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Basta Ram
Department of Soil Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Ajeet Pratap Singh
Department of Soil Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Veer Singh
Department of Soil Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Navneet Pareek
Department of Soil Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
Basta Ram
Department of Soil Science, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Effect of different land uses on soil physical properties at different depth in a Mollisol

Basta Ram, Ajeet Pratap Singh, Veer Singh and Navneet Pareek

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Abstract
The present study was undertaken to assess the effect of different land uses on physical properties in a Mollisol. The study area was located at *Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, which lies* at 29^0 N latitude, 79^0 3' E longitude and 243.84 m above the mean sea level altitude. The land use systems selected for study were S_1 (rice – potato – okra), S_2 (rice – pea (vegetable) – maize), S_3 (sorghum multicut (fodder) – yellow sarson – black gram), S_4 (rice – wheat – green gram), S_5 (rice – berseem + oat + mustard (fodder) – maize + cowpea (fodder)), S_6 (guava + lemon), S_7 (poplar + turmeric), S_8 (eucalyptus + turmeric), S_9 (fallow (uncultivated land)). The soil sample collected from D_1 (0-15 cm depth), D_2 (15-30 cm depth), D_3 (30-45 cm depth) and D_4 (45-60 cm depth) for analysed soil physical properties (soil colour, soil texture, bulk density, particle density, porosity and water holding capacity). Among the different land use systems S_9 treatment obtained significantly high value. The highest value of pH, EC, bulk density and water holding capacity were reported with D_4 depth (7.59), with D_1 depth (0.289 dSm^{-1}), with D_4 depth (1.47 g cm^{-3}) and with D_1 depth (55.47%), respectively. While the lowest value was observed with D_1 depth (7.51), with D_4 depth (0.244 dSm^{-1}), with D_1 depth (1.38 g cm^{-3}) and with D_4 depth (50.15%), respectively. Results indicated that soil under agroforestry based systems was found superior with respect to soil physical environment followed by field crops, horticultural crops and the uncultivated land.

Keywords: land use systems, assessment, physical properties, Mollisol

1. Introduction

Soil is very diverse and complex system consisting of mineral particles, organic matter, water and pore spaces. The mineral particles contain nutrients, which are slowly released in the process of weathering; organic matter and humus vary in quantities, resulting from the decomposition of biomass and minute pores are filled with air or water (IFOAM, 2002) [1]. Soils are characterized by a high degree of variability due to the interplay of physical, chemical, biological and anthropogenic processes that operate with different intensities at different scales (Goovaerts, 1998). These processes in turn influence the nature and properties of soil hence, knowledge of soil properties is important in determining the best use to which a soil may be put (Amusan *et al.*, 2004) [14].

Morphological and physical properties of soil are important indicators of the soil fertility. Soil physical properties provides information related to water and air movement through soil, as well as various conditions affecting germination, root growth and erosion processes. Since, many soil physical properties form the foundation of other chemical and biological processes, which may be further governed by variation in the land use type. Therefore, the present study was undertaken with the objective of assessment of physical properties of soil under different land use systems.

2. Materials and Methods

Present study was undertaken at Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University, Pantnagar, and District U.S. Nagar in terai region of Uttarakhand. The order of the soil was Mollisol. Pantnagar falls under sub-humid and sub-tropical climate zone with hot, dry summer and cool winter. The region has thick vegetation because of prevalence of high moisture in Tarai belt and the forest area is classified as low alluvial savannah (Puri, 1960). Soil samples collected from four different depth (0-15, 15-30, 30-45, 45-60cm) representing the whole area were collected randomly from different land use systems comprising of field crops, horticultural crops, agroforestry crops and fallow (uncultivated land) from the same block during kharif, 2017-18. Each soil sample was air dried, processed with the help of pestle and mortar, passed through 2 mm sieve and used for the analysis of physical soil properties. Soil colour was determined both under moist and dry conditions in the laboratory by Munsell Soil Colour Chart. Texture of soil was determined by by Hydrometer method (Bouyoucos, 1927). Textural classification was made using USDA textural triangle. Bulk density, particle density and porosity were determined by procedure given by Baver (1956). Water holding capacity (WHC) was determined with the help of Hilguard apparatus (Piper, 1950). The data were analysed statistically by using Randomized block design (RBD). The data collected on different soil properties were analysed applying ANOVA technique (Pansa and Sukhatme, 1985). In case of significant F test, C.D. at 5% was calculated for comparing treatment means.

3. Results and Discussion

3.1. Soil colour

Soil colour is one of the morphological indicators of soil fertility status which depends mainly on the amount and state of organic matter and iron oxide as well as the amount of air and water in soil pores.

Dry soil

Variation in soil colour under different land use systems at different depth in S_8D_1, S_8D_2, S_9D_1, and S_9D_2 treatment combination were found Dark grey (5Y4/1), Light yellow colour (2.5Y6/2) (10YR5/2), and Light Grey (5Y7/1)(Table-1) respectively.

Table 1: Dry soil colour under different land use systems at different depths.

Land use systems	Soil colour (Dry)			
	Depth (cm)			
	D_1 (0-15)	D_2 (15-30)	D_3 (30-45)	D_4 (45-60)
S_1 (Rice – potato – okra)	5YR4/1 (Dark grey)	10YR5/2 (Greenish brown)	2.56/2 (Light brownish)	5Y5/2 (Olive grey)
S_2 (Rice – pea vegetable – maize)	8Y5/2 (Olive grey)	5Y6/1 (Grey olive)	5Y5/2 (Olive grey)	5Y6/2 (light olive)
S_3 (Sorghum multi cut fodder – yellow sarson – black gram)	5Y3/2 (Grey)	2.5Y5/2 (Greyish brown)	5Y3/2 (Olive)	5Y6/1 (Grey)
S_4 (Rice – wheat – green gram)	10YR5/2 (grey)	10YR4/2 (Dark grey)	5Y4/4 (Olive)	10YR4/2 (Dark grey)
S_5 Rice– berseem + oat + mustard – maize + cowpea fodder	10YR5/1(Grey)	5Y7/2 (Light grey)	4YR7/2 (Light grey)	2.5Y7/2 (Light grey)
S_6 (Guava + lemon)	10YR5/2 (Dark garnish brown)	10Yr5/2 (Greyish brown)	10YR5/2 (Greyish brown)	5YR5/2 (Olive grey)
S_7 (Poplar + turmeric)	10YR5/2 (Dark greyish brown)	2.5Y6/2 (Light brown grey)	5Y5/2 (Olive grey)	10YR7/2 (Light grey)
S_8 (Eucalyptus + turmeric)	5Y4/1 (Dark grey)	2.5y6/2 (Light brown colour)	2.5y3/2 (Light light)	10Y8/1 (Light brown)
S_9 (Fallow uncultivated land)	10YR5/2 (Light grey)	5Y7/1 (Light Grey)	4YR7/2 (Light grey)	2.5Y7/2 (Light grey)

Variation in soil colour under different land use systems at different depth in S_8D_1, S_8D_2, S_9D_1, and S_9D_2 treatment combination were found 5Y4/1 (Dark brown) 2.5Y6/4 (Light yellow brown) 10YR4/1 (Dark greyish brown)(Table-2) respectively. Variation of colour in S_8D_1 and S_8D_2 due to presence of higher amount of organic matter in surface soil. Colour change of S_9D_1 treatment due lower amount organic matter presence in surface soil.

3.2. Soil texture

The variation in soil texture was obtained under different land use systems at different (0-15, 15-30, 30-45, 45-60) depth. Present study indicate most of treatment combination have sandy clay loam textural triangle. While texture of S_4D_2, S_4D_3 and S_7D_4 treatment combination were found sandy clay among different land use systems (Table-3).

Table 3: Soil texture under different land use systems at different depths.

Land use systems	Soil texture			
	Depth (cm)			
	D_1 (0-15)	D_2 (15-30)	D_3 (30-45)	D_4 (45-60)
S_1 (Rice – potato – okra)	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
S_2 (Rice – pea vegetable – maize)	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
S_3 (Sorghum multi cut fodder– yellow sarson – black gram)	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay
S_4 (Rice – wheat – green gram)	Sandy clay loam	Sandy clay	Sandy clay	Sandy clay
S_5 Rice– berseem + oat + mustard –maize + cowpea fodder	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay
S_6 (Guava + lemon)	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay
S_7 (Poplar + turmeric)	Sandy clay loam	Sandy clay loam	Sandy clay	Sandy clay
S_8 (Eucalyptus + turmeric)	Sandy clay loam	Sandy clay	Sandy clay	Sandy clay
S_9 (Fallow uncultivated land)	Sandy clay loam	Sandy clay loam	Clay loam	Clay loam

3.3. Bulk density

The bulk density data was affected by significantly with different depth the bulk density was less in surface soil than in sub-surface soil. The depth has significant effect on bulk density in soils at all the depths. The highest bulk density was obtained in control D_4 (1.47 g cm^{-3}) as in compare to all depths. The Lowest bulk density was recorded with D_1 (1.38 g cm^{-3}) (Table-4). The bulk density was as influence significantly by different land use systems.

The highest bulk density was recorded with S_9 (1.62 g cm^{-3}) land use system compare to all other land use systems. The lowest bulk density was recorded with S_8 (1.25 g cm^{-3}) land use systems (Table-6).

Interaction effect of the depth (D) and different land use systems (s) was found none significantly among all land use systems.

The lowest bulk density obtained in agroforestry based land use systems i.e. eucalyptus + turmeric because high soil organic carbon content which lead to decline in soil bulk density of soil. Similar result were also reported by Kumar *et al.*, (2002) [3] and Gupta *et al.*, (2010) [3, 4]. Generally, the highest bulk density record under uncultivated land and this is due to low organic carbon and low clay content in soil. Reduced tillage systems that cause soil bulk density is generally high due to less surface soil disruption caused by ploughing practice (Karamanos *et al.*, 2004 and Afyuni and Wagger 2006) [5].

Highest bulk density in the fallow land due to soil compaction, high decomposition and organic matter degradation was also reported by Wakene and Heluf, (2003) [6]. The change in bulk density among different land use systems was very low. The same result are obtained by Anken *et al.*, (2004) and Jabro *et al.*, (2008) [7].

Table 4: Bulk density under different land use systems at different depth.

Treatment	Bulk density (g cm^{-3})
Depth (cm)	
D_1 (0-15)	1.39
D_2 (15-30)	1.41
D_3 (30-45)	1.44
D_4 (45-60)	1.47
SE(m)±	0.01
CD at 5%	0.02
Land use systems	
S_1 (Rice – potato – okra)	1.44
S_2 (Rice – pea vegetable – maize)	1.46
S_3 (Sorghum multi cut fodder – yellow sarson – black gram)	1.44
S_4 (Rice – wheat – green gram)	1.53
S_5 (Rice– berseem + oat + mustard –maize + cowpea fodder)	1.46
S_6 (Guava + lemon)	1.35
S_7 (Poplar + turmeric)	1.28
S_8 (Eucalyptus + turmeric)	1.25
S_9 (Fallow uncultivated land)	1.65
SE(m) ±	0.01
CD at 5%	0.03
Interaction	NS

3.4. Particle density

The particle density was affected at different depth with different land uses. The particle density value was obtained less in surface soil than in sub-surface soil. The depth have significant effect on particle density of soil with all the depths.

The highest particle density was reported with D_4 (2.68 g cm^{-3}) an in compare to all the depths. The lowest particle density was reported with D_1 (2.61 g cm^{-3}) depth as compare different depth. Particle density data as influence significantly by different depth. Particle density was affected by significantly among all land use systems. The highest particle density was observed under S_9 (2.8 g cm^{-3}) (Table-5) then all other land use systems. Lowest Particle density was recorded under S_8 (2.42 g cm^{-3}) (Table-6) land use system compare to other land use systems. The interaction effect between different depth (D) and different land use systems (S) was found non-significant. The lowest value of particle density was observed under eucalyptus + turmeric land use system which was significantly lower than the value noted under all the land use systems. The lowest particle density under eucalyptus + turmeric because of high organic carbon content. The same result was found by Kumar and Singh (2007) [8]. Similar findings was reported by Pandy (2017).

Table 5: Particle density under different land use systems at different depth.

Treatment	Particle density (g cm^{3})
Depth(cm)	
D_1 (0-15)	2.62
D_2 (15-30)	2.63
D_3 (30-45)	2.65
D_4 (45-60)	2.68
SE(m) ±	0.01
CD at 5%	0.03
Land use systems	
S_1 (Rice – potato – okra)	2.54
S_2 (Rice – pea vegetable – maize)	2.76
S_3 (Sorghum multi cut fodder – yellow sarson – black gram)	2.69
S_4 (Rice – wheat – green gram)	2.65
S_5 (Rice– berseem + oat + mustard –maize+ cowpea fodder)	2.62
S_6 (Guava + lemon)	2.80
S_7 (Poplar + turmeric)	2.48
S_8(Eucalyptus + turmeric)	2.43

S_9 (Fallow uncultivated land)	2.81
SE(m) ±	0.01
CD at 5%	0.04
Interaction	NS

3.5. Porosity

The porosity was influence by significantly among different depth. The porosity value (Table-6) was low in surface soil than in sub-surface soil. The depth have significant effect on porosity in soils at all the depths. The maximum porosity was reported with D_1 (46.97%) depth as compare other depths. Lowest porosity was recorded with D_4 (45.03%) depth as compare to different depth. while the value of porosity for the D_2 (45.98%) and D_3 (45.66%) was statistically *at par*. The porosity of soil was affected by significantly among all land use systems. The highest porosity was observed with S_6 (51.71%) land use then all other land use systems. The lowest porosity was reported with S_9 (41.21%) land use system in relation to other land use systems. Porosity was observed highest under S_6 treatment because of surface of these land use systems have more grasses density and litter. Interaction effect of the different depth (D) and different land use systems (S) was obtained non-significant. Might porosity was observed under S_6 (Guava + lemon)> S_7 (Poplar + turmeric)> S_8 (Eucalyptus + turmeric) land use systems. This was due to high organic carbon content in the soil. Same result were also reported by Kumar *et al.*, (2005). Similar finding was made by Pandy (2017).

Table 6: Porosity under different land use systems at different depth.

Treatment	Porosity (%)
Depth(cm)	
D_1 (0-15)	46.97
D_2 (15-30)	45.98
D_3 (30-45)	45.66
D_4 (45-60)	45.03
SE(m) ±	0.35
CD at 5%	0.99
Land use systems	
S_1 (Rice – potato – okra)	43.27
S_2 (Rice – pea vegetable – maize)	47.06
S_3 (Sorghum multi cut fodder – yellow sarson – black gram)	46.51
S_4 (Rice – wheat – green gram)	42.32
S_5 (Rice– berseem + oat + mustard –maize+ cowpea fodder)	44.49
S_6 (Guava + lemon)	51.71
S_7 (Poplar + turmeric)	48.25
S_8 (Eucalyptus + turmeric)	48.38
S_9 (Fallow uncultivated land)	41.21
SE(m) ±	0.53
CD at 5%	1.49
Interaction	NS

3.6. Water holding capacity

The water holding capacity was influence significantly with different depth. The depth have significant effect on water holding capacity in soil. The highest porosity was reported with D_1 (55.47%) as compare to different depths (Table-7). The lowest water holding capacity was observed with D_4 (50.15%). while the value of water holding capacity for the D_3 (51.33%) was found statistically *at par*. The water holding capacity of soil was influence with significantly among different land use systems. The greatest water holding capacity was obtained with S_8 (57.13%) compare to different land use systems. The lowest water holding capacity was observed S_9 (47.77%) land use system. Interaction effect of different depth (D) and different land use systems (S) for water holding capacity was found non-significant. Higher porosity was observed under S_6 (Guava + lemon)> S_7 (Poplar + turmeric)> S_8 (Eucalyptus + turmeric) land use systems. This was due to high organic carbon content in the soil. Same result were also reported by Kumar *et al.* (2005). And similar finding was made by Pandy (2017). Highest water holding capacity was recorded under agroforestry based land use system i.e. eucalyptus + turmeric grater then poplar + turmeric. It was due to more organic matter contain and highest percentage of clay fraction which increase the available water. These results are in similarity with those of Khongjee (2012) [19], Kiakojouri, A. and Taghavi, G. M. M. (2014) and Pandy (2017). Lowest water holding capacity was reported under uncultivated land because of soil have low organic matter and lower plough disturbance. Lowest soil moisture content and water holding capacity in guava based land use system was also observed by Ekka *et al*. (2017) [13].

Table 7: Water holding capacity under different land use systems at different depths.

Treatment	Water holding capacity (%)
Depth (cm)	
D_1 (0-15)	55.47
D_2 (15-30)	53.44
D_3 (30-45)	51.33
D_4 (45-60)	50.15
SE(m) ±	0.46
CD at 5%	1.29
Land use systems	
S_1 (Rice – potato – okra)	53.89
S_2 (Rice – pea vegetable – maize)	52.25
S_3 (Sorghum multi cut fodder – yellow sarson – black gram)	52.45
S_4 (Rice – wheat – green gram)	52.55
S_5 (Rice– berseem + oat + mustard –maize+ cowpea fodder)	52.85
S_6 (Guava + lemon)	47.43
S_7 (Poplar + turmeric)	57.05
S_8 (Eucalyptus + turmeric)	57.13
S_9 (Fallow uncultivated land)	47.77
SE(m) ±	0.69
CD at 5%	1.94
Interaction	NS

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