factors such as parent material, weathering, climate, and vegetation, which are linked to human activities. It affects plant growth, species distribution, crop productivity, and the viability of the seed bank. High pH negatively affects the germination rate of seeds from many species (Gahoonia and Nelson, 2015).

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 (Smiek *et al.,*2020). 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 (Riley and Barber, 1969). 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 (Anderson *et al.,*, 2017). The soil seed bank serves as a reservoir of viable seeds or vegetative propagates that can contribute to the restoration of natural vegetation.

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 (Belovsky *et al.,* 2019).

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 (Gregory, 2010).

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 (Abella *et al.,* 2013).

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.* (2012) 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.

1.3.3 Effect of soil pH

Soil is crucial for human life, but our actions can cause environmental problems, soil loss, and degradation. Soil degradation is a process that impairs soil function, whether it's caused by humans or occurs naturally. For instance, in 3000 BC, the Sumerians built cities in Southern Mesopotamia's deserts and farmed the desert soils using irrigation. This allowed them to produce large food surpluses and thrive as a civilization. However, around 2200 BC, their civilization collapsed, and soil may have played a role in this downfall.

In intact grasslands, soil pH was positively correlated with seed density, as stated by Yang *et al.*(2021). However, in degraded grasslands, this correlation was negative. Basto *et al.,* (2015) found that the reduction in grasses and sedges with increasing soil pH was responsible for the negative effect on seed density in degraded grasslands. In this study, a significant decrease in soil seed bank size as soil pH increased was observed. This contradicts the findings of Pakeman *et al.,* (2012), who reported greater seed survival in soils with higher soil pH. The results align with Basto *et al.,* (2015), who found decreasing seed persistence with increasing soil pH. Soil pH appears to have a significant influence on the size of soil seed banks, potentially affecting nutrient availability and other environmental factors.

The natural pH of soil Is influenced by the rock it originated from and the weathering processes it underwent, including climate, vegetation, topography, and time. These processes typically lead to a decrease in pH, making the soil more acidic. However, human activities, such as the use of fertilizers, can alter soil pH and impact nutrient availability for plants. Fertilizers like crushed sulfur and certain ammonium-based nitrogen fertilizers can lower pH and address issues caused by high pH in soils. Soil pH directly affects the concentration of major nutrients

and the availability of microelements for plant uptake. When soil pH becomes extremely high or low, it can result in nutrient deficiencies or toxicities, which in turn affect plant diversity.

The influence of pH on soil microbial communities has been extensively studied and confirmed by multiple researchers (Fierer and Jackson, 2006; Lauber *et al.,*2009; Chu *et al.,* 2010; Griffiths *et al.,* 2011; Fierer, 2017; Delgado-Baquerizo *et al.,* 2018).

In recent studies, researchers discovered strong connections between soil pH levels and the diversity and composition of soil bacteria in wheat fields located in the North China Plain. These findings were reported by Shi *et al*. (2018) and Shi *et al*. 2020.

In natural terrestrial ecosystems, microorganisms coexist with numerous species, creating intricate interaction networks (Faust et al., 2015; Ma et al.,2020).

Soil nutrient cycling is influenced by surrounding environmental factors, as noted by Faust *et al*. (2015) and Ma *et al*. (2016).

A recent study by Ratzke and Gore (2018) discovered that changes in pH can affect the competitive outcomes between two bacterial species through dynamic feedback loops. However, the influence of soil pH on microbial co-occurrence networks at large spatial scales remains poorly understood.

1.4 Justification of the Study

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 alters the pH of the soil, hence the question to what extent would pH influence the diversity of plant in an environment?

This project aims to investigate the relationship between soil pH levels and the composition and viability of the seed bank present in the soil. The project is justified for several reasons:

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.

The seed bank is the accumulation of dormant seeds in the soil, representing the potential for future plant growth. It serves as a reservoir of plant biodiversity and plays a critical role in ecological restoration, natural succession, and plant community resilience. Studying how pH affects the seed bank helps us understand the factors influencing plant community dynamics and ecosystem functioning.

Climate change and human activities such as agriculture and land-use change can alter soil pH levels. This can have significant impacts on plant species composition and ecosystem structure and function. Investigating the relationship between pH and the seed bank can provide valuable information for land managers, conservationists, and policymakers to make informed decisions about soil management and ecological restoration practices. While the influence of pH on plant growth and soil properties is well-established, there is still a knowledge gap regarding the

specific effects of pH on the seed bank. This project aims to fill this gap by studying the germination and persistence of different seed types under varying pH conditions. The findings from this research will contribute to the existing body of scientific knowledge and enhance our understanding of plant-soil interactions.

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. The study is justified due to the importance of maintaining soil pH, the significance of the seed bank, the relevance to climate change and land management, the existing knowledge gap, and the practical applications that can be derived from the research findings.

The Earth's most unique feature is the existence of life, which is also its most extraordinary feature due to its incredible diversity. There are approximately 9 million types of plants, animals, protists, and fungi that inhabit the Earth, along with the 7 billion people. Two decades ago, at the first Earth Summit, it was acknowledged by the majority of nations that human actions were causing significant harm to the Earth's ecosystems, resulting in the loss of genes, species, and biological traits at an alarming rate. This loss of biological diversity raises concerns about how it will impact the functioning of ecosystems and their ability to provide society with the necessary goods and services for prosperity (Cardinale *et al.,* 2016).

This research will examine the relationship between soil pH levels and the soil seed bank. Specifically, we will focus on how alterations in pH impact seed viability, germination rates, and overall seedling growth. By investigating the composition, diversity, and germination

potential of the soil seed bank, we aim to gain a comprehensive understanding of the effects of pH changes on these important factors.

The research problem focuses on examining the relationship between pH changes and the soil seed bank. It aims to understand how variations in soil pH levels can impact seed viability, germination potential, and the overall composition and diversity of the seed bank. Specifically, it aims to investigate the effects of pH changes on seed viability, germination rates, and seedling growth. By addressing this problem, the study aims to contribute to the understanding of ecological implications and potential management strategies related to soil pH and the soil seed bank.

The experiment aims to examine the impact of pH changes on the soil seed bank. 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.

This experiment seeks to understand how these pH changes affect seed viability, germination, and the composition of the soil seed bank.

The experiment involves collecting undisturbed soil samples. These samples will undergo different pH treatments to simulate acidic or alkaline conditions. Seeds and spores from the natural soil seed bank will be allowed to grow under varying pH levels. The germination rates and overall seedling growth will be monitored and compared across the different pH treatments.

The experiment's results offer insights into the ecological implications of pH changes on seed banks and plant community dynamics. This knowledge helps researchers and land managers understand the effects of soil pH alterations on plant establishment, biodiversity, and ecosystem resilience. Additionally, these findings have practical applications in agriculture, forestry, habitat restoration, and land management practices, guiding decisions on soil amendment strategies and species selection for ecosystem rehabilitation.

1.5 Aims and Objectives

1.5.1 Aim of the study

The aim of the study was to investigate the impact of varying pH levels on the development of soil seed bank.

1.5.2 Objectives of the study

The specific objectives were to;

1. Determine how changes in soil pH affect the number and types of seeds that are present in the soil;
2. Identify which types of plant species are most affected by changes in soil pH;
3. Assess the potential for changes in soil pH to impact plant community composition: The study might investigate whether changes in soil pH have the potential to alter the overall composition and diversity of plant communities in the area; and
4. Estimate the extent of the potential impact of changes in soil pH on plant diversity.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Reconnaissance Study

This is a preliminary study aimed at understanding the overall features and qualities of a specific region. The research was conducted near the Keystone Hostel, which is located at the University of Benin in Benin City. 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.

2.1.1 Experimental Area

The region referred to as "2.1" is 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. 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.

2.1.2 Determination of Soil Physiochemical 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 determination of plant identification and determination for soil seed bank assessment. Top soil was collected. Soils was analyzed for soil

physicochemical parameters according to methods described by Hanway and Heidel (1952); Metson (1961); Nelson and Sommers (1982); APHA (1985).

To determine pH value of soil used in the experiment, 20ml distilled water was added to 20g of the sieved soil sample and left to stand for 30 minutes. The content was intermittently stirred with a stirrer. A pH meter (Model 238 PHS-3C) was used to detect the pH, and a hand-held conductivity meter was used to estimate the soil conductivity (HI 70039P, Hanna Instruments). For determination of total organic carbon (TOC), 2.5 ml of 1N $K_2Cr_2O_7$ solution was added to 0.5g of soil sample in a conical flask and stirred carefully to distribute the sample in the solution. Thereafter, 5 ml conc. H_2SO_4 was added in quick succession, into the flask and stirred carefully until both the reagents and sample were thoroughly blended, and then violently whirled for about a minute. For 30 minutes, the flask was placed in a fume cupboard. The solution was titrated with 0.5N $FeSO_4$ to a maroon colour after adding five to ten (5 to 10) drops of the indicator.

To standardize the dichromate, a blank determination was performed (Nelson and Sommers, 1982). TOC was calculated as follows:

$$\text{TOC (\%)} = \frac{(meq\ K2Cr2O7 - meq\ FeSO4) \times 0.003 \times 100 \times 1.3}{Weight\ \ of\ \ sample(g)} \ldots \quad \ldots \quad \ldots \quad \ldots \quad (iii)$$

Where,

meq $K_2Cr_2O_7$ = 1N X 2.5 ml

meq $FeSO_4$ = 0.5 N X Volume of titrant in ml

0.03 = Mill equivalent weight of carbon

1.30 = Correction factor

In order to determine the nitrogen content of soil, the soil sample was air dried, and oven dried at 105^{o}C for 5 hours, then ground into powder. The nitrogen content was determined colometrically. 1g of the soil was weighed into a boiling tube and 100ml of sulphuric acid was measured and added. Two tablets of Kjedahl catalyst was added and heated slowly until the solution became clear. It was then filtered into a 100ml standard flask and made up to mark. 5ml of the digest was taken into a 25ml flask. 2.5ml of alkaline phenol was added and shaken thoroughly 1.5ml of sodium potassium tartarate was added and shaken as well. 1ml of sodium hypochlorite was added and shaken. The mixture was read colorimetrically using UV/VIS Spectrophotometer (Jenway 6715 model) at 630nm wavelength, the standard N was also treated similarly.

The %N was calculated thus:

$$\%N = \frac{Instrument\ \ reading \times Slope\ \ reciporcal\ \times Colour\ volume \times Digest\ vol \times 10^{-6}}{Weight\ \ of\ \ sample \times Aliquat\ \ taken} \ldots \qquad (iv)$$

2.1.3 Determination of soil seed bank

This study was conducted in an experimental area, where five specific locations were selected based on their coordinates (6.4004664, 5.6259830, 6.4004987, 5.6259948, 6.4004954, 5.6260263, 6.4004317, 5.6260132, 6.4004580, and 5.6260216). The purpose of the study was to determine the taxonomic distribution of plant species within these areas.To achieve this, a one meter squared quadrant was randomly thrown on the ground in each of the five locations. 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.

2.2 Materials

In this study, the researchers collected soil samples from specific locations and pooled them together. They used a 1 meter by 1 meter quadrant and a shovel was used to collect the topsoil samples for analysis. Sodium hydroxide was used to prepare a basic solution, while hydrochloric acid was used to prepare an acidic solution.To prevent waterlogging, 15 perforated bowls with a circumference of (109.96 cm) each was used. Additionally, 200 ml spray bottles was used to spray the varying pH concentration on the soil samples.

2.3 Methods

2.3.1 Collection of Soil

Soil was collected from the experimental area, as mentioned in section 2.1.1. The objective was to obtain topsoil for the study. The soil was collected from various locations within the cleared area using a shovel. The depth of collection was limited to 0-15cm. 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.

2.3.2 Distribution Into Bowls

In this scientific experiment, we used fifteen (15) bowls that were perforated, meaning they had small holes in them. These bowls had a height of 17cm and a diameter of 35cm. We filled each bowl to the very top with a total of sixteen kilograms (16kg) of soil that we were testing.To conduct the experiment accurately, we arranged these bowls in a screen house. The screen house allowed us to control the amount of water that we applied to each bowl, as well as ensured that the only source of wetting for the soil was the solutions we prepared. We had a control group where we did not add any solutions, which allowed us to compare the effects of the solutions on the experimental soil.

2.3.3 Preparation of solution

Distilled water was obtained from the plant Biology and Biotechnology lab. 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 we're adopted. Water from a tap source was taken as the control.

2.3.4 Application of pH treatment

Initially, 300 milliliters (ml) of each pH solution was utilized to adequately saturate 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.

2.3.5 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. 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.

2.4 Data analysis

In this study, three replicates of measurements and the mean of these measurements were taken. 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.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.

CHAPTER THREE

RESULTS

Table 3.1 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 speciesabundance 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 3.2).

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 3.3). 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 3.4).

Table 3.1: 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

Table 3.2: 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 3.3: Diversity indices of plant species found within soil collection area

	Quadrant					
Diversity indices	Q1	Q2	Q3	Q4	Q5	Mean±SEM
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 3.4: Herbarium specimen number for plants collected and submitted to the University of Benin Herbarium

S/N	Plant name	Specimen voucher number
1	*Amaranthus viridis*	UBH-A191
2	*Axonopuscompressus*	UBH-A513
3	*Ageratum houstonianum*	UBH-A339
4	*Asystasisgangetica*	UBH-A460
5	*Cynodon dactylon*	UBH-C291
6	*Delonixregia*	UBH-D431
7	*Desmodium trifolium*	UBH-D654
8	*Diodia sarmentosa*	UBH-D518
9	*Ludwigia decurrens*	UBH-L656
10	*Linderniacrustacea*	UBH-L524
11	*Mimosa pudica*	UBH-M426
12	*Oldenlandia corymbosa*	UBH-0298
13	*Plastostomaafricanum*	UBH-P487
14	*Panicum laxum*	UBH- P237
15	*Physalis angulata*	UBH-P600
16	*Sida acuta*	UBH-S454
17	*Solenostemon monostachyus*	UBH-S392
18	*Solanum*sp.	UBH-S310
19	*Spermaco ceocymoides*	UBH-S655

Species abundance and citation index as affected by pH solutions after 8 weeks have been presented on Table 3.4. With a total of 41 plant species, species abundance was more in the soils at pH 7. This was followed by soils exposed to pH5 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 influence of pH in specie abundance have been demonstrated on Table 3.5. 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 pH7 and pH5-exposed soils (taxa, 11 - 12), compared to the control (taxa, 5). There were more individuals in pH7-exposed soils compared to the control. Chao-1 index was highest in pH7, 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 pH3 (or 0.600) when compared to pH7. Observable, diversity indices were lower at the extremes of pH at 3 and 11 respectively.

Table 3.5: 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 3.6: 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

Ludwigia decurrens, in the Control, had a plant height of 6.3cm, compared to *Ageratum conyzoides* (5.3cm) (Figure 3.1). Under pH 3, the plant maintained similar plant height (Figure 3.3). 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 pH3 had a plant height of 6.3 cm; it was however higher at pH 5 (11.3cm) and pH7 (8.4 cm)(Figure 3 and 4). Under pH3 *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 (Table 3.3, 3.4, and 3.6).

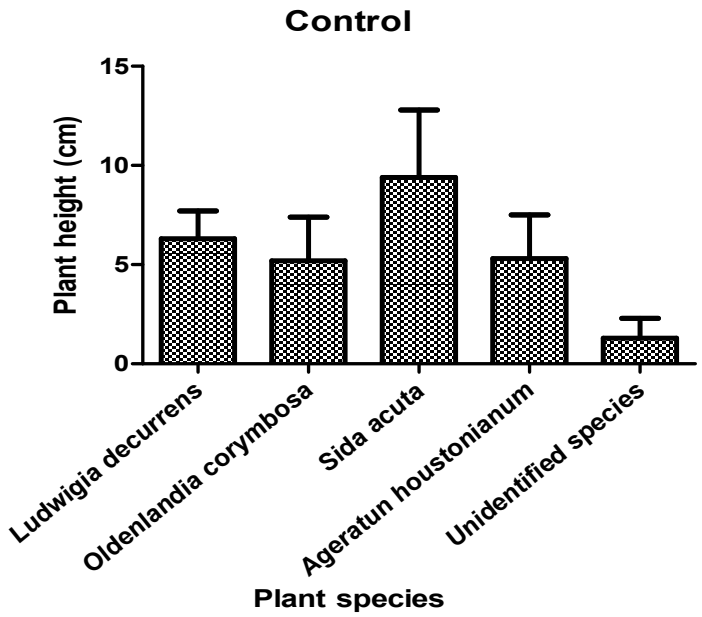

Figure 3.1: Plant height of weeds affected by soil wetting with water (Control)

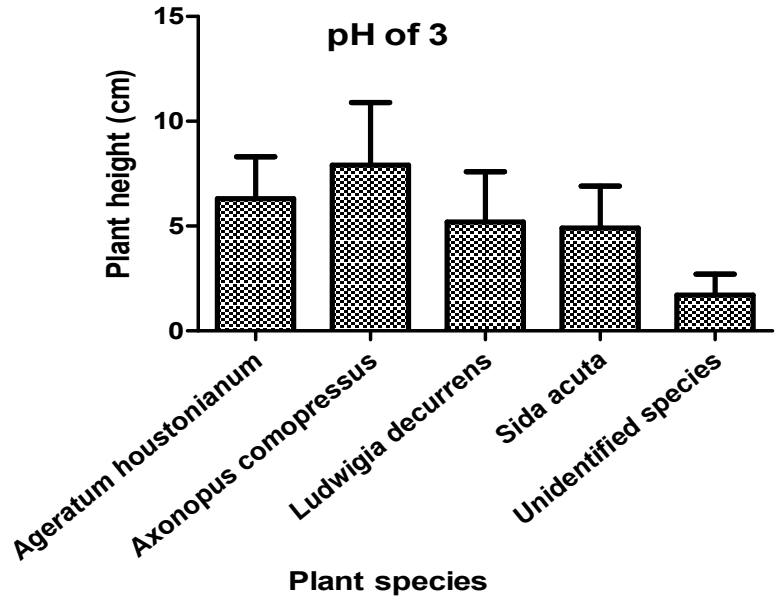

Figure 3.2: Plant height of weeds affected by soil wetting with water adjusted to pH 3.

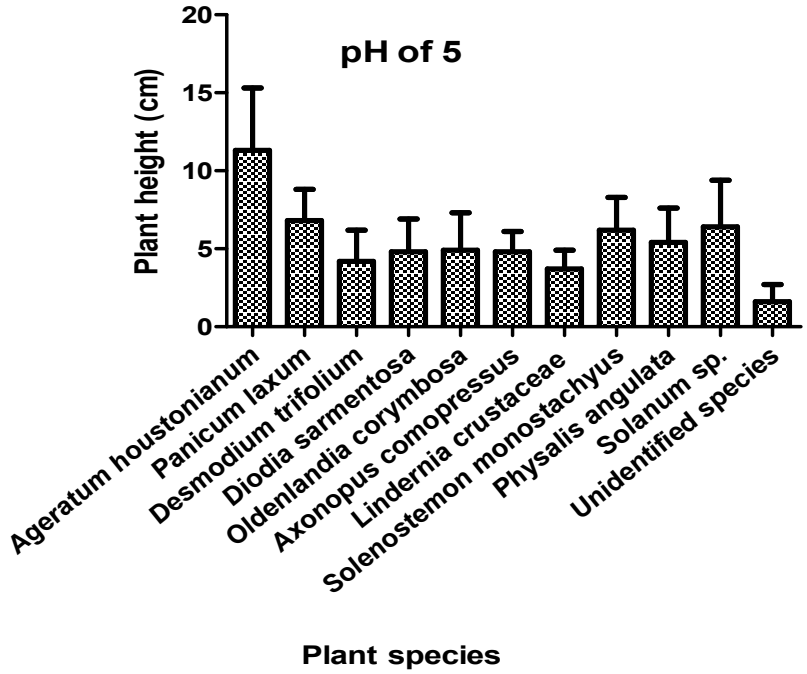

Figure 3.3: Plant height of weeds affected by soil wetting with water adjusted to pH 5.

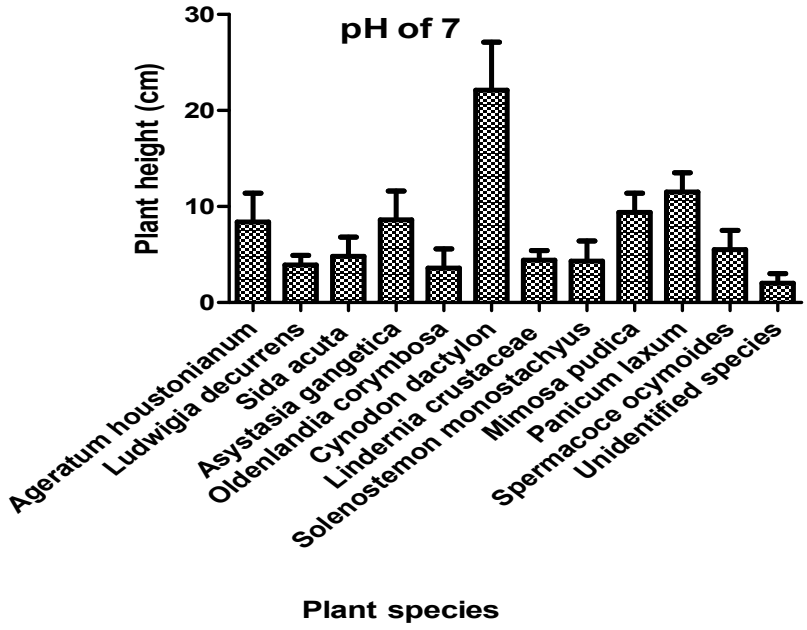

Figure 3.4: Plant height of weeds affected by soil wetting with water adjusted to pH 7.

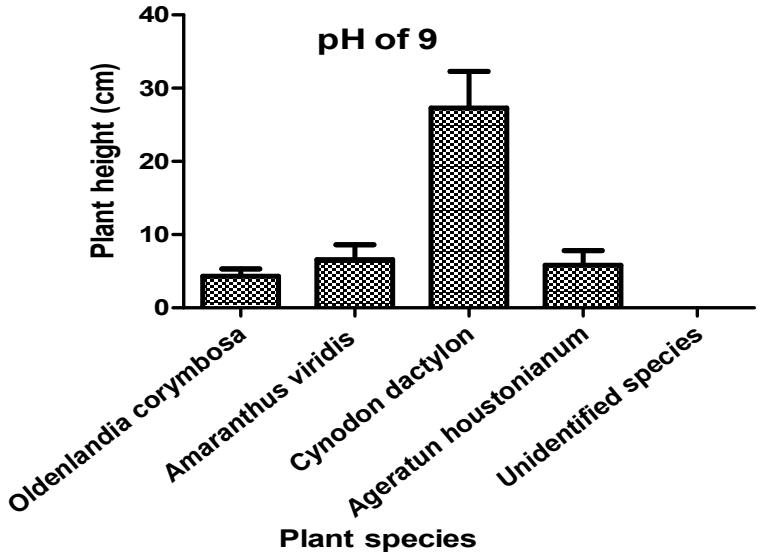

Figure 3.5: Plant height of weeds affected by soil wetting with water adjusted to pH 9.

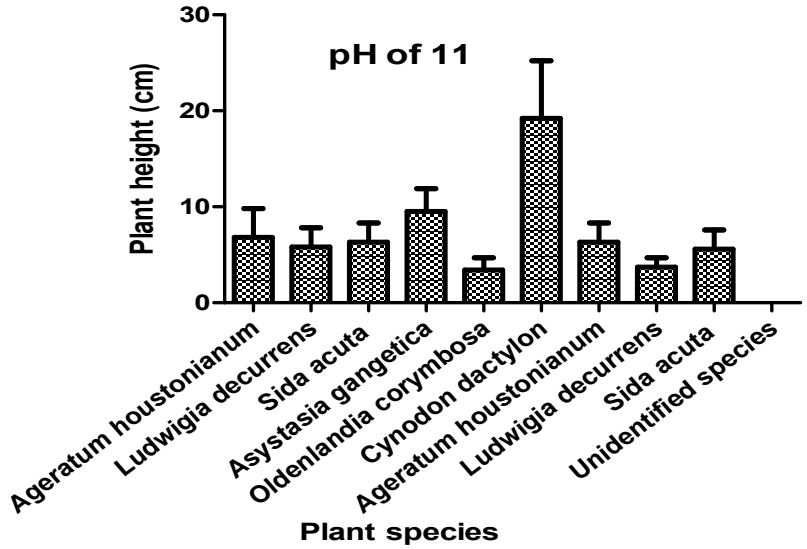

Figure 3.6: Plant height of weeds affected by soil wetting with water adjusted to pH 11.

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 3.7). Dry weight of sprouted plants in the control was 1.59g, compared to 4.9g in the pH7-exposed soil, and 2.00g under alkaline conditions.

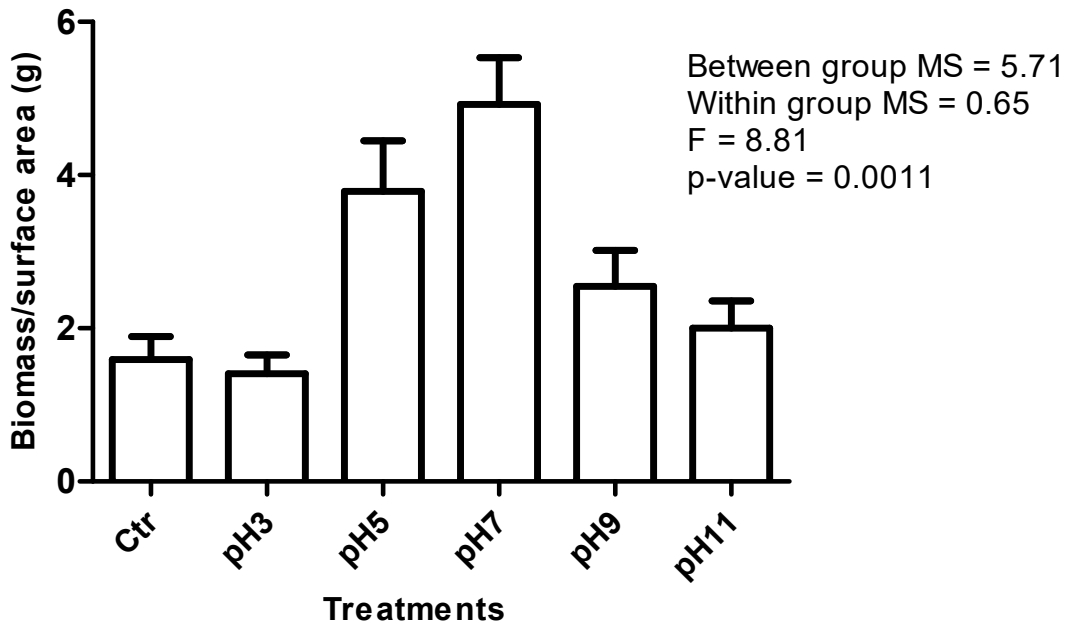

Figure 3.7: Impact of pH on the total biomass of sprouted plants from soil seed bank after 8 week.

(a)

(b)

Plate 3.1: Impact of pH on the development of soil seed bank at 4 weeks after exposure

CHAPTER FOUR

DISCUSSION

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. 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.

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, 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 successional 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. Amiaudet. al (2004). 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 plantsas tomato remained the only plants to not exhibit productivity decline at very high solution pH in a study carried out by Islam *et al.,*(1980). 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.

Ginger and cassava however were the species most resistant to low solution pH, while tomato and ginger were the only ones to exhibit no yield reduction at the highest solution pH. All species' roots showed visible signs in the root systems for cassava and ginger at pH 3.3 as well as in some species at pH 4.0. In addition, at these pH levels, the magnesium, nitrogen, and manganese concentrations in the tops of the six species, as well as the amount of magnesium and nitrogen in the caps of the tomato and cassava were insufficient for optimum growth. For

wheat and maize, iron deficit was linked to growth decrease at high solution pH, but for cassava, a copper or nitrogen deficiency was linked to growth depression at high solution pH in wheat and maize, and to inadequate nitrogen and/or copper in cassava. At extreme pH levels, there was a high abundance of a particular species. This suggests that extreme pH conditions may have a negative impact on the development and diversity of plants. In other words, when the pH was at an extreme level, it seemed to suppress the growth and development of plants. It was also observed that pH 5 and 7 had even better growth and more diverse weed species than the control which was pH 6.4.A significant difference was observed also with more diverse growth at slightly acidic conditions to basic than the control, it could be suggested that the slight drop in pH could have impact on the metabolism and the utilization of micro and macro elements by the plant in the soil compared to neutrality. Several elements become less accessible to plants at low pH levels, while others, like iron, aluminum, and manganese, turn toxic to them. Additionally, phosphorus, iron, and aluminum can interact to create insoluble compounds hence the reason why pH 3 had the least diverse growth.

When the pH is high, calcium binds phosphorus, rendering it unusable to plants, while molybdenum, in some soils, is toxic. In some soils, boron can also be poisonous but some plants species can withstand high alkalinity and it is toxic to others. In conjunction to what was gotten in the results, *Cynodon dactylon*was able to adapt to pH 11 and at the same time the growth of other plant species was greatly suppressed. Hence the reduced diversity noticed at pH 11. *Cynodon dactylon* prefers a pH range of 4.5 to 7.5, well-drained, fertile-poor, moist, sandy to loamy soil ranging from acidic to highly alkaline pH concentration (Holm *et al.,*1977).

CONCLUSION

Soil pH is influenced by various factors, including natural processes and human activities. Human activities such as agriculture, industrial pollution, and the use of certain fertilizers and chemicals can alter soil pH levels. For example, excessive use of acidic or alkaline fertilizers can lower or raise the pH respectively. These alterations in pH can have significant impacts on weed populations and overall biodiversity.

The study provides evidence that soil pH significantly affects the development of weeds from the soil seed bank. pH levels of 5 and 7 were found to promote greater diversity in weed growth. This suggests that a slightly acidic to neutral pH range is favorable for supporting a wider range of weed species and that moderate pH levels within this range create favorable conditions for a wider range of weed species to thrive.

This study also identified that extreme pH levels of 3 and 11 have distinct effects on weed development. These extreme pH values were found to facilitate the growth of specific plant species that are well-adapted to such extreme conditions. This implies that certain weed species have a preference for acidic (pH 3) or alkaline (pH 11) environments, allowing them to outcompete other species and establish dominance under these extreme pH conditions.

On the other hand, extreme pH levels of 3 and 11 were observed to enable the growth of specific plant species that are adapted to highly acidic or alkaline conditions. These extreme pH levels create selective environments where only certain plant species can thrive, leading to reduced weed diversity. The implications of these findings are significant for agricultural and ecological management practices. Understanding how soil pH affects weed populations can inform strategies for weed control. For instance, in areas where diverse weed growth is desired, maintaining a pH level around 5 or 7 could be beneficial. Conversely, in situations where

specific plant species need to be controlled, manipulating pH towards the extremes (pH 3 or 11) may be effective.

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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