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EVALUATING SOIL FERTILITY STATUS UNDER VARIOUS LAND-USE SYSTEMS IN WESTERN CHITWAN VALLEY, NEPAL

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ABSTRACT

Field experiments were conducted at Mangalpur VDC of the western Chitwan to evaluate the effects of different land use systems on soil physical and chemical properties. Six land use systems [Cultivated upland (cereal based), Cultivated lowland (cereal based), pasture land, silvipasture, forest land and farmer's managed forestland (fodder land)] were selected and replicated five times designed in a RCBD method. Soil samples from 0-20 cm depth from the soil surface were collected from each study site. Soil properties were significantly affected by the land use systems. Clay content was found greater in fodder land and pasture (11%) compared to cereal based lowland (5%). Soil bulk density was found highest in fodder land (1.12 g cm^{-3}) and the lowest (0.93 g cm^{-3}) from the cereal based upland. Among the treatments, highest amount of soil organic matter was found in fodder land (10.72%) and the lowest was in forestland (0.47 %). A significant difference in pH was observed between different land use systems with range of soil pH value from 6.3 (Cereal based upland) to 8.5 (pastureland).The total soil nitrogen content was observed significantly higher from pasture land (0.27 %) than other land use systems and the lowest was from cereal based upland (0.14 %). available soil phosphorous content was highest (157.7 kg ha^{-1}) in fodder land and was the lowest (32.56 kgha^{-1}) in soils under the pastureland. Available soil potassium was significantly affected by land use systems with highest potassium content from forestland (148.4 kg ha^{-1}) and lowest from that of cereal based lowland (22 kg ha^{-1}). Various options for soil fertility management such as pastureland conservation with controlled grazing, conservation tillage with addition of organic matter, use of leguminous crop, etc. can be best utilization of resources and help for better productive and sustainable agriculture.

Keywords: Pasture land, Silvipasture land, Fodder land, RCBD method, Bulk density, Sustainable

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

1. INTRODUCTION

Soils are the basis of life on earth. From ancient civilization to modern world all people are in one way or another dependent on soil. Our relationship with soil is based upon cultivation of soil throughout human history and led to the success of civilizations. This relationship between humans, the earth and the food sources upholds the soil as the foundation of agriculture (Parikh and James, 2012).Soil is a basic natural resource accompanying various ecosystem of the world delivering a wide range of functions. Soil is the integral component of agriculture, forest and grassland ecosystems (Brady and Weil, 2005).

The ecosystem approach in the study of soil allows us to use an integrated approach in the management of soil problems (Goh, 2004). Soil health and soil quality are especially important as they are interlinked with agricultural sustainability. Soil quality reflects a combination of chemical, physical and biological properties (Brady and Weil, 2012). Average land holding in Nepal has decreased (from 0.88 ha to 0.66 ha (25%)) in the decade from 1995/96 to 2003/04 and led to with soil and agro-ecosystem impacts (CBS, 2004). Nepal is facing a problem of soil quality decline and subsequent low crop yield because of the deforestation and other land use changes such as conversion of agricultural land to non- agricultural uses, land fragmentation and cultivation in marginalized areas, cultivation in the slopes, overgrazing, burning crop residues, imbalanced use of agrochemicals and declining use of organic manures. This ultimately affects SOM, N, P, K, and soil pH, and subsequently allows land to degrade furthermore (Alfred et al, 2008).

The issues of land uses and its associated problems must be taken into consideration in our agriculture and make it more environmentally friendly via techniques like agroforestry, permanent forestry, conservation agriculture, organic farming and ecological agricultural approaches. These farming systems are beneficial from various perspectives that they increase system productivity, soil and overland biological diversity and sustainability in the production system (Dalsgaard et al, 1995).

2. METHODOLOGY

2.1 Site description

The study was conducted in Chitwan district of Nepal. Manglapur VDC of Chitwan district was selected for this study. Chitwan district is small district situated in mid-south part of Nepal with east west length of 98 Kilometer (Km) and North south width of 46 km with North Latitude 27°21’45’’ to 27°52’30’’ and East longitude 83°54’45’’ to 84°48’15’’and at 141m to 1947 m above the mean sea level This VDC occupies 21.94 Km^2 of total area of Chitwan district. It is

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Volume:04, Issue:03 "May-June 2018"

located 7 Km from Bharatpur (District Headquarter) and situated at 184 m above the mean sea level. Bharatpur headquarter is in east, sharadanagar VDC is in west, Naryani rivers flows north and Fulbari VDC is south to it.

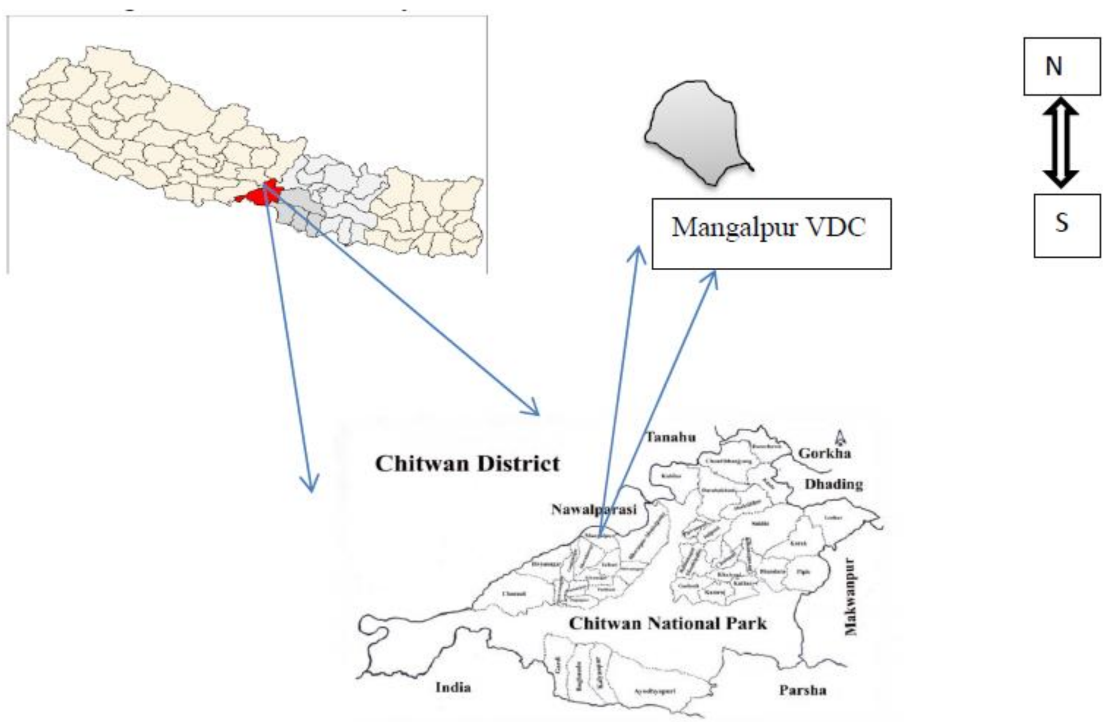

Figure 1: Map showing the study area

2.2 Treatment details

Specific area was identified based on the availability of land use systems aimed for each study site. Field experiments were conducted with six land use systems as treatments. Among them 2 land use systems (cereal based lowland, cereal based upland) were disturbed soil and 4 other types of land use systems (pasture land, silvipasture, forest land and farmers managed forest land) were undisturbed soil.

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

Table 1: Treatments used in study

Symbols	Treatments
T1	Cultivated upland (cereal based)
T2	Cultivated lowland (cereal based)
T3	Pastureland
T4	Silvipasture
T5	Forestland
T6	Farmers managed forestland (Fodder land)

2.3 Soil sample collection and Preparation

Composite Soil samples were collected from each study site from 20 cm depth of land use systems using a screw auger. The top 20cm depth was chosen because it is the depth where most changes are expected to occur as a result of long term land use and soil management practices. The five soil samples were collected randomly from each land use system and a total 30 soil samples were collected from 6 study sites. Collected soil samples were labeled, brought to laboratory, and was air dried in the shade. Air-dried samples were ground and sieved through 2.0 mm sieve and stored for physical and chemical analyses. Some samples were sieved through a 0.2 mm sieve for SOM analysis. Soil samples were collected on Randomized complete Block Design (RCBD).

2.4 Laboratory analysis

Soil texture, soil color, soil bulk density and soil pH was analyzed at the Soil science Laboratory of the Institute of Agriculture and Animal Sciences, Tribhuvan University. However, total nitrogen, available phosphorous and available potassium, Soil organic matter (SOM) were analyzed in the Regional soil laboratory, Central region, Hetauda, Government of Nepal. Standard laboratory procedures were followed for the analysis of the soil physicochemical properties.

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

Table 2: Laboratory analysis techniques used to analyze soil physical and chemical properties

Parameters	Analysis techniques
Soil Texture	Mechanical analysis method (Day, 1965)
Soil Color	Munshell color chart
Soil Bulk Density	Undisturbed core sampling method
Soil pH	Using 1:2 soil water ratio and pH color chart
Total Nitrogen	Kjeldhal distillation unit (Bremner, 1965)
Available Phosphorous	Modified Olsen bicarbonate method (Whatanabe and Olsen, 1965)
Available Potassium	Ammonium Acetate Extraction Method (Pratt, 1965)
Soil Organic Matter	Wet digestion method (Walkley and Black, 1934)

2.5 Statistical analysis and data presentation

The data related to soil quality and soil fertility analysis were coded and tabulated for computer entry. They were analyzed by descriptive as well as inferential statistical tools wherever possible. Soil organic matter, NPK and pH data obtained from laboratory analysis were rated according to the standard rating of NARC, Soil Science Division, Khumaltar, Lalitpur, 2000 & Khatri-Chhetri (1991). Different descriptive techniques such as average and standard error were used for computing results. Duncan's Multiple Range Test and coefficient of variation as a measure of inferential statistics were also used for data analysis. A one way ANOVA table was used to test the differences in soil physical and chemical properties between different land uses. All statistical analyses were performed using R package.

3. RESULT & DISCUSSION

3.1 Effect of land use systems on soil properties

3.1.1 Effect on Soil Physical properties

i. Soil color:

The soil color of cereal based lowland is found to be black. This may be due to the higher moisture content of these soils (Brady and Weil, 2012). Various range of soil color was found in the various treatments (land use system).

Table 3: Soil color under various land uses

Treatments	Soil color
Cultivated upland (cereal based)	Light gray
Cultivated lowland (cereal based)	Black
Pastureland	Very pale brown
Silvipasture	Yellowish brown
Forestland	Very pale brown
Fodder land	Yellowish brown

ii. Soil texture & Soil bulk density:

The highest sand content (87%) was recorded from the cereal based lowland and the lowest (51%) from the forest land. Clay content was greater in farmers managed forest land and pasture compared to cereal based lowland. The highest silt (42%) was found on the forestland and highest clay contents (11%) were found on the fodder land and pastureland. The lowest silt (8%) and clay (5%) fractions were recorded on the cereal based lowland. Sandy loam texture was the textural class on all the land uses except cereal based lowland where sandy texture was the class (Table 4).

Soil bulk density values obtained from laboratory analysis were presented in Table 4. Soil bulk density was found highest in fodder land (1.12 g cm^{-3}) and the lowest (0.93 g cm^{-3}) from the cereal based upland. The reason for the highest soil bulk density from fodder land could be due to higher compaction by trampling action of human inside the forest. The lowest bulk density of cereal based upland may be due presence of considerable amount of organic matter.

Table 4: Effects of land use systems on soil physical properties

Land use systems	Sand (%)	Silt (%)	Clay (%)	Soil Textural class	Bulk Density (g cm^{-3})
Cereal Based Upland	73	20	7	Sandy loam	0.93
Cereal Based Lowland	87	8	5	Sandy	1.02
Forestland	51	42	7	Sandy loam	0.96
Fodder land	67	22	11	Sandy loam	1.12
Pastureland	55	34	11	Sandy loam	0.96
Silvipasture	61	30	9	Sandy loam	0.99

3.1.2 Effect on Soil Chemical properties

Soil chemical properties varied between different land use systems. The contents of soil NPK, SOM and pH of different land uses are shown in Table 5 and described in subsequent sectors**.**

Table 5: Soil chemical properties affected by land use systems

Land use systems	N (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	SOM (%)	pH
Cereal based upland	0.47^{c}±0.01	83.55^{bc}±52.7	42.08^{bc}±27.2	4.77^{b}±0.3	6.3^{d}±0.3
Cereal based lowland	0.17^{bc}±1.02	132.5^{ab}±47.3	22^{c}±17.9	10.67^{a}±1.6	6.5^{cd}±0.4
Forest land	0.16^{bc}±0.03	45.18^{c}±18.7	148.4^{a}±56.2	0.47^{d}±0.2	6.9^{c}±0.6
Fodder land	0.17^{bc}±0.03	157.7^{a}±67.1	81.04^{b}±63.5	10.72^{a}±0.5	7.96^{b}±0.3
Pastureland	0.27^{a}±0.05	32.56^{c}±71.8	38.53^{bc}±5.3	4.59^{b}±0.5	8.44^{a}±0.1
Silvipasture	0.19^{b}±0.01	65.13^{bc}±71.7	55.07^{bc}±9.8	1.90^{c}±0.5	8.34^{ab}±0.2
Grand Mean	0.18	86.11	64.51	5.52	7.41
CV (%)	15.82	58.33	55.45	13.31	4.62

Note: Means followed by the same letter in a column are not significantly different at 5% level of significance as determined by DMRT.

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

i. Soil pH:

A significant difference in pH was observed between different land use systems. The range of soil pH value was from 6.0(Cereal based upland and lowland) to 8.5(grassland and silvipasture). In this study soil pH tends to increase in grassland and silvipasture. The pH of fodder land was found to be moderately alkaline (7.96). This could be due to the effect of leaf litter which can increase the pH of soil as suggested by Noble et al (1996). We found lower soil pH in agricultural land than the other land use. This might be due to the depletion of basic cations in crop harvest and drainage in stream in runoff generated from accelerated erosion or due to higher microbial oxidation that produces organic acids causing lower soil pH (Tilahun, 2007)

ii. Available soil phosphorous:

A one way analysis of variance showed an overall significant effect of land uses on available soil phosphorus. The effects of different land use systems on available phosphorous are shown in table 5. Available Phosphorus content of the surface soils of the study area varied from 237.53 kg ha^{-1} (highest) in fodder land to 4.48kgha^{-1} (lowest) in soils under the silvipasture lands with significant differences between soil samples. There was no significant difference in available P between cereals based upland and silvipasture & available soil P status from the silvipasture, forestland and grassland was medium. This can be because of erosion and runoff. The soils of these sites are near the river and hence the nutrient may run to the river due to absence of closed cycling of nutrients.

iii. Soil organic matter (SOM)

The highest amount of soil organic matter (12.83%) was recorded from the fodder land whereas the lowest (0.23%) was from the forestland (Table 5). Organic matter content of fodder land is high which may be due to the addition caused by return of plant residue in the soil (Brady and Weil, 2012). The soils of forestland were near riverside and hence prone to erosion leading to low amount of organic matter in those soils. A considerable high amount of organic matter was found in wetland soil. This may account from the addition of animal manures and compost from the upland sites resulting higher amount of organic matter in these soils. Organic matter content of cereal based upland and grassland was not significantly different and found to be 4.768% and 4.592% respectively. The organic matter content of grassland may be attributed to the role of plant biomass in maintaining organic matter levels.

iv. Available soil potassium

The highest potassium content was obtained from forestland (235.73 kg ha^{-1}) and lowest from

ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

that of cereal based upland and lowland (5.47 kg ha^{-1}). Available soil potassium was significantly affected by land use systems (Table 5). According to the available K rating chart given by NARC, Soil Science Division, Khumaltar, and forestland qualified for medium, silvipasture and fodder land for low and the other land use systems for very low available K status. The lowest (22.0 kg ha^{-1}) amount of available soil potassium determined in the soils of cereal based lowland compared to other land use systems might be due to higher leaching loss of potassium from soil surface, more K harvest from the soil, crop intensification and low external input. Kanwar (1976) reported the higher K leaching loss from humid tropics as a major factor of limiting productivity. The higher available K in the forestland might be due to recycling of nutrients. The shed leaves are mixed with soil and undergo recycling to release K.

v. Total soil nitrogen

The magnitude of residual total soil nitrogen varied greatly with the production system and adopted crop and land management practices. Nitrogen content of soil was significantly affected by the land use systems as revealed by statistical analyses. Total soil nitrogen content was the highest (0.34 %) from pasture land and the lowest (0.13 %) was from cereal based upland, forestland and fodder land. According to the total N rating chart given by NARC, Soil Science Division, Khumaltar, Lalitpur 2000, grassland soil was qualified for high and all other land use was qualified as medium. The high amount of N in grassland soil may be due to closed nutrient cycling of nutrients in such land uses due to high plant biomass. Among the land uses lowest amount of N was obtained from cereal based upland. This might be due to frequent tillage operation which causes rapid mineralization of soil organic matter and organic nitrogen and transforms them in to mineral N, CO_2 and nitrogenous gases.

4. CONCLUSION

Field experiments were conducted to evaluate soil properties under different land use systems. Six land use systems: cereal based upland, cereal based lowland, forestland, fodder land, pastureland, silvipasture of Mangalpur VDC as treatments were used. From our research, we found variation in the soil color in the different land use system. Among them the black color was found in the cereal base lowland. Similarly, there were various kinds of soil texture among different treatments. Sandy loam texture was the textural class on all the land uses except cereal based lowland where sandy texture was the class. Soil bulk density was found highest in fodder land and the lowest from the cereal based upland. Available Phosphorus content of the surface soils of the study area found to be highest in fodder land & lowest in soils under the pastureland. There was no significance difference in available P between cereals based upland and silvipasture. The highest amount of SOM was recorded from the fodder land whereas the lowest was from the forestland. A considerable high amount of organic matter was found in wetland soil. Organic matter content of cereal based upland and pastureland was not significantly different. The highest potassium content was obtained from forestland & lowest from that of cereal based lowland. Total soil nitrogen content was found highest from pasture land and the lowest was from cereal based upland.

Soil properties were significantly affected by the land use systems. Various options for soil fertility management can be done in such land uses for sustainability. Pastureland conservation with balanced vegetation in such soils through controlled grazing can be a best option for sustaining its quality. Conservation tillage with addition of organic matter can be suggested as fertility management options in cultivated land. Leguminous crop incorporation in such soils can best help in restoring soil N for better productivity.

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ISSN: 2455-6939

Volume:04, Issue:03 "May-June 2018"

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