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Impact of Soil Depth and Environmental Factors on Microbial Diversity and Physicochemical Properties of Agricultural Soils

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Abstract: Environmental factors and microorganisms play a pivotal role in shaping soil microbial diversity. Variables like temperature, moisture, pH levels, organic matter, and the presence of organisms influence the types and abundance of microbial life in the soil. This research was aimed at assessing the impact of soil depth and environmental factors on microbial diversity and physiochemical properties of agricultural soils. A total of 27 samples were collected at various depths of (0-15, 15-30 and 30-60cm), the samples were subjected to standard laboratory analysis using standard procedures. The temperature of tomatoes field soils ranged from 14-31°C, rice field soils 15-36°C and corn field soils 12-24°C. The pH of tomatoes field soils varied from 4.8-8.0, rice field soils 3.8-6.8 while corn field soils were 5.8-8.1. The moisture content of the tomatoes field soils ranged from 20-33%, rice field soils 17-28%, and corn field soils 10-22%. Organic carbon of tomatoes field soil varied from 6.35-6-61, rice field soil 6.20-6.60 and corn field soils 5.88-6.96, Organic matter for tomatoes field soils varied from 10.93-11.39%, rice field soils 10.74-11.38% while corn field soils 10.14-11.53%. Nitrogen of tomatoes field soils ranged from 0.46-0.43mg/kg, rice field soils 0.42-0.43mg/kg and corn field soils 0.38-0.56mg/kg. The phosphorus content of the tomatoes field soil ranged from 0.06-0.07mg/kg, rice field soils 0.06-0.06mg/kg while corn field soils 0.06-0.07mg/kg. The tomatoes field soil total fungal count based on various depths varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL), the rice field varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL) while the corn field varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL). The molds isolated were *Aspergillus niger, Aspergillus flavus, Rhizopus microspores, Rhizopus arrhizus, Trichophyton mentagrophytes, Aspergillus fumigatus, Aspergillus nidulans* and *Trichophyton tonsurans*. This study demonstrated that there are significant differences in the physicochemical properties and mycological characteristics of the various crops soil type analyzed. It also highlights that sustainable soil management boosts productivity.

Keywords: Physicochemical properties, Farm lands, Soil, Fungi, Gusau.

Research Paper

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1. INTRODUCTION

Soil microbes, including bacteria, fungi, and other microorganisms, break down complex organic matter like dead plants or animals, releasing essential elements such as nitrogen, phosphorus, and potassium. They aid in the process of mineralization, converting organic matter into inorganic nutrients that plants can readily absorb. Certain microbes can form symbiotic relationships with plants, aiding in nutrient uptake and enhancing their growth (Chakraborty, 2022).

Soils are stratified and soil depth is a key factor influencing biotic and abiotic soil parameters, such as carbon (C) and nitrogen (N) concentrations (Baisden *et al.,* 2002) and microbial diversity (Frank-Fahle et *al.,* 2014) which declines beyond the soil surface zone corresponding to the location of the root biomass. Soil depth affects the abundance of soil microorganisms and the structures of their microbial communities (Oehl *et al.,* 2005; Taniguchi *et al.,* 2012; Becerra *et al.,* 2014) and shapes their abilities to contribute to the ecological services of plant production (Koven *et al.,* 2013; Fan *et al.,* 2016; Jiao *et al.,* 2018).

Maintaining soil health quality is indispensable for sustaining the agricultural productivity at higher

level. Soil quality includes three groups of mutually interactive attributes (i.e., Soil physical, chemical and biological quality, which must be restored at its optimum to sustain productivity (Kumar *et al.,* 2012). Soil degradation is one of this generation's most serious global environmental issues (Adnan *et al.,* 2015; Antonio, 2016). Even while the degree of degradation varies from location to location, it affects people all across the world (Pimentel and Burgess, 2013). Assessing soil fertility declination is difficult because most soil chemical properties either change very slowly or have large seasonal fluctuations. This decline includes; nutrient depletion, nutrient mining, acidification (decline in pH and an increase in exchangeable Al), loss of organic matter and increase in toxic elements (e.g., Al, Mn) (Hartemink, 2016).

Environmental factors play a pivotal role in shaping soil microbial diversity. Variables like temperature, moisture, pH levels, organic matter, and the presence of other organisms influence the types and abundance of microbial life in the soil. Some bacteria thrive in acidic conditions, while others prefer alkaline environments. Likewise, moisture levels and the availability of nutrients impact the diversity and distribution of soil microbes (Zhao *et al.,* 2021). Soil physicochemical properties are important contributors to soil fertility, which is a critical factor determining crop productivity and agricultural sustainability (Liu *et al.,* 2018). Various environmental factors play a crucial role in influencing soil microbial diversity. Unfavorable environmental factors have a negative impact on living organisms. One of the serious consequences of unfavorable environmental factors is the reduction of biodiversity and changes in the relationships between plants and microorganisms. Currently, global warming is of particular concern, which, according to most environmental scientists, may exacerbate other environmental problems (Yadollahie 2019).

Temperature plays a crucial role in influencing soil microbes and their activities. Different types of soil microbes thrive at specific temperature ranges, influencing their metabolic rates, reproduction, and overall functioning (Schulte 2015). Sorensen *et al.,* (2020), investigated the impact of winter air temperature upon soil bacterial and fungal communities in northern hardwood forests by incubating root in growth and exclusion cores across a winter climate–elevation gradient for 29 months. They concluded that the rise in winter air temperature enhanced bacterial phylogenetic diversity and richness; however, the fungal communities did not show any significant change in response to temperature variation.

pH is the measure of acidity or alkalinity, significantly influences soil microbes and their activities. The pH level of soil plays a crucial role in shaping microbial communities and their ability to perform essential functions (Neina 2019). Soil pH is a mainstream factor that defines the structure of microbiome communities (Thomas, 2018). Significant variations in soil pH disturb microbial communities and soil microorganisms, which demonstrate an extensive range of optimal pH tolerance. Numerous researchers have focused on the influence of pH at dissimilar scales. pH is considered to be the optimal indicator of microbial diversity at the phylum level (Van Horn *et al.,* 2014; Zhao *et al.,* 2014). The pH of soil is directly associated with the availability of nutrients for plants, as it governs the chemical forms of soil-resident compounds. Yoon *et al.,* (2024) carried out a study on the microbial diversity of soils under different land-use and chemical conditions in South Korea. Soil samples were collected from seven distinct locations in South Korea, each representing different land-use types and chemical conditions. The sampling locations included paddy field soils, upland field soils (UFS), and greenhouse soils (GHS), cultivated with rice, pepper, and tomato, respectively, at the time of sampling. Forest soils (FOS) were collected from uncultivated forest areas dominated by *Pinus densiflora*. They reported that Forest soil (FOS) exhibited the highest acidity (pH 4.96).

Nutrient availability determines the plant communities above and below ground productivity, ecosystem stability, and nutrient dynamics as a result of intermittent, essential nutrient (e.g., N and P) deficiencies and limitations in natural systems. Plant microorganism interaction becomes necessary to offset such nutrient challenges (Liang *et al.,* 2022). Soil microorganisms supply their host with the requisite N and P in return for soil carbon. One such plant–soil microbe interaction is the leguminous–rhizobia interaction that replenishes N naturally into the soil referred to as biological nitrogen fixation (Bano *et al.,* 2016). Nitrogen addition has a negative impact on bacterial richness and diversity in urban green space, the decrease in biodiversity induced by N deposition may pose a serious threat to the stability of urban soil ecosystems, which emphasizes the necessity of thorough and concerted studies to prompt adequate policies to counteract these globally increasing threats (Mo *et al.,* 2021).

Microbial populations in soil are determined by various factors such as soil depth, organic matter, porosity, oxygen and carbon dioxide concentration, soil pH, etc. Factors that influence microorganisms' roles in nutrient building and cycling in soil and organic matter decomposition are of unique interest. These microbial entities have the potential to be utilized in various biotechnological applications that are necessary to improve soil health and quality (Anandham and Sa 2021).

Fungi are abundant in soil, but bacteria are more abundant. Fungi are important in the soil as food sources

for other, larger organisms, pathogens, beneficial symbiotic relationships with plants or other organisms and soil health. Fungi can be split into species based primarily on the size, shape and color of their reproductive spores, which are used to reproduce. Most of the environmental factors that influence the growth and distribution of bacteria and actinomycetes also influence fungi. The quality as well as quantity of organic matter in the soil has a direct correlation to the growth of fungi, because most fungi consume organic matter for nutrition. Compared with bacteria, fungi are relatively benefited by acidic soils. Fungi also grow well in dry, arid soils because fungi are aerobic, or dependent on oxygen, and the higher the moisture content in the soil, the less oxygen is present for them (Msimbira and Smith 2020).

Fungi adapt to diverse environmental conditions due to their high plasticity and capacity (Islam *et al.,* 2017). They produce multiple types of extracellular enzymes that convert organic matter to CO_2, biomass, and organic acid while decomposing soil constituents to maintain nutrient balance (Žifčáková *et al.,* 2016). Fungi can also absorb heavy metals, i.e., Cd, Cu, Hg, and Pb (Ali *et al.,* 2013). Fungal diversity and activity are controlled by various factors including plant and soil structures, pH, water, and temperature. Fungi are found in nearly all environments and can survive under variable pH and temperatures (Midgley 2012; Watkinson 2015; Adnan *et al.,* 2018).

Soil fungi are categorized into three functional clusters, which include biological controllers, ecosystem regulators, and organic matter decomposers or compound transformers. Ecosystem regulators are involved in the formation of soil structure and alter habitats for other living inhabitants by modulating the dynamics of soil-based physiological processes (Midgley 2012). Biological controllers control diseases, pests, and the growth of other organisms (Perotto *et al.,* 2013). Fungal populations are strongly impacted by plant diversity and community composition. Therefore, plant growth influences mutualism and pathogenicity or can affect nutrient cycling and availability. Moreover, fungi are involved in hormone production and drought protection (Levy-Booth *et al.,* 2014; Armada *et al.,* 2015) while also stabilizing soil-resident organic matter and decomposing residues (Voriskova and Baldrian 2013). In forest, soils fungi are the leading microbial biomass producers and respirators. Within or across biomes, fungal biomass variations are associated with the decomposition of litter and nutrient availability, where ~ 20% of decomposing plant litter is attributed to fungi. Decreased pH leads to incremental fungal growth as well as the ratio of fungal–bacterial biomass (Pepe *et al.,* 2016). It has also been observed that other than pH, nitrogen–phosphorus availability influences fungal mycelia.

The purpose of this research is to investigate the physicochemical properties and microbial diversity of different agricultural soils, focusing on fungal populations and their interactions with environmental factors such as soil depth, temperature, pH, moisture content, and nutrient availability. By analyzing soil samples from corn, tomato, and rice farmlands at varying depths, this study aims to determine how these factors influence fungal abundance, diversity, and ecological functions in nutrient cycling and soil health. Understanding these relationships is crucial for sustainable agricultural practices, soil fertility management, and improving crop productivity through microbial applications.

The scope of this study focuses on agricultural soils from three distinct farmland types such as corn, tomatoes, and rice fields also examining soil samples collected at varying depths (0-15 cm, 15-30 cm, and 30-60 cm). The research encompasses a comprehensive physicochemical analysis, including temperature, pH, moisture content, nitrogen levels, organic carbon, organic matter, and phosphorus concentration. Furthermore, the study involves the isolation, characterization, and identification of fungal populations present in these soils. By analyzing variations in fungal diversity across different depths and agricultural conditions, this research highlights the ecological significance of fungi in soil health and crop productivity.

This study contributes novel insights into the interactions between soil fungi and environmental variables in different agricultural systems. This research integrates both aspects to provide a more comprehensive understanding of soil microbial ecology. Additionally, while many studies have investigated bacterial diversity in soil, fewer have focused specifically on fungal populations and their role in nutrient cycling across different crop farmlands. By comparing fungal communities in corn, tomato, and rice fields at different depths, this study offers unique data that can inform sustainable soil management practices and enhance agricultural productivity through microbial applications.

2. MATERIALS AND METHODS

2.1 Sample Collection

Random sample collection method was used. 27 samples were collected from different agricultural farm lands which consist of 9 samples each from different corn field soil, tomatoes field soil and rice field soil. The samples were collected at different depths of (0-15cm, 15-30cm and 30-60cm). A shovel was used to clear the top soil debris; a measuring tape was used to measure the depth. The samples were aseptically collected using a sterile blade spade and transferred into a sterile sample container, transported to microbiology laboratory of Federal University Gusau in nylon and analyzed within 24 hours of collection.

2.2 Sample Preparation

The samples collected were air dried for a period of one week in a well-ventilated location in the laboratory, after the period of air drying it was then homogenized by grinding using mortar and pestle and sieved through a 2mm stainless steel and transferred in a sterile sample container for further analysis.

2.3 Physicochemical Analysis of the Different Agricultural Farm Land Soils

2.3.1. Temperature

This was done according to the description of Campbell *et al*., (2014). The temperature was measured at the collection point using a Centigrade thermometer. The thermometer was inserted into the soil and left undisturbed for 15 minutes until the temperature was stabilized, after which the reading was recorded.

2.3.2. pH

A paper Ten grams of 2mm sieved air-dry soil were placed in a 50ml plastic beaker, and 25ml of distilled water was added. The suspension was stirred several times over a period of 30 minutes and then left to settle undisturbed for another 30 minutes. The pH meter was calibrated with pH buffers 4, 7, and 9. The electrode was carefully immersed in the soil without touching the bottom of the beaker. The pH was read after 30 seconds. The procedure was then repeated using a 0.01M $CaCl_2$ solution and the readings were carefully recorded (Zhang *et al.,* 2016).

2.3.3. Moisture Content

Two (2) g of the soil sample was weighed in aluminum dishes and oven dried at $105^{O}C$ to constant weight, loss of weight due to drying was converted to percentage moisture content (McCleary *et al.,* 2020). Moisture content = Loss of weight (W2-W3) (g) X 100/ Origins weight of sample W2-W1. W1= Initial weight of empty crucible, W2= Weight of crucible+ sample before drying, W3= final weight of crucible + sample after drying.

2.3.4. Nitrogen

The One (1) g of the sieved soil was weighed into a Kjeldahl flask (digestion tube). A few drops of water were added and left to stand for approximately 30 minutes. Five grams of the Kjeldahl catalyst mixture (a blend of 500 grams of Na_2SO_4, 50 grams of $CuSO_4$, and 0.5 grams of finely ground selenium catalyst) were added. Then, 20 milliliters of concentrated sulfuric acid were introduced. The mixture was heated on a digestion block until frothing ceased, and the temperature was raised until the solution cleared. After cooling, a small amount of water was carefully added, and the contents were rinsed into a 100-milliliter volumetric flask. After allowing it to cool, the flask was filled to the mark. 10ml were pipetted from the digest into a distillation flask. Twenty milliliters of boric acid were measured into a 100-milliliter conical flask, and three drops of mixed indicator were added. Ten milliliters of NaOH and the 10 milliliters of the digest from the distillation flask were immediately introduced into the distillation unit to distill the digest, collecting approximately 60 milliliters of distillate. The distillate was titrated with 0.01N H_2SO_4 until the color changed from green-blue to purple, indicating the endpoint (Stafilov *et al.,* 2020).

2.3.5. Organic Matter

One 1-gram soil sample was weighed, passing through a 0.2 mm sieve, and exactly 10 ml of 1N $K_2Cr_2O_7$ solution was added to it in a 500 ml conical flask.20 ml of concentrated sulfuric acid was added and mixed by gentle rotation for 1 minute to ensure complete contact of the reagent with the soil, taking care to avoid throwing up soil to the sides of the flask. The mixture was allowed to stand for 30 minutes. A standardization blank (without soil) was run in the same way. After half an hour, about 200 ml of distilled water, 30 drops of diphenylamine indicator, and about 0.2 grams of sodium fluoride were added. The solution was back titrated with ferrous ammonium sulfate solution. The color was dull green with chromos ion in the beginning, and then shifted to a turbid blue as the titration proceeded. At the end point, this color sharply shifted to brilliant green (Poudel, 2020).

2.3.6. Organic Carbon

One (1) g of the soil was weighed into 250ml Erlenmeyer flask. 10ml of 1N $K_2Cr_2O_7$ (potassium dichromate) was pipetted into a flask. The flask was swirled gently in order to disperse the soil. Exactly 10ml of concentrated H_2SO_4 was rapidly added from a measuring cylinder and was swirled again for a minute. The flask was allowed to stand on asbestos sheet for about 30 minutes. 100ml of distilled water was added to the flask, and was allowed to cool. 3 drops of the indicator (phenanthroline) was added, and was then titrated with ammonium ferrous sulphate solution with a white background. Blank determination was made in the same manner but without soil. The endpoint of the titration was reached when all the excess dichromate has reacted with the ferrous sulfate. An indicator diphenylamine sulfonate was used, which changes color and indicate the blue-green as endpoint more clearly (Sohail *et al.,* 2019).

2.3.7. Phosphorus

Two grams of soil samples were weighed and placed in a beaker. Fifty milliliters of distilled water were added and vigorously shaken until a uniform mixture was achieved. The mixture was then filtered through filter paper into a conical flask, which was subsequently transferred to a sterile beaker. Two milliliters of stannous chloride and two milliliters of ammonium molybdate were added. Immediate color changes were observed, and the solution was analyzed using a spectrophotometer to quantify the phosphorus concentration (Mackay *et al.,*

2017).

2.4 Fungal Isolation

This was done according to the method of Okoye *et al.* (2024). The soil samples were serially diluted before the analysis. The fungal isolation was carried out using spread plate method. One-milliliter aliquots of the serially diluted sample (10^{-6}) were evenly spread across the surface of Potatoes dextrose agar (PDA) and placed in a sterile petri dish. Streptomycin was added to prevent bacterial proliferation. The plates were incubated in an inverted position at 37℃ for 3 days. Subsequently, the fungal colonies that developed were counted using a colony counter and the result was recorded. Each colony was subcultured on sterile PDA plates and stored on PDA slants, for further characterization and identification.

2.4.1 Characterization and Identification of the Fungal Isolates

The isolate was characterized based on their colony morphology, cellular morphology and gram staining. The fungi were identified using fungal atlas (David *et al.,* 2007).

2.5 Data Analysis

Data obtained were subjected to ANOVA (two way) for statistical analysis to compare the means of soil properties between tomatoes, rice and corn soils and between soils depth using a statistical analysis system (SAS) package (EXCEL, 2010).

3. RESULTS

Table 1: Physicochemical parameters of different agricultural farm lands soils in Damba, Gusau metropolis

Crop type	Depth (cm)	Temperature (^{O}C)	pH	Moisture content (%)	Soil organic carbon (%)	Soil organic matter (%)	Nitrogen (mg/kg)	Phosphorus (mg/kg)
Tomatoes	0-15	14	4.8	20	6.35	11.39	0.464	0.065
	15-30	25	6.1	30	6.54	11.27	0.443	0.038
	30-60	31	8.0	33	6.61	10.93	0.425	0.065
Rice	0-15	15	3.8	17	6.2	11.38	0.422	0.059
	15-30	26	5.1	23	6.41	11.05	0.529	0.069
	30-60	36	6.8	28	6.6	10.74	0.608	0.08
Corn	0-15	12	5.8	10	5.88	11.53	0.383	0.063
	15-30	18	6.9	18	6.2	10.69	0.495	0.072
	30-60	24	8.1	22	6.96	10.14	0.555	0.068

Table 2: Total fungal count of different agricultural farm lands soil in Damba, Gusau Metropolis

Location	Crop type soil	Depth (cm)	Total fungal count (cfu/mL ×10^{-6})
Damba A	Tomatoes	0-15	2
		15-30	1
		30-60	1
Damba B	Rice	0-15	2
		15-30	2
		30-60	1
Damba C	Corn	0-15	2
		15-30	2
		30-60	1

Table 3: Colonial and microscopic characteristics of molds isolated from different agricultural farm lands in damba, Gusau Metropolis

Isolates	Colonial characteristics	Microscopic characteristics	Suspected organism
1.	Colonies consist of a compact white or yellow basal felt covered by a dense layer of dark brown to black conidial head	Conidial heads are large (up to 30mm by 15-20um in diameter), globose, dark brown, becoming radiate and tending to split into several loose columns with age.	*Aspergillus niger*
2.	Colonies are typically are suede-like to floccose, with white interspersed grey green patches of conidia.	Conidial heads are short, columnar and uniseriate. Condia globose (2-3um in diameter) smooth to finely roughen.	*Aspergillus flavus*
3.	Colonies are dark greyish-brown, up to 10mm high producing simple rhizoids.	Sporangia are greyish-black, spherical, up to 100um in diameter	*Rhizopus microspores*
4.	Colonies are very fast growing, about 5-8mm high with some tendency to collapse,	Sporangia are globose, often with a flattened base, greyish black, powdery in	*Rhizopus arrhizus*

	white colony at first becoming brownish grey to blackish depending on the amount of sporulation	appearance, up to 175um in diameter and many spores	
5.	Colonies are generally flat, white to cream in color, with a powdery granular surface	Microconidia are hyaline, smooth-walled and are predominantly spherical usually up to 20um in diameter	*Trichophyton mentagrophytes*
6.	Colonies are typically blue-green with suede-like surface consisting of a dense felt of conidiospore	Conidial heads are typically columnar (up to 400×50um but often much shorter and smaller) and uniseriate	*Aspergillus fumigatus*
7.	Colonies are typically plain green in color with dark red-brown cleistothecia developing within and upon the conidial layer	Conidial heads are short, columnar (up to 70×30um in diameter and biseriate	*Aspergillus nidulans*
8.	Colonies are small, buttons or disk-shaped, white to cream-colored, with suede-like to velvety surface	Macroconidia are only rare produced, but when present have a characteristics tail or string bean shape usually 20-30 um in diameter	*Trichophyton tonsurans*

Table 4: Frequency of occurrence of mold isolated in different agricultural farm lands soils in damba, Gusau Metropolis

Organisms	Tomatoes field	Rice field	Corn field	Total	Frequency (%)
Aspergillus niger	2	4	3	9	11.25
Aspergillus flavus	3	1	2	6	7.5
Rhizopus microspores	4	3	6	13	16.25
Rhizopus arrhizus	5	6	2	13	16.25
Trichophyton mentagrophytes	8	4	3	15	18.75
Aspergillus fumigatus	2	1	4	7	8.75
Aspergillus nidulans	2	5	3	10	12.5
Trichophuton tonsurans	2	1	4	7	8.75
Total	28	25	27	80	100

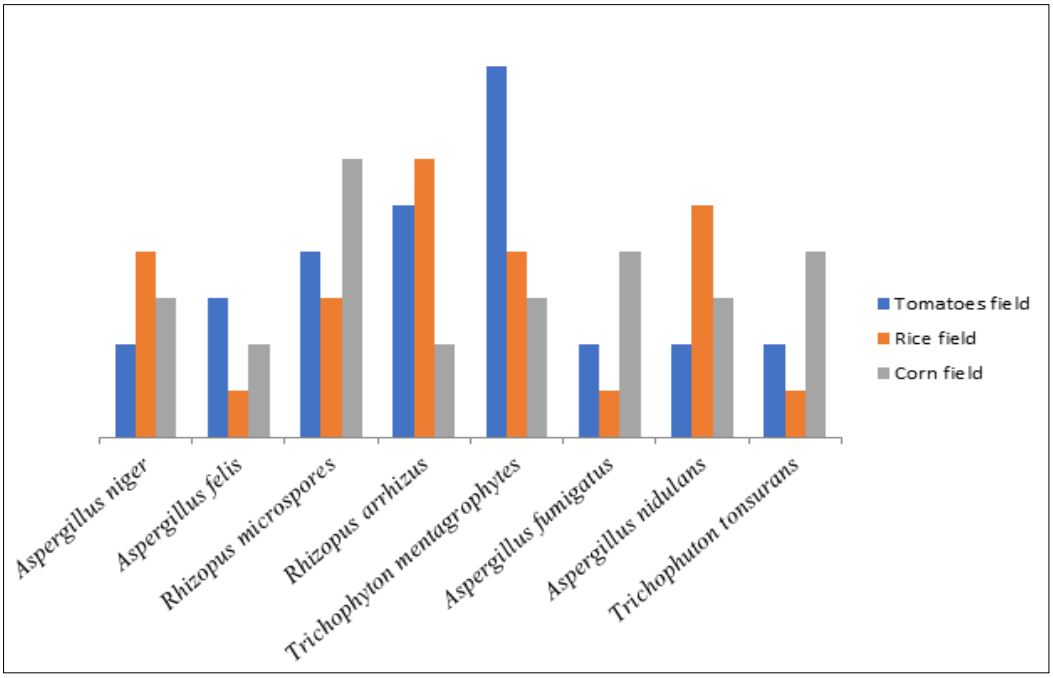

Fig. 1: Frequency of occurrence of mold isolated in different agricultural farm lands soils in Damba, Gusau Metropolis

4. DISCUSSION

The physicochemical and fungal analysis of different agricultural farm lands soils which encompass

tomatoes, rice and corn field soil at different depth of 0-15cm, 15-30cm and 30-60cm was done based on various standard procedures.

The tomatoes field soil temperature based on various depths varied from 14 ºC -31ºC, the rice field soil temperature varied from 15ºC-36 ºC while the corn field soil temperature varied from 12 ºC-24 ºC. The temperature of all the various crops farm land soils analyzed was higher at the depth of 30-60cm (Table 1). Comparing the three crops farm land soil analyzed rice field recorded higher temperature, this could be attributed to vegetative and reproductive stages, high temperature have different effects on plants at different stages of development (Zhang *et al.,* 2018), and it could be as a result of rice root respire and released heat contributing to rise in soil temperature (Fahad *et al.,* 2019).

The tomatoes field soil pH based on various depths varied from 4.80-8.00, the rice field soil pH varied from 3.80-6.80 while the corn field soil pH varied from 5.80-8.10. The pH of all the various crops farm land soil analyzed was higher at the depth of 30-60cm (Table 1). The result showed that most of the depths of 0-15cm to 15-30cm were moderately acidic for all the crops type analyzed while at the depth of 30-60cm are in the alkaline state. Comparing the three crops farm land soil analyzed corn field soil recorded higher value of soil pH, this could be attributed to type fertilizer used in the farm land, and it could also be as a result of mineral decomposition of the soil. This finding is in accordance with the observation of Onwudike *et al*., (2015), who studied variability in the physicochemical properties of soils of similar lithology in three land use types in Imo state and found it`s pH to range between 5.47-5.9.

The tomatoes field soil moisture content based on various depths varied from 20%-33%, the rice field soil moisture content varied from 17%-29% while the corn field soil moisture content varied from 10%-22%. The moisture content of all the various crops farm land soil analyzed was higher at the depth of 30-60cm (Table 1). The result showed that most of the depths of 0-15cm to 15-30cm have less moisture content for all the three crops farm lands soil analyzed, this could be attributed to precipitation, solar radiation and air temperature (Wang *et al.,* 2019). This research agrees with the finding of Fatihu *et al*., (2022), who studied assessment of physicochemical properties of soil in selected farm land in Kaduna and stated that soil moisture content tends to increase in gravimetric moisture content depth. Comparing the three crops farm land soil analyzed, the tomatoes field recorded high moisture content and this could be attributed to use of organic or biodegradable mulches. Mulching has several essential applications including reducing soil water loss and soil erosion, enriching soil fauna, improving soil properties and nutrient cycling in the soil (El-Beltagi *et al.,* 2022).

The tomatoes field soil phosphorus based on various depths varied from 0.065mg/kg-0.038 mg/kg, the rice field soil phosphorus level varied from 0.059 mg/kg-0.081 mg/kg while the corn field soil phosphorus level varied from 0.063 mg/kg -0.068 mg/kg. The phosphorus level of all the various crops farm lands soils analyzed was higher at the depth of 30-60cm (Table 1). Comparing the various crops farm land soil analyzed, the rice field soil recorded high phosphorus level, and this could be attributed to manure application. Increase in available phosphorus after manure application to soils is a function of various soil characteristics including soil pH, organic matter content and clay type (Chatterjee *et al.,* 2014). This research is in accordance with the work of Zhou *et al*., (2021), who studied changes in physicochemical properties and bacterial communities at different depths in china and reported high phosphorus level of 0.88 mg/kg.

The tomatoes field soil nitrogen content based on various depths varied from 0.46g/kg-0.43g/kg, the rice field soil nitrogen content varied from 0.46g/kg-0.61g/kg while the corn field soil nitrogen content varied from 0.38g/kg -0.056g/kg. The nitrogen content of all the various crops farm land soil analyzed was higher at the depth of 0-15cm to 15-30cm (Table 1). Comparing the three crops farm land soil analyzed the rice field recorded high content of nitrogen, this could be attributed to the type of fertilizer used in the farm and could also be as a result of organic matter decomposition. This finding is in line with the work of Shrestha *et al*., (2022), who studied application of nitrogenous fertilizer in rice production in Bangladesh and reported that ammonia volatilization, denitrification and leaching all contribute to the partial loss of nitrogen fertilizer applied to rice crops, these losses may result in pollution of atmosphere, aquatic systems and ground water among others.

The tomatoes field soil organic carbon based on various depths varied from 6.35g/kg-6.61g/kg, the rice field soil organic carbon varied from 6.20g/kg-6.60g/kg while the corn field soil organic carbon varied from 5.88g/kg -6.69g/kg. The organic carbon of all the various crops farm land soils analyzed was higher at the depth of 0-15cm to 15-30cm (Table 1). The result showed that most of the depths of 0-15cm to 15-30cm have lower concentration of organic carbon. This finding agrees with the work of Guo *et al*., (2023), who study linking soil organic carbon mineralization to physicochemical properties in China and attributed this to rapid mineralization and decomposition of organic carbon due to nutrient uptake by plants. Comparing the three crops farm lands soils analyzed, the corn field soil recorded high concentration of organic carbon and this could be attributed to addition of biochar. Biochar enhances soil organic carbon contents, cation exchange capacity and soil porosity and as a result making the soil conditions better for root development and nutrient uptake (Olmo *et al.,* 2016).

The tomatoes field soil organic matter content based on various depths varied from 11.39%-10.93%, the rice field soil organic matter content varied from 10.74%-11.38% while the corn field soil organic matte content varied from 10.14%-11.53%. The organic matter content of all the various crops farm land soils analyzed was higher at the depth of 0-15cm to 15-30cm compared to the depth of 30-60cm (Table 1). Comparing the three crops farm land soils analyzed, the corn field recorded high percentage of organic matter content and this could be attributed to addition of animal manure, and it can also be as a result of application of inorganic fertilizer. The buildup of soil organic matter as a function of manure application depends greatly on the manure type and the type of manure bedding (Currel, 2016). The benefit of building or maintaining soil organic matter are many, some of which are reduced erosion and run off (Mohammed *et al.,* 2021).

The tomatoes field soil total fungal count based on various depths varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL), the rice field varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL) while the corn field varied from 2×10^6(cfu/mL) - 1×10^6(cfu/mL), the total fungal count of all the various crops type analyzed are higher at the depth of 0-15cm (Table 2). The result showed that most of the depths of 0-15cm to 15-30cm had high total fungal count compared to depth of 30-60cm and this could be attributed to shifts and changes in soil properties and fertility (Yusuf *et al.,* 2015). Comparing the three crops type analyzed they all recorded the same total fungal count.

The morphological and biochemical characteristics of the bacteria isolated from different agricultural farm lands (Table 3). The bacteria isolated were *Pseudomonas syringe, Pseudomonas aeruginosa, Xanthomonas oryzae, Bacillus subtilis, Xanthomonas gardneri, Clavibacter michiganensis* and *Xanthomonas vasicola,* this in accordance with work of Enez (2020), who studied isolation and identification of *Bacillus subtilis* from root soil in Turkey and isolated *Bacillus* spp from the root oil of the Astragalus.

The frequency of occurrence of bacteria isolated from different agricultural farm lands (Table 4), *Xanthomonas vasicola* was the predominant organism in tomatoes field, *Bacillus subtilis* was the predominant organism in rice field while *Pseudomonas aeruginosa* was found as the predominant in all various crops type analyzed. This is in accordance with the work of Sharma *et al.,* (2017) who studied bacterial blight of rice caused by *Xanthomonas spp* in India who isolated *Aspergillus niger, Aspergillus flavus* and *Rhizopus* spp.

The colonial and microscopic characteristics of the molds isolated from different agricultural farm lands (Table 5). The suspected molds isolated were *Aspergillus niger, Aspergillus flavus, Rhizopus microspores, Rhizopus arrhizus, Trichophyton mentagrophytes, Aspergillus fumigatus, Aspergillus nidulans* and *Trichophyton tonsurans.* This is in accordance with the work of Sharma *et al.,* (2023), who studied isolation and identification of keratinophilic fungal biota from different soil samples of agricultural lands of kota city in India and isolated *Aspergillus niger, Aspergillus flavus* and *Rhizopus* spp.

The frequency of occurrence of the molds isolated from different agricultural farm lands (Fig.1). *Trichophyton mentagrophytes* was the predominant organism in tomatoes field, *Rhizopus arrhizus* was the predominant organism in rice field while *Rhizopus microspores* was the predominant in corn field. This agrees with the work of Sharma *et al*., (2023), who studied isolation and identification of keratinophilic fungal biota from different soil samples of agricultural lands of kota city in India who isolated *Aspergillus niger, Aspergillus flavus* and *Rhizopus* spp.

5. CONCLUSION

This study demonstrated that there are significant differences in the physicochemical properties and microbiological characteristics of the various three crops soil type analyzed. The results varied across different soil depths and soil type, where tomatoes field had high moisture content, rice field had high temperature, nitrogen and phosphorus, while corn field had high pH, organic carbon and organic matter content.

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