STUDY OF SOIL BIOCHEMICAL PROPERTIES OF DIFFERENT FARMING SYSTEMS OF AIZAWL, MIZORAM

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY

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SCHOOL OF EARTH SCIENCE AND NATURAL RESOURCE MANAGEMENT

DECEMBER, 2022

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PHILOSOPHY IN FORESTRY OF MIZORAM UNIVERSITY, AIZAWL.

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CERTIFICATE

This is to certify that the thesis entitled "**Study of soil biochemical properties of different farming systems of aizawl, mizoram**" submitted to the Mizoram University, Aizawl for the award of the degree of Master of Philosophy in Forestry is the original work carried out by Mr. Stephen Lalsangzuala (Regd. No.: MZU/M.Phil./589 of 29.05.2020) under my supervision. I further certify that the thesis is the result of his original investigation and neither the thesis as a whole nor any part of it was submitted earlier to any University or Institute for the award of any degree. The candidate has fulfilled all the requirements laid down in the Ph.D. regulations of Mizoram University. His passion oriented hard work for the completion of the research is to be duly appreciated.

Date: (Prof. S. K. Tripathi)

Place: Mizoram University Supervisor

Department of Forestry

DECLARATION

MIZORAM UNIVERSITY

DECEMBER, 2022

I, **Stephen Lalsangzuala,** hereby declare that the subject matter of this dissertation entitled **"Study of Soil Biochemical Properties of Different Farming Systems of Aizawl, Mizoram."** is the record of work done by me, that the contents of this dissertation did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the dissertation has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of Master of Philosophy in the Department of Forestry.

(Stephen Lalsangzuala)

(Head) **(Supervisor**

ACKNOWLEDGEMENTS

With respect I wish to express my heartfelt gratitude to my incomparable guide Prof. Shri Kant Tripathi for his patience and reiterating check, noble guidance, constructive criticism, innovative ideas, valuable suggestions, enduring patience coupled with amicable nature and affection during the course of this study and without which this work would have been incomplete. He has not only been a fathomless ocean of knowledge and wisdom to me but most of all, his words of insight and hands of blessing has been my pillar of strength and courage to complete this work. My fortune may not give anything more but has given me the opportunity to work under a great teacher and human being such as him. I express my esteemed gratitude to Prof. Kalidas Upadhyaya, Head, Department of Forestry for extending laboratory and other necessary facilities required for this research work. I also thank all the faculty members and staffs of the Department for their constant support and help in completion of this work. I would also like to acknowledge Dr Lungmuana Singson, Scientist, ICAR RC NEH Region, Mizoram Centre, Kolasib for providing necessary laboratory facilities which contributed and shaped a part of this study. It is my immense pleasure to express my profound sense of gratitude to Ministry of Tribal Affairs, Government of India for providing financial assistance in the form of National Fellowship for higher education for ST students (NFST) to carry out the present research work. All praises to our "Almighty God" whose omnipotence is the success behind this work. I would also like to express my heartfelt sense of gratitude to my family for their support for my higher education, spring of inspiration and sacrifice since I saw light on this earth. I would like to keep on record the cordial co-operation received from my colleagues and seniors for their untiring help and support during the entire course of this study. Academic life without friends is beyond imagination. I am grateful to our Almighty God who has blessed me with such wonderful friends who ungrudgingly took pain and spared both time and energy so as to enable me to learn and enjoy these priceless experiences of Education and life itself.

Place: MZU Campus Stephen Lalsangzuala

Date: December 2022

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CHAPTER 1
INTRODUCTION

Shifting cultivation is practiced around the world specifically in the region of tropical rain forests in south America, central and west Africa, and southeast Asia. The cultivation landscapes currently cover roughly 280 million hectares worldwide, including both cultivated fields and fallows (Heinimann *et al.*, 2017). It is usually practiced by the tribal around the world. Shifting cultivation is known by different name across different region: Ladang in Indonesia, Caingin in Phillippines, Milpa in Central America and Mexico, Ray in Vietnam, Taungya in Myanmar, Tamrai in Thailand, Chena in Sri Lanka, Conuco in Venezeula. As per UN report, estimated populations of more than 250 million people depends on shifting cultivation for their livelihood but often have deleterious effect on the ecosystem. In the tropical hilly areas of Southeast Asia, the Pacific, Latin America, The Carribean and Africa, this slash and burn cultivation has been a habitual agricultural practice for many decades as golden age (Craswell *et al.*, 1998).

Slash and burn (SB) agricultural farming also known as Jhum or shifting cultivation is oneof the oldest farming systems in Mizoram. In this farming practice, a piece of forest isslashed and burned followed by cropping. Burning of the land in Mizoram usually takes place between February and March; the burnt ashes enriches soil with various nutrients. Just after the burning seeds are sown in the month of April-May and crops are harvested during September-October. The cultivation is continued for a period of one to two years depending on the fertility of soil or length of the fallow. When theproductivity decreases after 1-2 years of cultivation due to decreased soil fertility the land is abandoned as fallow for few years to recover soil fertility through natural regeneration (Grogan et al 2012).

Adeniyi (2010) reported that microorganism (bacteria and fungi) abundance increase 40 days after burning of biomass because of increase in soil pH, which probably induced bacterial diversity and abundances. It is important to understand the impact

of slash and burn on soil microorganism, as they are crucial to the stability, regulation and functioning of forest ecosystems (Reichle, 1977). The rhizosphere is a narrow region of soil around the roots, which is directly influenced by root secretions and associated soil microorganisms (Hauchhum and Tripathi 2019). Microbial community in the rhizosphere epitomizes a wide scale of essential group of microbes that emerge in response to plant metabolic products. The release of plant exudates comprising amino acids, vitamins, sugars, plant hormones, and other nutrients, the rhizosphere region is nutritionally rich. This environment is influenced by external parameters including soil type, moisture, pH, and nature of plants (Bhosale and Kadam, 2015).

Soil depth, pH value, organic matter, total nitrogen, available phosphorus, and exchangeable cation levels altogether influence the number of microorganisms. Fungi populations tends to increase with time in forest and continuous cropping soils, with the greatest concentrations in the top 0-15 cm of soil. At lower depths, bacteria and actinomycetes outnumbered fungi, algae, and cellulolytic members (15–30 cm). The abundance of fungi on the surface layer of soil (0-15 cm) may be credited to the fact that fungi are strict aerobes with selection preferences for different depths of the soil. Within few weeks of burning, the microbial populations were very high, and evenhigher than the pre-burn population (Okonkwo, 2010).

Both natural and anthropogenic disturbances are sensitive to soil enzyme activities thatcan easily induce changes. Soil dehydrogenase enzymes are considered as one of the most importantcomponents of soil enzymatic activities, as they participate in all biochemical routes in soil biochemical cycles. INT (iodonitrotetrazolium) and 2, 3, 5 – triphenyl tetrazolium chloride (TTC) substrate are the methods used for measuring dehydrogenase activity. In autumn seasons forest soil have highest dehydrogenase activity and coal mines have lowest dehydrogenase activity which shows that enzymehave least activity in polluted sites. The dehydrogenase enzyme is frequently employed as a direct measure of soil microbial activity, as well as a measure of any disruption produced by pesticides, trace elements or management methods to the soil Kumar et al., (2013).

Earlier the shifting cultivation practice was ecologically balanced and economically beneficial when the population densities were low and the fallow periods (20-30 years) were long enough. In recent years, the shifting cultivation practice has become uneconomical due to diminished in fallow length (<5 years) with tremendous demographic strain pressure in the region. Therefore, the farmers have adopted some other forms of cultivation, for example, terrace farming, log bunding, SALT farming along with shifting cultivation. Therefore, there is a need to test the efficient farming practice in the region with respect to their soil fertility levels. This study is designed to compare the soil fertility levels of different farming practices operated in Aizawl districts of Mizoram.

Major objectives of the present study are:

- To determine soil physico-chemical properties of various farming practices.
- To isolate microbial population of various farming practices.
- To analyze soil biochemical properties of various farming practices.

CHAPTER 2
REVIEW OF LITERATURE

Nath *et al.* (2016) proposed an alternative way of farming for shifting cultivation thatis practiced among NEH people of India. They envisioned the implementation of the "grains for forest management programme" by providing farmers access to food grains as an alternative to shifting agriculture. By restoring soil health and the depleted ecosystem, the suggested programme aimed to attain food security without harming the environment. Sharma (1981) reported that manmade fire affect the soilmicrobiome in comparison with unburnt area. The study was conducted in old pine*(Pinus kesiya* Royle) forest. The slashing of pines followed by burning of the remaining trunk destroyed the soil micro-organisms completely; recolonized bacteria, actinomycetes and fungal population were found few month on the unburned area and colonizing fungi like *Cladosporium* spp., *Penicillium*s spp. and *Trichoderma* spp. were found right after the burning. In unburnt forest ecosystem *Penicillium*s spp., *Trichoderma* spp., *Fusarium* spp. and *Absidia* spp. were found to be dominant. Diaz-Ravina et al. (1993) concluded that soil microorganisms are higher in spring-autumn and lowest in winter and summer. Available N and K were correlated with seasonal trends of the microbial population while, Ca, Mg, Na, and P did not show any discernible and uniform seasonal pattern. In addition to the season, Soil microorganism exhibited higher population and activity in soil originated from basicrocks in comparison with soil from acid rocks.

Deka and Mishra (1983) reported that there is drastic reduction in microflora in the burnt area. The revert of fungal population surpass the original population within a month after the burning. As compared to that bacteria and actinomycetes took shorter span (approx. 20 days) to fungus. However, there is no discernible market difference between the species composition of fungus in burnt and unburned soil. Furthermore, they asserted that *Trichoderma* spp., *Aspergillus* spp., *Pénicillium* spp., and *Fusarium* spp. species were the most prevalent fungi in the burnt soil of initial mycoflora.

Trabelsi and Mhamdi (2013) highlighted the results of microbial inoculants on microbial communities. The impact of microbial inoculation depends mainly on the adoption of procedures and technique which addressed the dynamics of soil microbial communities. They found that effect on plant growth and fortification might be an induction or repression of local/indigenous microbial population rather than the direct effect of the inoculation strain. These modifications may affect beneficial soil processes like nitrogen fixing or N-cycling bacteria. They proposed further research is needed for understanding the dynamics of these effects in relation to the host crop, the side-distance effect, the midterm and long-term effects, the crop-rotation, and site variation.

Arunachalam (2003) reported a study on the impact of shifting cultivation (jhum) on soil physicochemical properties and soil microbial biomass at lowland areas (< 260 m asl) of Arunachal Pradesh that the pH of the top 0 to 10 cm soil increased after the burn, but gradually decreased during cropping phase and the soil moisture content declined sharply, While C and N concentrations fell dramatically during cropping but recovered with increasing periods of jhum cycling with low microbial biomass carbonand nitrogen.

Deka and Mishra (1984) studied the effect of different amount of fuel burning on the microbial population of forest soil. Fuel burning was found to have a detrimental effect on the surface layer of soil but not much variation on the distribution pattern of soil microflora. The influence increased as more fuel was burned, which caused an increase in microorganisms. When compared to the control soil, there was no discernible difference in the fungus species composition.

Miah *et al.* (2010) investigated the effects of shifting cultivation on soil fungi and bacterial population on two pair sites of Chittagong Hill Tracts in Bangladesh. The study shows that the soil types varies from sandy loam to sandy-clay loam in surface (0-10 cm) and sub-surface (10-20 cm) layer of soil. The soil pH and SMC were lower in shifting cultivation land as compared to village forest. The results also showed that both fungal and bacterial population in surface and subsurface soils was significantly ($p \leq 0.05$) lower,

Okonkwo (2010) conducted a study on the effect of burning and cultivation on soil prosperities and microbial population of four different land use systems in Abakaliki. The result shows organic carbon has been reduce by 36%, 44% and 34% in forest land, continuous cropping land and alley cropping land respectively after burning. improving soil pH from highly acidic to moderately acidic in the bush fallow and mildly acidic (pH 6.1) in the alley cropping, respectively. While available phosphorous, exchangeable Calcium, Magnesium, and Potassium increased after burning and no effect on the microbial population was seen, the total soil N decreased across all land use systems.

Saharjo and Nurhayati (2005) studied changes in chemical and physical properties of hemic peat under fire-based shifting cultivation revealed that high fire intensity duringburning and flame height from 2.9 to 3.6 m caused 39.5 to 51.8 ton ha-1 of fuel load to be burnt and resulted in 2552.3 to 5050.9 kW/m of heat, thus negatively impactingthe peat by significantly affecting the chemical and physical properties of hemic peat. They also reported that the pre-burning of peat enhance only the chemical property of base saturation(hemic 2 and 3) and the physical property of water holding capacity after three and six months respectively.

Giardina *et al.* (2000) study the effects of slash and burn method on ecosystem nutrients during the land preparation phase of shifting cultivation and reported the most generally witnessed in change of soil due slash and burn method is beneficial only for a short-term increase in nutrient availability. The field investigations of soil heating as a method of slash and burn for enhancing available nutrients rarely evaluate the effects of soil heating on nutrient availability, and it is typically thought that these research have little practical significance. They suggest that it is necessary to update the conceptual models of shifting cultivation to better reflect these fluxes and losses.

Adeniyi (2010) reported the effects of slash and burning on soil microbial diversity and abundance in the tropical rainforest ecosystem; the results showed that the diversity and abundance of the soil microorganisms decreased significantly ($p \leq 0.05$) within the fourteen and twenty-eight days after burning. However, a substantial increase in the richness and diversity of the soil microorganism was

recorded after forty-two days of burning.

Ramchhanliana (2018) conducted a studied the impact of various fallow ages and treatments (such as litter, soil, and microbial inocula) on rhizosphere microbial populations, soil carbon and nitrogen dynamics, and quantification of annual plant root in shifting cultivation sites in Mizoram. With fallow periods, the rhizosphere effect of annual crops on the biochemical properties of the soil considerably decreased. Moreover, the study report that soil nutrition enhance the rhizosphere soil in comparison with bulk soil. The dynamic rhizosphere nutrient cycling sped up the re-establishment of vegetation in various fallows. He conclude that rhizosphere microorganisms of annual plants and litter treatment play a significant influence in changing the soil's structure and nutrient availability for sustainable shifting agricultural systems.

Meena and Rao (2021) studied the effect of different land use systems respectively on soil parameters, enzymes and microbial activities and concluded that in comparison toforest sites, there was a significant reduction in soil carbon (SC), soil nitrogen (SN), and thus soil microbial biomass carbon (SMBC), soil basal respiration (SBR), soil substrate-induced respiration (SSIR), and soil enzyme activities (-glucosidase, acid phosphatase, and dehydrogenase) under cultivated sites. A positive connection of SC with SMBC, SBR, SSIR was found in Pearson’s correlation and enzymatic activities (i.e., -glucosidase, dehydrogenase) also shows SC plays a critical role in microbial andenzymatic activity regulation. There was also a positive association between soil moisture and urease activity (P 0.01), indicating that soil moisture is an important abiotic component for soil biological processes.

Hauchhum and Tripathi (2017) have studied on rhizosphere effects of *Melocanna baccifera* on soil microbial properties under different Fallow phases of shifting cultivation and found that there is greater effect in short fallow phases than in the longer phase. The rhizosphere effect in young fallow is influence more by microbes growing under C and nutrient limited condition while in the older allows it is influenceby exploitation of the organic matter and nutrients accumulated in the area

by the microbes.

Järvan, *et al* (2014) conducted a study to examine how different farming approaches affected soil microbial populations and dehydrogenase activity (DHA). From 2008 to 2013, the five-field crop rotation was treated with organic, ORGFYM (organic with cattle manure), and CONFYM (conventional) (cow manure, fertilisers and pesticides). Three duplicates of soil samples from the treatments were gathered for microbiological testing in September every year. It was determined that the presence of solid cattle manure in ORGFYM increased the amount of bacteria, cellulose-decomposing bacteria, and dehydrogenase activity by 19.4%, 45.3%, and 22.7%, respectively. However, when taken as an average, there were no obvious or significant differences between ORFGYM and CONFYM. CONFYM show significant affect in microboal polulation and dehydrogenase activity due to use of pesticides.

The above reviews of literature revealed that the studies are more in field the soil physic-chemical properties and diversity of micro-organisms and the type of microbespresent in the area. However study on effect of microbial population due to slash and burn is still limited especially in the state of Mizoram. Therefore this research aims more on the study of changes in microbial population rather than its change in diversity.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study area

Depending on the types of farming structure within Aizawl district. The present studyis carried out within 15-20 km circle of Aizawl district in two village i.e. The first site was selected at Tachhip village located at $23^0$33’75” N and $92^0$43’26” E which the shifting area has bunding (BS) with log and bamboo along the contourline and anothersite was located at Lungverh village which is located at $23^0$47’273” N and 92^0 40’147”E which normal shifting cultivation (NS) is practiced. Both site comes under humid tropical area. NS have a vegetation type of mustard, sesame, chilli, brinjal, maize etc and cucumber, maize, brinjal, paddy, broad beans, winged beans, pigeon peas, ginger, chilli are found to be grown in BS.

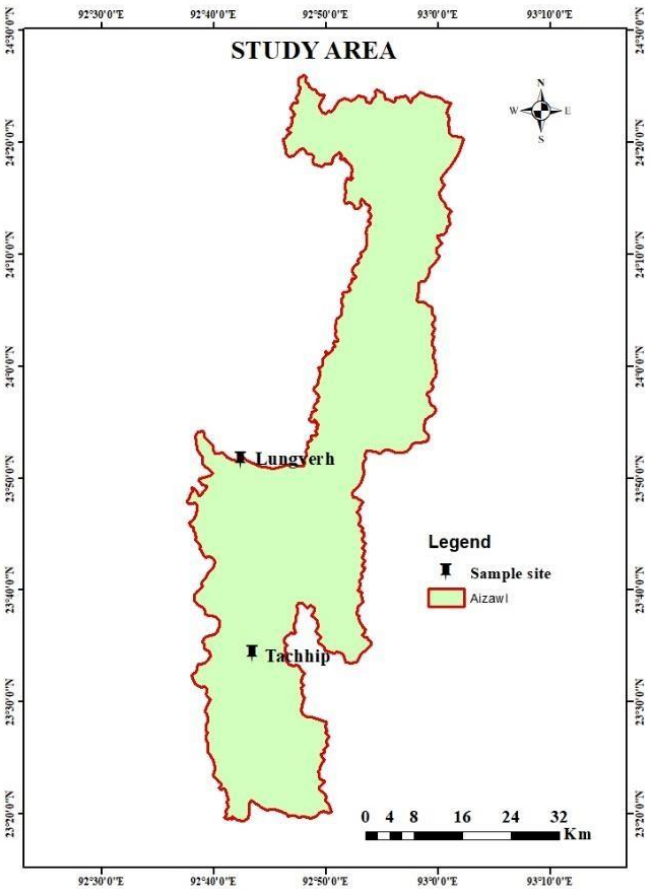

Fig-1: Location map of the study site

3.2 Soil collection

For microbial count the soil samples are collected from the rhizosphere zones in the depth of 0 – 15 cm. The soil samples are packed in sterile polythene bags which is sealed properly and then brought back to laboratory and 100g of each is stored at 4^0Cfor analysis of microbial population and for soil physic-chemical properties they werecollected at depth of 0-10, 10-20 and 20-30 cm and sieved at 2 mm to remove any impurities and stored at room temperature after air drying for analysis. Soils were collected after burning the fallow land from NS and BS.

3.3 Isolation of microbial population

Serial dilution method (Dutta et al., 2015) was used for isolation of microbial population. 1g of homogenized soil from top layer (0 – 5 cm) is suspended in 10 ml of saline solution (NaCl 9g/100 ml of distilled water) and then kept in shaking condition (200 rpm) at 30^0C for 30 minutes. The soil suspension is then serially diluted up to 10^{-6}. An aliquot of 0.1 ml or 100µl of each dilution is evenly spread over the surface of isolation media namely nutrient agar (NA) for bacteria and potato dextrose agar (PDA)for fungus. Nystatin and Rose Bengal are used as antibiotics in the media nutrient agarand PDA respectively. Plates were incubated BOD at 26 ^{0}C for fungus and 37 ^{0}C for bacteria for a duration of 2 – 3 days and 12 – 24 hrs respectively. The fungus and bacteria colonies appeared on the plates are counted after the incubation period. Both the bacteria and fungi population are calculated from the highest number of colonies forming units (CFU's) obtained with dilution factor 10^{-4}. Microbial population is then determined by the standard formula:

$$\text{Total microbial population} = \frac{\text{Total numner of colonies} \times \text{Amount of aliquot}}{\text{Dilution factor}}$$

3.4 Soil analysis in laboratory:

3.4.1 Determination of Soil Moisture Content (SMC):

Soil Moisture Content (SMC) is to determined by gravimetric method on a dry weight basis where 10g of fresh soil samples are taken on a petridish followed by drying in hot-air oven at 105ºC until constant weight is obtained. Then, oven dry weights are recorded and moisture content was expressed as percentage of the dry weight (Bandyopadhyay et al., 2012).

$$\text{Moisture Content (\%)} = \frac{\text{Fresh weight} - \text{Oven dry weught} \times 100}{\text{Oven dry weight}}$$

3.4.2 Determination of soil pH value:

Soil pH is determined by using digital pH meter with soil- water ratio 1:2 w/v. 10 gm of fresh soil samples are mixed with 20 ml of distilled water and then shake for 15-30minutes and left for 24 hours. After 24 hrs, soil solutions are measured using the digital pH meter. The pH meter are calibrated before sample reading with a buffer solution of pH 4 and pH 7 for accurate results. Lastly, the pH values of the different soil samplesare recorded (Bandyopadhyay et al., 2012).

3.4.3 Determination of Bulk density (BD):

Bulk density was measured by collecting a known volume of soil using soil corer anddetermining the weight after drying for 6 hours in hot air oven at a temperature of 105ºC. The diameter and height of the soil corer was recorded for volume calculation(Blake &Hartge, 1986).

$$\text{Bulk density} = \frac{Dry\ weight\ of\ the\ soil}{Volume\ of\ the\ soil}$$

3.4.4 Determination of soil texture:

Soil texture was determined by using hydrometer method (Bouyoucos, 1962) in which 50g of an air dried (2mm sieved soil) is taken in a beaker and added 200ml distilled water and 5ml hydrogen peroxide and covered with foil papers which are then kept in hot water bath. The samples were made up to 250 ml with distilled water and 10 ml of sodium hexa-metaphosphate is added and kept for 15 minutes. The soil suspension in the cup is stirred and kept for 10 minutes. The soil suspension is then transferred to 1000 ml measuring cylinder and the volume is made up to 1000 ml with distilled water. Finally, the hydrometer reading is taken after 4 minutes and 2 hours respectively. The percentage of sand, silt and are calculated and textural classes was determined using the textural classification (USDA).

3.4.5 Estimation of Soil Organic Carbon (SOC):

Total Organic Carbon (TOC) was determined by using Walkley and Black (1934) rapid oxidation and titration method. About 0.5 gram of air dried soil is mixed with 10 ml of 1N $K_2Cr_2O_7$ and 20 ml concentrated H_2SO_4 were in 500 ml conical flask and is then swirled and kept for 30 minutes. After that 100ml of distilled water and 5 ml of orthophosphoric acid was added followed by 1 ml diphenylamine indicator that gives dark blue color and then titrate with 0.5N FAS until it changes to parrot green colour and the readings are then recorded for each sample. Blank reading was also taken with the same procedure but without soil sample and the reading was taken for the analysis of total organic carbon.

$$100\text{ g SOC content (\%)}, A = \frac{(\text{Blank} - \text{Sample reading}) \times 0.5 \times 0.003 \times 100\text{ g}}{\text{Sample Weight}}$$

Organic matter (OM) content (%) in soil= A × 1.724

3.4.6 Estimation of Available Phosphorus (P):

Available Phosphorus was determined by using Bray and Kurtz method (1945). In thismethod air dried soil of 0.5g (2 mm sieve) is put in 250 ml conical flask with 50 ml extractants and shake for 5 minutes and filter through Whatman number 42 filter paper.Then 5 ml of Bray's reagent was added to 5 ml of aliquot in 25 ml volumetric flask followed by 1 ml stannous chloride. The intensity of colors are measured using spectrophotometer at 660nm after volumes were made upto 25 ml with distilled water.

$$\text{Available P kg ha}^{-1} = \frac{\text{Conc.of P} \times \text{dilution factor} \times 2.24 \times 10^6}{10^6}$$

$$P_2O_5 \text{ kg ha}^{-1} = P \times 2.29$$

3.4.7 Estimation of Total Nitrogen (TN):

Total Nitrogen content in the soil samples were determined using Kjeldahl Method of Nitrogen estimation (Baethgen & Alley, 1989). This method involves several steps such as digestion, distillation and titration. In this method, 5g of air dried soil was transferred to digestion tube then 10-15 ml of concentrated H_2SO_4 and 5 – 7 g of catalyst mixture (K_2SO_4 & $CuSO_4$ $5H_2O$ in the ratio of 5:1) was added. The digestion tubes are then heated at 410ºC till samples turn colourless or light green colour. Afterthat digested samples are diluted with 10 ml distilled water and shake and added 40 ml of 40 % NaOH. In distillation process, 250 ml of conical flask containing 25 ml of 4%boric acid and 3 drops of methyl red and bromocresol green is added in it and boric acid turned colourless after distillation. Then the conical flasks are then taken for titration. Then the solutions are titrated with 0.1 N HCl until the solution turn pink colour. The burette readings are taken and then percentages of TN is calculated usingthe formula given below,

$$\text{Total Nitrogen (\%)} = \frac{14 \times \text{normality of acid} \times \text{titrant value} \times 100}{\text{sample weight} \times 100}$$

3.4.8 Estimation of Ammonical Nitrogen (AN):

Ammonical nitrogen in the soil sample was determined by indophenol blue method. This method involves 10 g of fresh soil mixed with 100 ml of distilled water and shake for proper extraction. Then 5 ml of aliquot was mixed with 8 ml of rochelles reagent, 1 ml of sodium nitroprusside solution, 2 ml of sodium phenate reagent and 0.5 ml of hypochlorite solution (pure). The volumes of this content was made up to 50 ml then kept in hot water bath at 40ºC for 20 minutes. After that the samples are set cool and the absorbance value was taken at 625 nm in spectrophotometer (Jackson, M. L., 1958).

$$NH_4\text{-N (\%)} = \frac{X \times \text{extractant volume (50 ml)}}{10 \times \text{aliquote (5 ml)} \times \text{sample dry wt.}}$$

Where, $NH_4 - N$ (µg/g) = 10000 * $NH_4 - N$ (%) µg/ g

3.4.9 Estimation of Nitrate Nitrogen (NN):

Nitrate nitrogen in soil sample was determined by phenol di-sulphonic acid method in which 10 g of fresh soil is added in 50 ml distilled water and then shaken. After that, 10 ml of aliquot was transferred into 100 ml beaker which was then kept in hot water bath till dry. After the samples were cooled, 2 ml of phenol di-sulphonic acid and 20 ml of distilled water were added. Then ammonia hydroxide solution is added till yellow color persists. Then the volume solutions were made up to 50 ml by adding dtilled water. Using spectrophotometer the absorbance value was measured at 410 nm(Jackson, M. L., 1958).

$$\text{Nitrate nitrogen } (NO_3\text{-N}) = \frac{X \times \text{ectracted volume (50 ml)} \times 102}{\text{Aliquot (10 ml)} \times \text{sample dry wt.}}$$

Where, X = Value of spectrophotometer reading

3.4.10 Estimation of available potassium (K_{Avail})

Available potassium was estimated by using flame photometer (Black, 1965). For thismethod a standard curve is prepared by taking 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 ml of 100 mg/kg K solution in different 25 ml volumetric flask and the volume was made up with 1N NH_4OAc solution. The flame photometer reading is adjusted at zero with blank (zero K) solution and at 100 for 40 mg/kg K solution. Then the flame photometer readings or every dilution were taken and used for plotting the standard curve by takingK concentration reading on X axis and flame photometer reading in Y axis which givesthe factor (F) of 1 flame photometer reading = 0.4 mg/kg K.

After preparation of the standard curve, 5 g of soil sample was mix with 25 ml of 1N NH_4OAc solution and then shake for 5 mins and then the solution is filtered through Whatman No. 1 filter paper and the potassium extract was measured using flame photometer after calibration. And the available K is be calculated using the formula given below.

$$\text{Available K (kg ha}^{-1}) = \frac{R \times F \times 25 \times 100 \times 20 \times 1.121}{5 \times 1000}$$

$$= R \times F \times 11.217$$

Where, R = Reading from graph μg K ml^{-1} in extract

F = dilution factor

3.4.11 Determination of enzyme activity

3.4.11.1 Dehydrogenase activity (DHA)

For determination of DHA Casida et al. (1964) method was used. In this method 0.015g of $CaCO_3$ is added to 1.5 g of soil in a test tube and 0.25 ml of 3% aqueous solutionof TTC is added. After this 0.625 ml of distilled water is added into the test tube and shaken well for a few minutes and the test tubes are then incubated at 37 ^{o}C for 24 hrs. After incubation the soil solution were then filtered using absorbent

cotton plugs with the aid of methanol. The filtrate solution solutions are then determined for its colour intensity using spectrophotometer at a wavelength of 485 mμ and the readings are recorded.

3.4.11.2 Urease activity

Urease activity was determined using Kandeler and Gerber (1988) method. In this method, 5 g of soil was taken in a conical flask and 2.5 ml of 0.08 M aqueous urea solution was added and then sealed and incubated in BOD at 37 ^{0}C for 2 hrs. The seal was then removed and 50 ml of 1N KCl was added and kept in a mechanical shaker for 30 mins. The suspention was then filtrated and the filtrates was analysed for ammonia by using calorimetric procedure.

CHAPTER 4
RESULTS

4.1 Soil physical properties

The percentage of SMC was observed to be significantly higher in NS than in BS. The SMC % in NS decreases with increase in soil depth which is found similar in BS. The average soil moisture content in NS in depth of soil are 0 – 10 cm (27.12%), 10 - 20 cm (25.57%) and 20 – 30 cm (19.54%) and the soil moisture content in BS in soil depth are 0 – 10 cm (17.53%), 10 – 20 cm (15.99%)and 20 – 30 cm (14.94%).

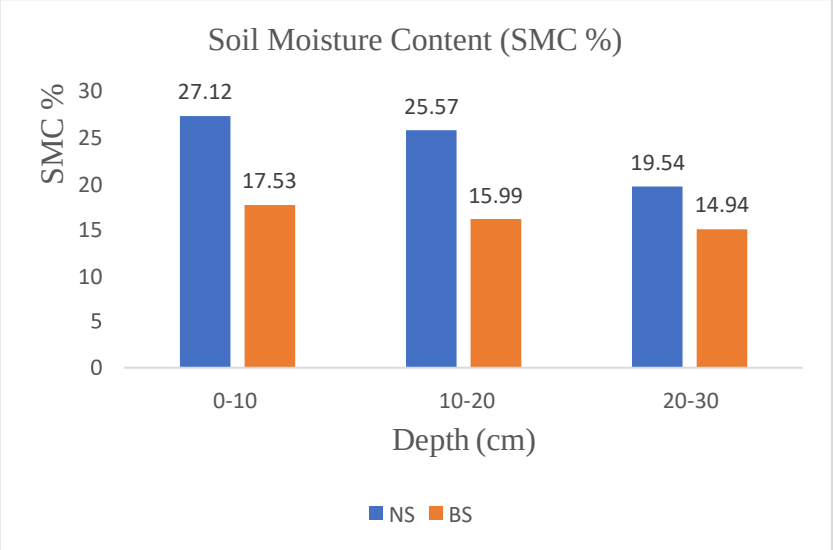

Fig - 2: Average soil moisture content (%)

For bulk density, the value ranges from 1.12 – 1.31 in NS and 1.21 – 1.35 in BS. The highest BD was found in depth 20 – 30 cm (1.35 g cm^{-3}) in BS and lowest in 0-10 cm depth (1.13 g cm^{-3}) in NS (Fig–3).

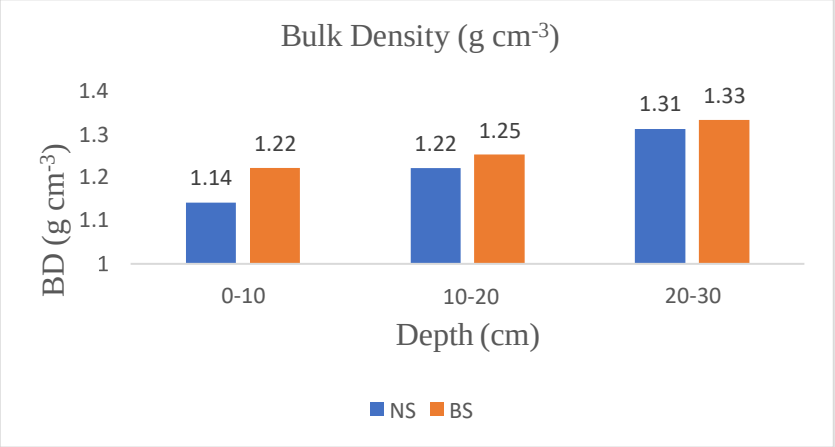

Fig - 3: Average Bulk Density (g cm^{-3})

Soil textural class was found to be sandy loam in all the layer studied for both NS andBS. With respect to depth of soil, sand was observed to decrease with increased in depth of the soil while the value of silt increases with increase in soil depth and clay concentration wasfound to be more at the lower depth of soil as compared to top layers of soil in both NS and BS. The sand concentration in the soil of NS was maximum at a soil depth of 0-10 cm with a value of 72 and the minimum value of 67.8 at a soil depth of 20-30 cm. The maximum silt content in NS was found at a depth of 10 - 30 cm (16.2), while the minimum was observed at a soil depth of 0 - 10 (10.8). The soil depth 20-30 (18.6) had the highest clay content, while the depth 0-10 had the lowest (14.5).

In BS the sand concentration in the soil of was maximum at a soil depth of 0-10 cm (72) and minimum 67.2 was observed in 20-30 cm depth. The silt presence was observed maximumin sub surface depth than the upper soil i.e. 16.8 in both 10-20 cm and 20-30 cm and 14.2 at the upper layer (0-10) of soil. The depth 20-30 cm contained the most clay (17.2) and the top soil 0-10 cm contained the least clay (13.6) as shown in Table 1.

Table 1: Soil textural class of NS and BS

Depth (cm)	**NS**				Textural class
0-10	Sand %	72	69.2	71.8	Sandy Loam
	Silt %	10.8	15.6	13.7	
	Clay %	17.2	15.2	14.5	
10-20	Sand %	67.2	68.6	67.8	Sandy Loam
	Silt %	16.2	13.8	15.4	
	Clay %	16.6	17.6	16.8	
20-30	Sand %	66.8	65.6	66.2	Sandy Loam
	Silt %	15	15.8	15.4	
	Clay %	18.2	18.6	18.4	
	BS				
0-10	Sand %	72	70.4	71.7	Sandy Loam
	Silt %	14.4	14.4	14.2	
	Clay %	13.6	15.2	14.1	
10-20	Sand %	68	69	68.3	Sandy Loam
	Silt %	14.8	16.8	15.6	
	Clay %	17.2	14.2	16.1	
20-30	Sand %	67.2	68	67.5	Sandy Loam
	Silt %	15.6	16.8	16.6	
	Clay %	17.2	15.2	15.9	

4.2 Soil chemical properties:

Both types of soils from NS and BS have acidic soil pH values. The pH values increase as depth increases as shown in Fig - 4. The pH ranged from 4.63-5.43 in BS and 5.37-6.26 in the BS area. The maximum pH (6.27) value was observed at 20-30 cm depth inBS and the least 4.63 was recorded at a depths of 0-10 cm NS area.

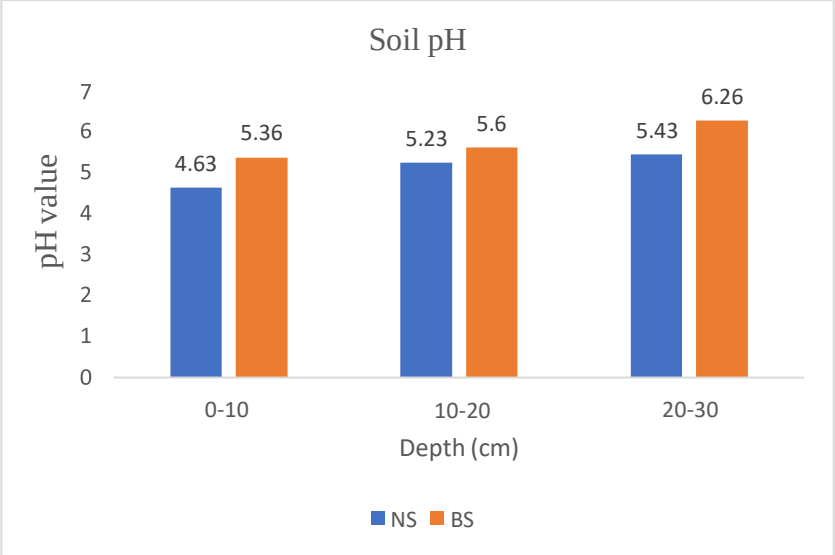

Fig - 4: Graphical representation of soil pH

The values of SOC % decreases with increase in depth (Fig - 5). The average value ranges between 2.62 - 3.24 in NS and 1.83 - 2.75 in BS respectively. The highest value 3.24 was observed in NS at 0 - 10 cm depth and the minimum 1.83 was observed in BS at 20 – 30 cm depth.

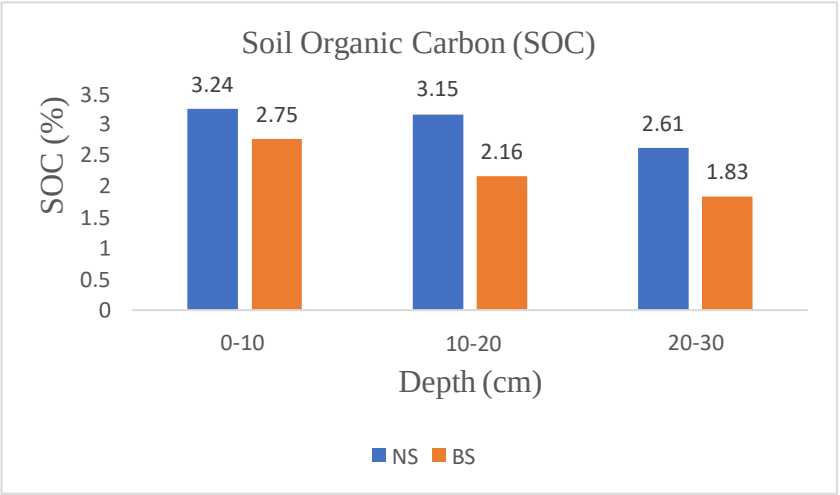

Fig - 5: Soil Organic carbon

Concentration of ammonical nitrogen was found to be higher at NS as compared to BS. The value of NH_4-N (µg g^{-1}) is indirectly proportional to depth of soil in both the study sites. Average highest value of NH_4-N (µg g^{-1}) in NS was recorded at a value of 8.54 in 0 - 10 cm depth of soil and lowest value is 6.05 at 20 – 30 cm depth of soil. At BS, the NH_4-N (µg g^{-1}) value ranges between 4.33 to 6.47 (Fig–6). The total nitrogen content (TNC) also decreases with increase in depth of soil. The highest TNCat 0-10 cm depth with a value of 3791.8 µg g^{-1} in NS and lowest at 20-30 cm with a value of 2896.5 µg g^{-1} in BS area. The average total nitrogen content is higher in NS ascompared to BS and the value ranges from 3791.8 µg g^{-1} to 2896.5 µg g^{-1}.

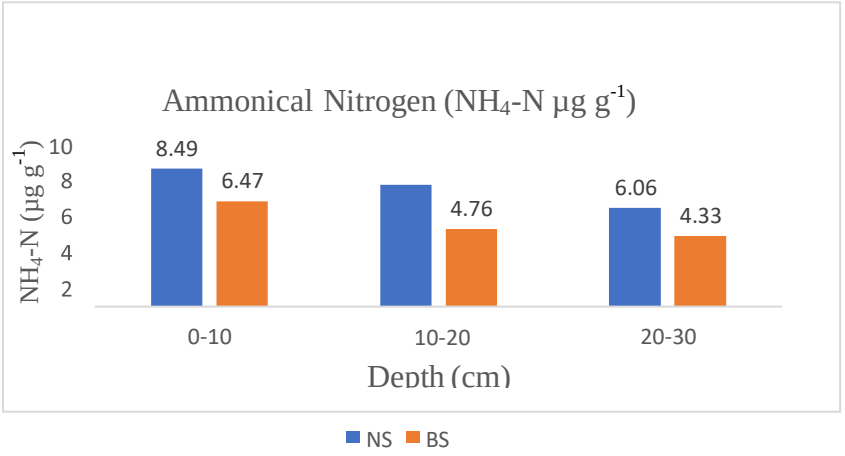

Fig - 6: Graphical representation for average content of NH_4-N (µg g^{-1})

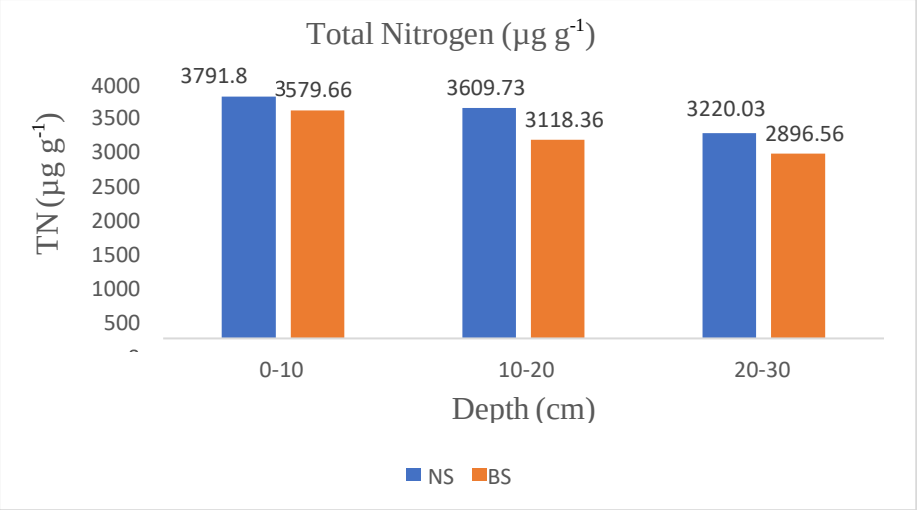

Fig – 7: Graphical representation of average Total nitrogen (µg g^{-1})

The values of nitrate nitrogen were decreasing with increase in depth. The average values range between 5.08 - 8.96 µg g^{-1} in NS and 3.51 - 5.62 µg g^{-1} in BS. The highest value was observed in the NS (8.96) at 0-10 cm depth and minimum was observed in BS (3.50) at 20-30 cm depth.

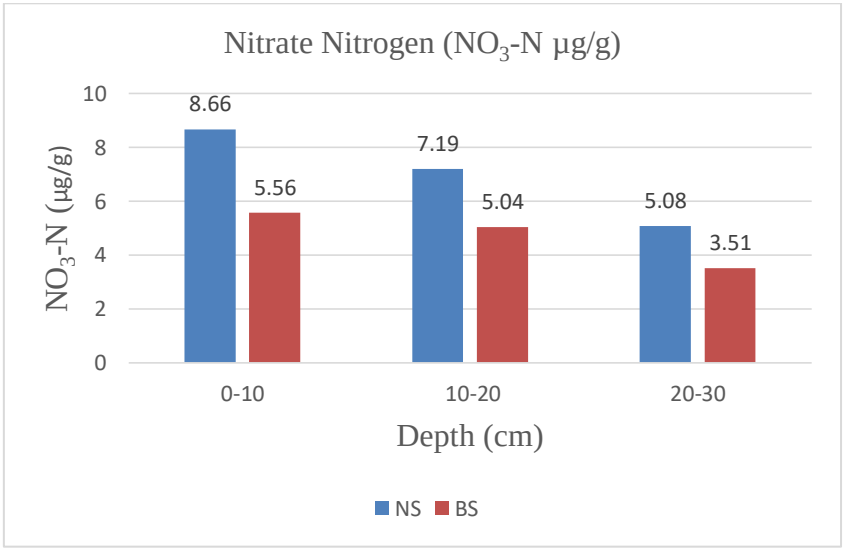

Fig - 8: Graphical representation of average Nitrate Nitrogen (NO_3-N µg g^{-1})

The values of available phosphorus were decreases with increase in depth. The averagevalues were range between 15.78 - 18.17 in NS and 13.61-17.65 in BS. The highest value was observed in the NS (18.18) at 0-10 cm depth and minimum was observed inBS (13.62) at 20-30 cm depth.

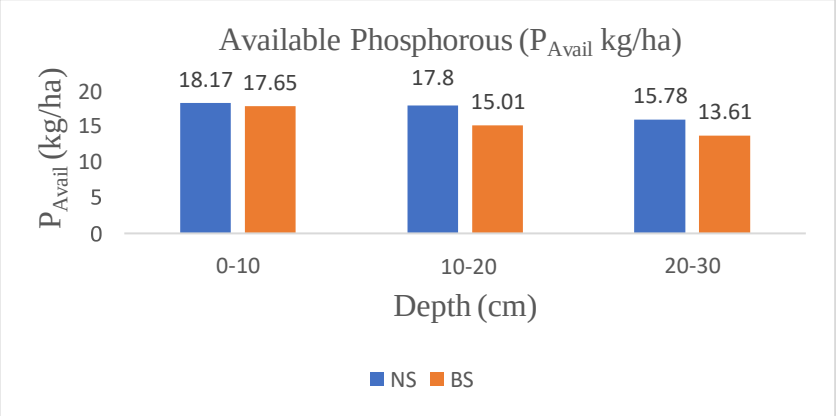

Fig - 9: Graphical representation of available Phosphorus

The availability of potassium in both the sites i.e. NS and BS decreases with increasing soil depth and is found to be more abundant in NS than in BS. The average value of availability of potassium in both the sites ranges from 143.7 – 459.94 (µg g^{-1}) as shown in Fig – 9. The lowest value of available potassium was found to be 140.71 µg g^{-1} in R_2 at 20 - 30 cm depth in BS and highest was 461.41 µg g^{-1} which is recorded from R_2 of 0 - 10 cm from NS area.

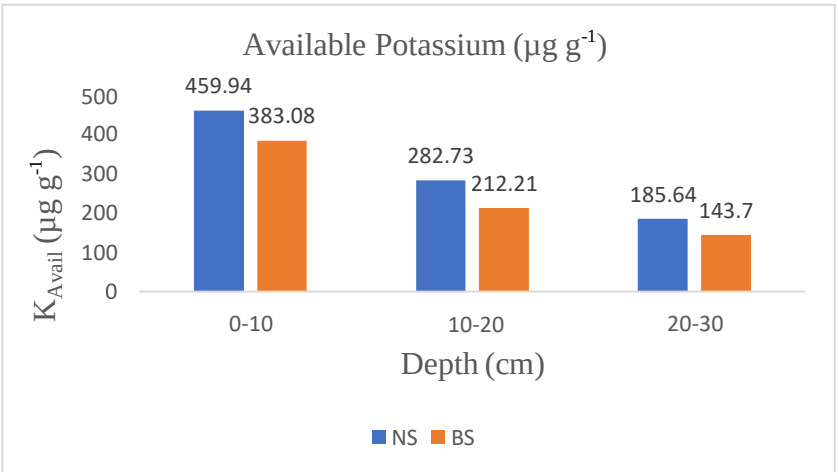

Fig - 10: Graphical representation of average Available Potassium (µg g^{-1})

4.3 Microbial population count

The average bacterial count in BS was 61.6 × 10^3 colonies forming units where as in NS it was 223.3 x 10^3. However fungal count for both the sites were less than bacteria. Fungal count was 14.3 x 10^3 in BS and 22 x 10^3 in NS area. The study showed that microbial population count was higher in NS soil which have lesser period of time interval between burning and growing of crops as compared to BS soil.

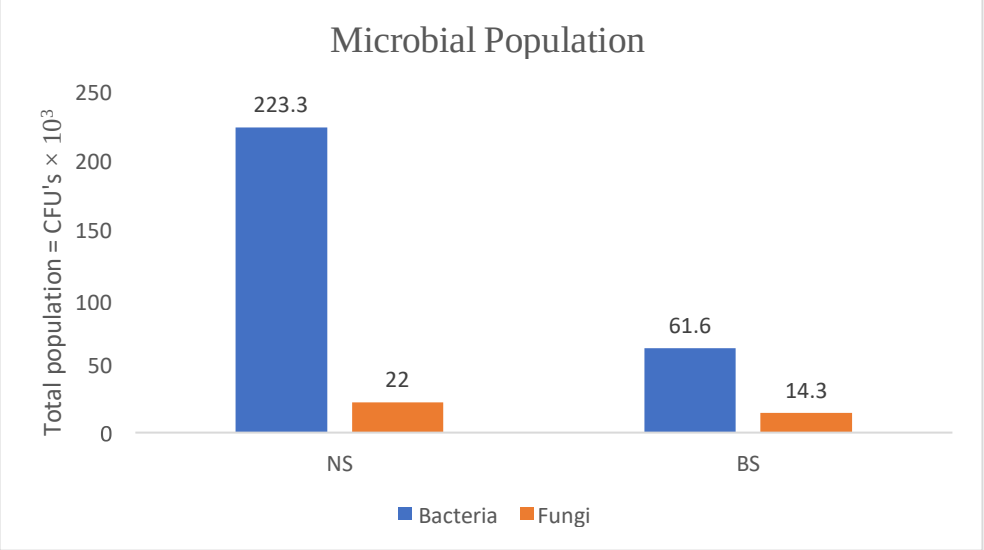

Fig - 11: Graphical representattion of average microbial count for NS and BS area (Total population = CFU's × 10^3 per gram of soil)

4.4 Enzyme activity

The study revealed that DHA and Urease activity was higher in BS than NS (Fig-11).In BS DHA was found to be 1.24 TTC µg g^{-1} soil/ hr where as in NS it was 0.82 TTC µg g^{-1} soil/ hr. Likewise, Urease activity was more than 50% higher in BS as compared to NS. Similar findings were also reported in cultivated land of Delhi (Meena & Rao,2021) where enzyme activity was higher in crops covered land than in open area.

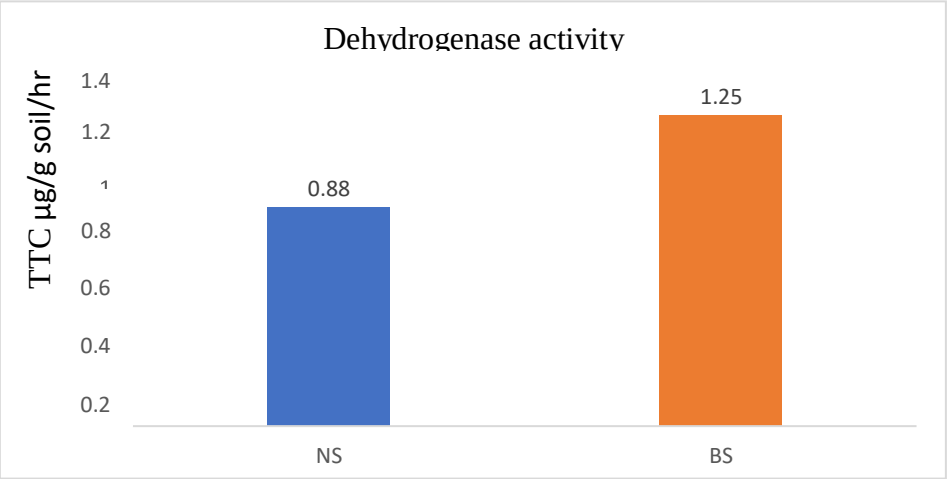

Fig - 11: Graphical representation of DHA

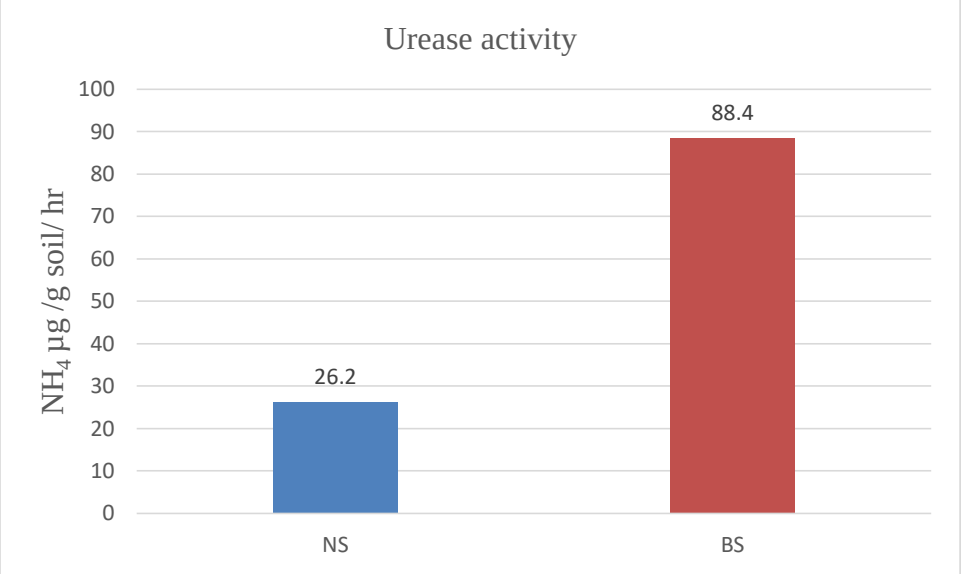

Fig - 12: Graphical representation of Urease activity

4.5 Correlation coefficients between different soil physico-chemical and biological parameters from Normal Shifting cultivation (NS) and Bunding Shifting cultivation (BS)

Pearsons correlation was taken for the total depth (0–30 cm) in which the average values are taken and the test revealed a significant correlation between different soil parameters (Table 2). The test revealed pH have a negative correlation with SMC, NH_4-N, NO_3-N, TN, K_{Avail} ($p<0.01$) and SOC, P_{Avail} ($p<0.05$) but shows a positive correlation with BD, Urease ($p<0.01$) and DHA ($p<0.05$). SOC have a strong positive correlation with SMC ($p<0.05$) and a negative correlation with DHA and Urease ($p<0.05$).

SMC shows a high positive correlation with NH_4-N, P_{Avail}, NO_3-N, TN, K_{Avail} ($p<0.01$) and high negative correlation with pH, BD, DHA, and Urease ($p<0.01$).

Sand, silt and clay doesn't show any correlation with any of the other soil parameters. BD have a high positive correlation with pH ($p<0.01$) and Urease ($p<0.05$) and high negative correlation with SMC ($p<0.01$) and K_{Avail} ($p<0.05$). Strong negative correlation was observed in NH_4-N with both DHA and Urease activity ($p<0.01$) and also with BD ($p<0.05$).

DHA have a positive correlation only with pH ($p<0.05$) and Urease activity ($p<0.01$) and shows a negative correlation or no relation with all the other soil parameters. Similarly urease activity also shows positive correlation only with pH, DHA ($p<0.01$)and BD ($p<0.05$) and negative correlation or no correlation with all the other soil parameters. Bacterial population shows a positive correlation with Fungi population ($p<0.05$). Both bacteria and fungi shows a negative correlation with BD and urease activity ($p<0.05$).

Table 2: Correlation coefficients (R) between soil pH, soil organic carbon (SOC), soil moisture content (SMC), ammonical nitrogen (NH_4-N), bulk density (BD), available phosphorous (P_{Avail}), nitrate nitrogen (NO_3-N), total nitrogen (TN), available potassium (K_{Avail}), sand, silt, clay, dehydrogenase activity (DHA), urease activity and microbial population (Bacteria and Fungi)

	pH	SOC	SMC	NH_4-N	BD	P_{Avail}	NO_3-N	TN	K_{Avail}	Sand	Silt	Clay	DHA	Urease	Bacteria	Fungi
pH	1	-.897*	**-.969****	**-.939****	**.934****	-.864*	**-.918****	**-.918****	**-.941****	.124	.003	-.303	**.884***	**.949****	-.762	-.764
SOC		1	**.912***	.851*	-.802	.815*	.864*	.852*	.838*	.027	-.263	.415	**-.847***	**-.862***	.739	.559
SMC			1	**.979****	**-.951****	**.928****	**.977****	**.957****	**.980****	-.195	-.145	.496	**-.924****	**-.986****	**.888***	**.820***
NH_4-N				1	-.901*	.979**	.996**	.979**	.998**	-.147	-.240	.596	**-.970****	**-.999****	.857*	.845*
BD					1	-.801	-.888*	-.854*	**-.917***	.356	-.104	-.308	.778	**.916***	**-.894***	**-.876***
P_{Avail}						1	**.985****	**.966****	**.969****	-.053	-.411	.721	**-.988****	**-.970****	.813*	.794
NO_3-N							1	.976**	.992**	-.140	-.302	.647	**-.971****	**-.994****	.880*	.834*
TN								1	.981**	-.220	-.220	.627	**-.980****	**-.982****	.834*	.740
K_{Avail}									1	-.209	-.187	.581	**-.959****	**-.999****	.872*	.851*
Sand										1	-.555	-.094	.037	.179	-.470	-.220
Silt											1	-.743	.378	.204	-.150	-.083
Clay												1	-.679	-.576	.623	.430
DHA													1	**.964****	-.763	-.714
Urease														1	**-.868***	**-.839***
Bacteria															1	**.823***
Fungi																1

. Correlation is significant at the 0.05 level (2-tailed).** *. Correlation is significant at the 0.01 level (2-tailed).**

CHAPTER 5
DISCUSSIONS

5.1 Effects on soil physical properties by land use systems and soil depths

Due to changes in plant species, their ages, and ecological factors, land use regimes and soil depths have had a significant influence on soil physical qualities. Because of the quantity and quality of regenerated plant biomass of secondary vegetation and associated microorganisms throughout time, fallow length also has a significant effect in soil fertility and crop productivity in slash and burnt cultivation. It is still unclear how the amount of litter affects the soil's fertility and related microbes throughout various fallow periods. According to scientific research, soil microbes and litter may have a significant impact on agricultural methods that are changing toward sustainability.

In this research, the overall SMC percent values decreased with depth in bothBS and NS (Fig-2). It has been reported that conversion of forest to plantations in Indonesia, Peru and Southern Cameroon led to low moisture availability due to losses in the top soil and vegetation (van Straaten et al., 2015; Guillaume et al., 2016).

SMC was observed to be higher in NS in comparison with BS. This maybe attributable to the presence of continuous vegetation cover in these land uses since lack of vegetation during rains lead to decreased infiltration rates due to losses through runoff which influences the conservation of moisture in the soil (Sadeghi *et al.,* 2007). SOM is considered as one of the most important dependent factors for SMC in the soil owing to its hydrophilic character and its ability to improve soil structure (Haynes andNaidu, 1998) which favours SMC conservation.

In this study, soil BD was found to be substantially lower in NS than BS. It appears that the transformation of natural forests to agricultural land or plantations causes more top soil loss during the rainy season in NS due to erosion, and

thus higher BD in BS where soil is protected using bunding with logs or bamboo, which results in more compacteness of soil as compared to NS.

The proportional increase in soil BD with increasing soil depth in both BS and NS can be associated with decreasing SOM as well as the particle size distribution and the overlying weight (Anteneh *et al.,* 2013). The lower BD in the surface soil layer is widely reported by the higher build-up and accumulation of SOM (Lalnunzira and Tripathi, 2018).

In case of soil texture, both the sites BS and NS have similar textural class i.e. sandy loam. Clay was observed highest in the sub-surface depth (20-30 cm) which is in accordance with the findings in the study by Tufa *et al.* (2019) from cultivated lands. Our findings on increasing clay content with increasing soil depth are in accordance with the findings from Awdenegest *et al.* (2012). Chemada *et al.* (2017) also stated that continuous and longer period of cultivation enhances increased in clay content from surface layer to sub-surface and deeper layers in cultivated lands. Sand concentration was also found to be greater in the upper layer than in the deeper levels. Which are in accordance with the findings from the study by Gebrelibanos and Assen(2013) where higher sand concentration was observed in the surface layer which is chiefly due to reason that sand concentration usually remains higher in the surface soillayer.

5.2 Effect on soil pH, available phosphorus and available potassium in differentland use systems and soil depths

All land use patterns had acidic soil at two distinct depths (10–20 cm and 20–30 cm). A higher surface soil pH is commonly attributed to the release of potash as a result of the standard slash and burn land use strategy. Burning enhances the release of nutrients in the soil and thus increasing the soil pH (Moraes *et al.,* 1996). Sarkar *et al.* (2010) reported that available phosphorous of soil increased with the addition and presence of litter in on the soil surface. Soil organic matter (SOM) content, which contributes to the phosphorous pool in the soils of the research

region, decreases with increasing soil depth, resulting in a decrease in accessible phosphorous of soil. In addition, SOM influences the available phosphorous through anion replacement of H_2PO from adsorption sites and the formation of organophosphate complexes which are readily taken up by plants as reported in different studies (Abebe and Endalkachew, 2012; Nega and Heluf, 2013).

Same trend was observed in Abakaliki, where Okonkwo (2010) investigated the effects of fire and agriculture on soil properties and microbial populations in four distinct land use regimes. In the alley cropping system, burning improved soil pH in the bush fallow system from strongly acid to moderately acid, and mildly acid. However organic carbon has been reduce by 36%, 44% and 34% in forest land, continuous cropping land and alley cropping land respectively.

The current study shows available phosphorus contents in soils from two different land use systems ranged from 15.78 to 18.18 in NS and 13.61 to 17.66 in BS. The concentration of readily available phosphorus was highest in NS and least in BS. The result indicated that the conversion of natural forest to other land uses significantlydecreases the available content in the soil, which reflected a consistent reduction in available content in soils under cropping in relation to native forest because of the disruption in nutrient cycling (Tripathi and Singh, 1994, Tripathi *et al*. 2008). Chacon and Dezzeo (2004) stressed that conversion of native forests to cultivated lands leadsto decrease in phosphorous concentration.

The different land use patterns and soil depths have great impact on the recent investigations into potassium availability. Aytenew and Kibret (2016) and Selassie and Ayanna (2013) both reported findings of a similar nature. Potential causes of the higher K_{Avail} concentrations in NS include the rapid growth of herbaceous vegetation, which prevented runoff and erosion, and the closed canopy, which protected the soil from the direct effects of rainfall. In addition, Ramakrishnan and Kushwaha (2001) indicated that longer fallow periods (>20 years) contained more soil available nutrients leading to better crop productivity in comparison to younger fallow lands. A prolonged period of fallow favours nutrient

conservation since the fallow period was crucial in promoting soil nutrients. Wapongnungsang (2017) also indicated that a fallow period of more than 10 years leads to higher conservation of nutrients in the soil than shorted fallow during cultivation throughout the cropping season. Our lower values of K_{Avail} in the lower layer of soil with higher concentrations in the surface layer (0-10 cm) are in conformity with the study carried out by Yimer *et al.* (2008) in Ethiopia where the values of the elements were observed to be lower in cultivated lands than in grasslands or native forests.

5.3 Effect on SOC, TN, nitrate nitrogen, ammonical nitrogen as influenced bydifferent land use systems and soil depths

Significant variations in SOC and TN were observed across a range of land use patterns and soil depths. With deeper soil levels across the land use systems, a declining trend in SOC and TN could be seen. The higher SOC and TN in the surface layer (0-10 cm) may be well attributed to the higher organic matter content (Poorter *et al*, 2016). Several other studies have also reported similar reports of decreasing TOC with increasing soil depths (Moges, 2013).

Maximum SOC and TN in BS and NS may be a result of elevated organic matter inputs from both above and below ground biomass in these soils (Materechera, 2010; Murovhi, 2012). Due to its vegetation and abundant litter, it is projected that NS soils will contain more organic matter than BS. Several studies from sub-tropical regions of Northeast India have indicated the role of root and leaf litter accumulation in maintaining soil Carbon and nitrogen (Ovung *et al.,* 2021; Wapongnungsang *et al.,* 2017, Lalnunzira and Tripathi, 2018). Another important factor contributing to loss of TN in cultivated soils such as homegarden can be related to the uptake of N by crops since N is one of the most rapidly absorbed nutrients (Salcedo, 2008).

It was observed that both nitrate nitrogen and ammonia nitrogen were found to follow the same general pattern. All the values were significantly higher in all the upper layer. The values or content of all the chemical parameters tested were significantly decreases with increase in depth. The main reasons for higher content of chemical parameters in maybe due to more vegetative cover and high leaf litter falls.

5.4 Effect on microbial population and biochemical (enzyme activity) propertiesof soil as influenced by the different land use systems

The study shows that microbial population was higher in BS than in NS. This can be related with the findings of Saplalrinliana et al. (2016) where they proposed that slash and burn can induce modification in below ground microbial community. So, burning can induce microbial population, however with the course of cropping microbial population decreases. Microbial activity is reduced as a result of routine weeding from the surface vegetation. These management approaches generally remove soil cover and decreases organic matter inputs leaving the soil bare and vulnerable to erosion by soil and water (Foley *et al.,* 2005; Giller *et al.,* 1997; Mills and Fey, 2004). The decrease in population of fungi, bacteria and actinomycetes with increasing depths may be attributed to the decreasing organic matter which acts as a source of carbon for the microbes for their metabolism (Bhattarai et al., 2015). The enzyme activity was also higher in BS whichhave more crops cover as compared to NS and this findings are in similar with the reporrt from from cultivated land of Delhi (Meena & Rao, 2021) where enzyme activity was higher in crops covered land than in open area.

CHAPTER 6
CONCLUSION

Land use change induced by anthropogenic involvements and management of the land has a significant effect on physical, chemical, microbial population of the soil. Crucial soil fertility indicators such as Soil organic carbon (SOC), total nitrogen (TN), and soil microbe diversity were considerably influenced by the different land use methods of the study. This study concluded that the practice of bunding does not have any advantages to normal shifting cultivation on the soil physico-chemical properties except for preventing the soil erosion. According to the current findings, soil that is being farmed is subject to a number of disturbances as a result of the different management practises that are used, as well as the regular growth and harvesting of crops that add little organic material, and thus accelerate the depletion of organic matter in the soil.

In addition, other management techniques outside only vegetation have a significant impact on the pattern of nutrient distribution. Less favourable findings for soil chemical characteristics in BS compared to NS suggested that management activities had an impact. Aside from the plant that is produced, the soil's chemical composition varies due to its texture and inherent parent material. A prospective land use system for intercropping, mixed cropping, or the rehabilitation of degraded lands could be identified by higher levels of TN in the upper surface of soil, which may be attributable to the leguminous property of the plant.

In comparison to the other land use system, NS, soil microbial populations were much greater in BS, showing the influence of the local land use system and crop varieties. Positive correlation between microbes (fungi & bacteria) and ammonical nitrogen and nitrate nitrogen signifies the nitrogen fixation of the local leguminous plants in the study site. Negative correlations between microbes and sand, silt, and clay, on the other hand, shows that unstable soils have fewer impact on the soil microbial population and vice versa.

It is evident from the analysis of the literature that additional research is required on this subject because the information on the influence of shifting agriculture on the soil's physical, chemical, and biological qualities in Mizoram is exceedingly scarce. The outcomes of this analysis are anticipated to aid in the creation of land use management policies or practises as well as future research endeavours focused on the sustainable use of land and restoration of Mizoram's damaged lands. In the current environment of land use change, adopting any agroecosystem requires appropriate management strategies targeted at protecting and enhancing soil qualities in order to attain sustainability.

Subsistence farmers in Mizoram's villages still rely solely on shifting agriculture. Therefore, the government should place a greater emphasis on the effective adoption of various sustainable alternative farming systems, such as agroforestry and farm forestry, where trees are grown alongside agricultural crops and animals on the same land management units. Growing leguminous trees in agroforestry systems can provide a remarkable quantity of nutrients to the soil, as the productivity and fertility of soil are highly correlated with the establishment of nitrogen-fixing trees or deep-rooted trees and leguminous crops. Adoption of agroforestry systems in the current context of land use change should focus on suitable management strategies targeted at protecting and enhancing soil qualities in order to attain sustainability.

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ABSTRACT

STUDY OF SOIL BIOCHEMICAL PROPERTIES OF DIFFERENT FARMING SYSTEMS OF AIZAWL, MIZORAM

AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY

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DEPARTMENT OF FORESTRY

SCHOOL OF EARTH SCIENCE AND NATURAL RESOURCE MANAGEMENT

DECEMBER, 2022

ABSTRACT

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PHILOSOPHY IN FORESTRY OF MIZORAM UNIVERSITY, AIZAWL.

ABSTRACTS

Shifting cultivation, commonly known as 'Jhum Cultivation', is a widespread upland slash and burn farming practice in the northeast part of India. Due to exponential increase in human population the practice of 'jhum' remained a difficult task to make it sustainable because of its shortened cycle and environment issues. Therefore, the environmental and ecological repercussions of shifting farming are severe and far-reaching, which has resulted in massive deforestation, soil loss, and depletion of biodiversity in the region. In recent years, the innovative farmers have developed various practices like log bunding, terracing and hedge row cropping to reduce the soil loss.

In this study, a comparative study on the soil physico-chemical properties was conducted in two humid tropical zone sites (like bunding site, BS and normal shifting cultivation, NS) of the Aizawl district. The first site (BS) was chosen at Tachhip village, where bunding (BS) with log and bamboo along the contour line is practice while the second site was chosen at Lungverh village; where conventional shifting cultivation (NS) is practiced. NS site has mustard, sesame, chilli, brinjal, and maize vegetation, whereas in BS site cucumber, maize, paddy, broad beans, winged beans, pigeon peas, ginger, and chilli were planted.

The proportion of soil moisture content (SMC%) in NS was much higher than in BS. Bulk density in NS ranges from 1.12 to 1.31 while in BS from 1.21 to 1.35. The largest BD was reported at depths of 20 - 30 cm (1.35 g cm^{-3}) in BS, and the lowest was recorded at depths of 0-10 cm (1.13 g cm^{-3}) in NS. The soil textural class was sandy loam in all of the layers studied for both NS and BS. Soils at both sites (NS and BS) were acidic in reaction. SOC% decreases with increase in soil depth.

The amounts of nitrate nitrogen and available phosphorus decreased with increase in soil depths in both sites. For both N and P, the highest value was witnessed in the NS at 0-10 cm depth, while the lowest amount was found in the BS at 20-30 cm depth. Potassium availability decreases with increasing soil depth in

both sites with more in NS compared to BS.

NS had higher concentration of NH_4-N. The value of NH_4-N (µg g^{-1}) is inversely related to soil depth at both sites. The NH_4-N (µg g^{-1}) value at BS ranges from 4.33 to 6.47. The total nitrogen content (TNC) decreases as soil depth increases. The TNC was highest in the NS zone at 0-10 cm of depth, and lowest in the BS region at 20-30 cm. NS has a higher average total nitrogen concentration than BS, with values ranging from 3791.8 µg g^{-1} to 2896.5 µg g^{-1}.

Further, the NS soil had a higher microbial population count than BS soil, which had a shorter time period between field fire and crop development. Urease activity was found to be more than 50% higher in BS than in NS.

Soil pH was positively correlated with BD and DHA ($p<0.05$) and Urease ($p<0.01$). SMC was significantly correlated ($p<0.05$) with SOC. SMC also showed high correlation ($p<0.01$) with NH_4-N, P_{Avail}, NO_3-N, TN, and K_{Avail}. Soil texture (like sand, silt and clay) did not show any relationship with any other soil properties. Soil BD was significantly positively correlated ($p<0.05$) with soil pH and urease activity, while the same was significantly negatively correlated with SMC ($p<0.01$) and K_{avail} ($p<0.05$).

Further, DHA was positively correlated pH with ($p<0.05$) and Urease activity ($p<0.01$) but it was negatively correlated or show no relations with all other soil parameters. Similarly, urease activity showed a positive correlation with pH, DHA ($p<0.01$), and BD ($p<0.05$) but negative correlation with all other soil parameters. The bacterial population was positively correlated with fungal population ($p<0.05$). Population of bacteria and fungi both showed a negative relationship with BD and urease activity ($p<0.05$).