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Effect of different land use systems on soil properties

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Abstract

A study was conducted to assess the impact of different land use systems on soil properties during the year 2020 at PJTSAU, Rajendranagar, Telangana**.** The soil samples were collected from four different land use systems *viz.* Silvi-agri system, Block plantations, Orchards and Agricultural crops from each three locations at three depths **(**0-15cm, 15-30cm and 30-45cm). The two way analysis of variance was used to compare the soil properties of different land use systems. Soil pH and EC ranged from 6.46-7.37 and 0.26-0.35 dSm^{-1} respectively. The cation exchange capacity ranged from 14.49-20.35 cmol (p^{+}) kg^{-1}, and organic carbon ranges from highest CEC (20.35 cmol (p^{+}) kg^{-1}) and organic carbon (6.13 g kg^{-1}) recorded in Silvi-agri system. The lower CEC (14.49 cmol (p^{+}) kg^{-1}) and organic carbon (2.05 g kg^{-1}) recorded in Agricultural crops (1.384 g cm^{-3}) which is having highest bulk density. The mean bulk density ranged from 1.38 -1.27 gcm^{-3}. The highest mean value of available nitrogen (202 kg ha^{-1}) and P_2O_5 (38 kg ha^{-1}) recorded in orchard crops. While highest K_2O (570 kg ha^{-1}) recorded in agricultural crops. In all land use systems EC, cation exchange capacity, organic carbon, available N, P_2O_5 and K_2O decreased with increase in depth. From the results of the study concluded that conversion of land use types from one to another has effected the soil properties.

Keywords: Bulk density, pH, EC, CEC, organic carbon, nitrogen, phosphorous, potassium

1. Introduction

Soil health has been defined as the capacity of a soil to support ecosystem functions and sustain biological productivity and environmental quality (Doran and Safley, 1997) [5]. Poor soil management and the replacement of native forests by farmland may compromise soil health. Because several chemical, physical and biological properties are used to characterize soil health, identifying the most sensitive of these is useful for assessing the impacts of land-use change. Land use is characterized by the arrangements, activities and inputs, that people undertake in a certain land cover type to produce change or maintain it (Gracia *et al*., 2000) [6]. It influences soil aggregation, aggregate stability and overall soil health. The practices affect the distribution and supply of soil nutrients by directly altering soil properties and thereby influencing biological transformations in the rooting zone (Wang *et al*., 2012) [20].

Successful agriculture requires the sustainable use of soil resource, because soil can easily lose its quality and quantity within a short period of time for different reasons such as intensive cultivation, leaching and soil erosion (Kiflu and Beyene, 2013) [9]. Agricultural practice, therefore, requires basic knowledge of sustainable use of the land (Takele *et al*., 2014) [17]. A success in soil management to maintain the soil quality depends on the understanding of how the soil responds to agricultural practices over time. Trees combine with farm land tend to improve the ecosystem by regulating microclimate of site and changing physical structure, infiltration capacity, moisture regime and other chemical properties of soils. Furthermore, litter fall, root extension and crown expansion facilitate the nutrient cycling and organic matter build-up in the topsoil (0-15 cm), leading to improvement of soil properties in the root zone.

Conversion of forests to agricultural land uses is of a great concern to ecologists as it reduces litter inputs (Pandey *et al*., 2000) [13], and alters biogeochemical cycles, especially that of nitrogen (N) and carbon (C), both at regional and global scales. These biogeochemical changes are directly linked with the future productivity and stability of the derived land uses. At different spatial and time scales, vegetation cover helps in protecting the soil from harsh climatic conditions mostly soil erosion. The presence of dense vegetation affords the soil adequate cover thereby reducing the loss in macro and micro nutrients that are essential for plants growth and energy fluxes (Iwara *et al*.,2011) [7] Dynamic properties such as soil organic matter (SOM), cation exchange capacity (CEC), total Nitrogen (TN), soil pH and texture are sensitive to land use practices and can provide valuable information about important soil processes such as nutrient cycling, decomposition and formation of SOM, and overall productivity potential (Mandal *et al*., 2007) [10]. In view of this the present study of the assessment of soil properties under different land use systems.

2. Material and Methods

2.1 Study area

The present study was carried out in Professor Jayashankar Telangana State Agricultural University during the year 2020, Rajendranagar, Hyderabad, Telangana**.** The climate of the region is semi arid tropics The description of the selected land use systems and their location is given in Table 1.

Table 1: Location of the site

Land use systems	Dominant species	GPS Points	Management practices
Silvi-agri system	Custard apple+grass based agroforestrysystem	17^{0} 19’1’’N 78^{0} 24’53’’E	Intercultural operations like weeding and Application of fertilizer
	Mango +curry leaf based agroforestry system	17^{0} 18’52’’N 78^{0} 25’ 9’’E	
	Melia dubia based agroforestry system	17^{0} 18’50’’N 78^{0} 25’9’’E	
Block plantations	Neem	17^{0}18’52’’N 78^{0} 25’13’’E	Intercultural operations and pruning
	Pongamia	17^{0} 18’50’’N 78^{0} 25’10’’E	
	Eucalyptus	17^{0} 18’49’’N 78^{0} 25’9’’E	
Orchard crops	Sapota	17^{0} 19’40’’N 78^{0} 23’56’’E	Intercultural operations Application of fertilizer
	Mango	17^{0} 19’36’’N 78^{0} 23’58’’E	
	Custard apple	17^{0} 19’50’’N 78^{0} 24’24’’E	
Agricultural crops	Maize	17^{0} 19’0’’N 78^{0} 24’53’’E	Intercultural operations like weeding and Application of fertilizer
	Red gram	17^{0} 13’40’’N 77^{0} 35’8’’E	
	Sunflower	17^{0} 19’12’’N 78^{0} 24’43’’E	

2.2 Sample collection and analysis

Soil samples were collected in three depths 0-15cm,15-30cm and 30-45cm in different land use systems and dried under shade, processed and passed through 2 mm and 0.5mm sieve and neatly labeled in bags for further analysis.

The bulk density (BD) of the soil was measured from undisturbed soil samples collected using a core sampler after drying the core samples in an oven at 105 °C (Black, 1965) [3]. The pH of soil was determined by soil suspension (1:2.5 soil:water) by glass electrode method pH meter after equilibrating soil with water for 30 minutes with occasional stirring (Jackson, 1973) [8]. EC was determined in soil suspension (1:2.5 soil: water) after equilibrium of soil with water and keeping the sample undisturbed till the supernatant solution is obtained and measured by conductivity meter (Jackson,1973) [8].

CEC was determined by five grams of soil was taken in a centrifuge tube to which 1N sodium acetate (pH 8.2) was added and centrifuged at 8000 rpm for 5 minutes. The supernatant was discarded and the procedure was repeated thrice. The excess sodium was removed by washing with 33ml of iso propyl alcohol and the supernatant was discarded and repeated thrice. The adsorbed sodium was extracted by 1N ammonium acetate (pH 7) and the supernatant was collected and stored in 100ml volumetric flask (Chapman, 1965) [4]. The sodium ions present in the extract was determined by flame photometer.

Nitrogen was determined by Alkaline permanganate method (Subbiah and Asija, 1956) [16]. Phosphorous was determined by Olsen’s method of 0.5M sodium bicarbonate as a extractant using double beam spectrophotometer at 420nm (Olsen *et al*. 1954) [12]. Potassium was determined by neutral normal ammonium acetate method using flame photometer (Jackson, 1973) [8]. Organic carbon was estimated by procedure given by Walkley and Black method (1965) [19].

3. Results and Discussion

3.1 Soil physico chemical properties

The soils of all the land use systems are slightly acidic to neutral in reaction (pH 6.46 - 7.37) as per USDA classification Table 3, 4 and 5. The pH under Orchard and Block plantations was lower when compared to Agricultural crops and silvi agri systems because of higher litter addition in these systems, which is acidic nature after its decomposition. These results are in accordance with Maqbool *et al*. (2017) [11].

The electrical conductivity of soils ranges from 0.26 - 0.35 Normal for all crops as per USDA classification. Among all the land use systems soil E.C decreases from surface soil (0-15cm - 0.31 dSm^{-1}) to subsurface soil layers (15-30cm - 0.29 dSm^{-1}, 30-45cm,0.27 dSm^{-1}). Lowest E.C found in block and orchard may be attributed to uptake of bases by tree biomass, acidic nature of litter after its decomposition. These results are in conformity with Tufa *et al*. (2019) [18].

Significantly higher soil cation exchange capacity recorded under Silvi agri systems (20.35 cmol(p^{+})kg^{-1}). The lower soil cation exchange capacity under Agricultural crops (14.49 cmol(p^{+})kg^{-1}). Among all the land use systems soil cation exchange capacity decreases from surface soil (0-15cm - 20.28 cmol (p^{+}) kg^{-1}) to subsurface soil layers (15-30cm - 17.23, 30-45cm - 13.65 cmol (p^{+}) kg^{-1}) due to decreases with increase in depth due to decrease in organic matter. There is no interaction between the land use systems and soil depths. Higher soil cation exchange capacity was observed under silvi agri systems due to the presence of soil organic matter, the amount and types of clay particles also determinant factor on cation exchange capacity of soil under different systems (Tufa *et al*., 2019) [18]. The lowest cation exchange capacity in agricultural crops is due to less soil organic matter because of intensive cultivation practices which was also reported by (Bhople and Sharma, 2020) [2] who reported that depletion of soil organic carbon under cropland could be due to intensive cropping contributed to the reduction of cation exchange capacity of soils.

3.2 Soil physical properties

Soil texture of the different land use systems comes under sandy loam, sandy clay loam and loam. In all the land use system sand fraction is dominant it ranged from 40% - 61%. In all the land use system sand fraction is dominant it ranged from 40% - 61%. The soil bulk density value was significantly affected by different land use systems and depth (Table 2). The highest bulk density recorded under Agricultural crops (1.384 g cm^{-3}) and the lowest was found under orchard crops (1.276 g cm^{-3}).

Among all the land use systems soil bulk density increases from surface soil (0-15cm - 1.292 g cm^{-3}) to subsurface soil layers (15-30cm - 1.318, 30-45cm - 1.330 gcm^{-3}) (Table-2), The higher bulk density in Agricultural crops and agri silvi systems might be due to the practice of ploughing in cultivated soil, which tends to lower the quantity of organic matter of that soil and expose the soil surface to temperature and moisture by irrigation practice. These results are in conformity with Tufa *et al*. (2019) [18].

Table 2: Effect of different land use systems on bulk density in soil at different depths

Land use systems	**Bulk density (Mg m^{-3})**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	1.29	1.31	1.32	1.30
Block plantations	1.27	1.28	1.30	1.28
Orchard crops	1.24	1.28	1.30	1.27
Agricultural crops	1.36	1.38	1.39	1.38
Mean (Depth)	1.29	1.31	1.33	
	S.Em ±	C.D @ 5%		
LUS	0.006	0.016		
Depth	0.005	0.014		
LUS × Depth	0.01	NS		

Table 3: Effect of different land use systems on soil pH at different depths

Land use systems	**Soil pH**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	6.59	6.76	6.93	6.76
Block plantations	6.30	6.45	6.62	6.46
Orchard crops	7.23	7.36	7.53	6.52
Agricultural crops	6.35	6.53	6.70	7.37
Mean (Depth)	6.62	6.77	6.94	
	S.Em ±	C.D @ 5%		
LUS	0.02	0.07		
Depth	0.02	0.06		
LUS × Depth	0.04	NS		

Table 4: Effect of different land use systems on soil EC at different depths

Land use systems	**Soil EC (ds m^{-1})**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	0.37	0.35	0.34	0.35
Block plantations	0.28	0.25	0.25	0.26
Orchard crops	0.28	0.26	0.24	0.26
Agricultural crops	0.32	0.29	0.24	0.28
Mean (Depth)	0.31	0.29	0.27	
	S.Em ±	C.D @ 5%		
LUS	0.02	0.009		
Depth	0.02	0.008		
LUS × Depth	0.016	NS		

Table 5: Effect of different land use systems on soil cation exchange capacity at different depths

Land use systems	**Cation exchange capacity (cmol (p^+) kg^{-1})**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	24.63	20.28	16.16	20.35
Block plantations	20.07	17.22	14.45	17.25
Orchard crops	18.78	16.56	13.01	16.11
Agricultural crops	17.64	14.86	10.96	14.49
Mean (Depth)	20.28	17.23	13.65	
	S.Em ±	C.D @ 5%		
LUS	0.44	1.25		
Depth	0.38	1.08		
LUS × Depth	0.77	NS		

3.3 Soil chemical properties

The results revealed that soil organic carbon contents were significantly affected by different systems (Table 6). But there is no interaction between the land use systems and soil depth. Significantly higher soil organic carbon under Silvi-agri systems (6.13 g kg^{-1}) and the lower soil organic carbon under Agricultural crops (2.05 g kg^{-1}). Among all the land use systems soil organic carbon decreases from surface soil (0-15cm - 5.85 g kg^{-1}) to subsurface soil layers(15-30cm, 4.47, 30-45cm - 3.10 g kg^{-1}).

Higher soil organic carbon under Silvi-Agri system where more residue is added through leaf litter and intercrops plant residue. These results are in conformity with Bhavya *et al*. (2018) [1]. Reza *et al*. (2014) [14] had also reported that soils under horticulture and forest systems showed greater amounts of soil organic carbon than agriculture land. Lower organic carbon in agricultural crops is due to exposure of plant residues and organic matter to higher temperature and moisture by the tillage operations, which in turn increases the decomposition of the organic matter by microbes. These results are in accordance with Selassie *et al*. (2013) [15].

Significantly higher soil available N recorded under Orchard crops (202.06 kg ha^{-1}). The lower soil available N recorded under Silvi-agri systems (166.32 kg ha^{-1}). Among all the land use systems soil available N decreases from surface soil (0-15cm - 236.30 kg ha^{-1}) to subsurface soil layers (15-30cm, 180.93, 30-45cm - 144.84 kg ha^{-1}). Higher soil available P_2O_5 was observed under Orchard crops (38.61kg ha^{-1}) which was on par with Agricultural crops (35.72 kg ha^{-1}). Lower was recorded under Silvi-agri systems(30.80 kg ha^{-1}). Among all the systems soil P_2O_5 decreases from surface soil (0-15cm,42.48kg ha^{-1}) to subsurface soil layers (15-30cm - 34.41, 30-45cm - 27.00kg ha^{-1}) (Table 7, 8 and 9).

Significantly higher soil available K_2O was observed under

Agricultural crops (570.57kg ha^{-1}). Lower soil available K_2O under block plantation (409.96 kg ha^{-1}). Among all the land use systems soil available K_2O decreases from surface soil (0-15cm - 549.14kg ha^{-1}) to subsurface soil layers (15-30cm - 473.66, 30-45cm - 413.59 kg ha^{-1}). In soil available macronutrients there is no interaction between the land use systems and soil depths

Among all the land use systems soil N, P_2O_5 and K_2O decreases from surface soil to subsurface soil layers this could be due to reduced organic matter content with increase in depth of soil organic compounds in soil release nutrients during decomposition and also increase P availability by the formation of organophosphate complexes that are more easily assimilated by plants (Selassie *et al.*,2013; Tufa *et al.*,2019) [15, 18].

Higher soil available N and P_2O_5 under Orchard crops due to the presence of high leaf litter which affords as mulch there by reducing the loss of macro and micro nutrients that are essential for plant growth (Iwara *et al.*, 2011) [7].

Soil organic carbon significantly and positively correlated with cation exchange capacity, available N, available P and available K in all land use systems, it ranges from r = 0.79** - 0.93**, r = 0.87** - 0.91**, r = 0.37** - 0.80** and r = 0.63**- 0.77**)

Table 6: Effect of different land use systems on soil organic carbon at different depths

Land use systems	**Soil organic carbon (g kg^{-1})**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	7.79	6.15	4.46	6.13
Block plantations	6.15	4.92	3.79	4.95
Orchard crops	5.84	4.82	3.58	4.75
Agricultural crops	3.59	2.00	0.56	2.05
Mean (Depth)	5.85	4.47	3.10	
	S.Em ±	C.D @ 5%		
LUS	0.14	0.40		
Depth	0.12	0.34		
LUS × Depth	0.24	NS		

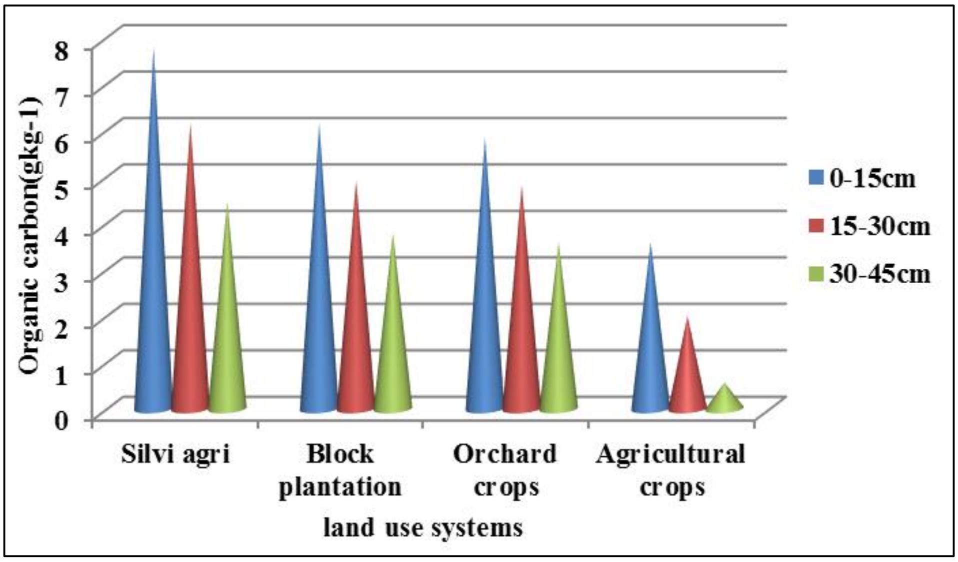

Fig 1: Soil organic carbon (g kg^{-1}) under different systems

Table 7: Effect of different land use systems on available N in soil at different depths

Land use systems	**Available N (kg ha^{-1})**			
	0 - 15 cm	**15 - 30 cm**	**30 - 45 cm**	**Mean (LUS)**
Silvi - agri system	210	155	132	166
Block plantations	243	184	146	191
Orchard crops	249	198	158	202
Agricultural crops	241	184	142	189
Mean (Depth)	236	184	142	
	S.Em ±	C.D @ 5%		
LUS	2.52	7.11		
Depth	2.18	6.16		
LUS × Depth	4.37	NS		

Table 8: Effect of different land use systems on available P_2O_5in soil at different depths

Land use systems	Available P_2O_5 (kg ha^{-1})			
	0 - 15 cm	15 - 30 cm	30 - 45 cm	Mean (LUS)
Silvi - agri system	37.2	29.2	25.8	30.8
Block plantations	42.4	31.6	26.0	33.4
Orchard crops	47.7	41.9	26.1	38.6
Agricultural crops	42.4	34.8	29.9	35.7
Mean (Depth)	42.4	34.8	29.9	
	S.Em ±	C.D @ 5%		
LUS	1.20	3.39		
Depth	1.04	2.94		
LUS × Depth	2.09	NS		

Table 9: Effect of different land use systems on available K_2O in soil at different depths

Land use systems	Available K_2O (kg ha^{-1})			
	0 - 15 cm	15 - 30 cm	30 - 45 cm	Mean (LUS)
Silvi - agri system	478	415	372	422
Block plantations	473	404	351	410
Orchard crops	592	515	428	512
Agricultural crops	651	558	501	571
Mean (Depth)	549	473	413	
	S.Em ±	C.D @ 5%		
LUS	17.01	47.90		
Depth	14.73	41.48		
LUS × Depth	29.47	NS		

4. Conclusions

The results cocluded that among the land use systems Silvi agri system recorded high organic carbon and CEC with low pH followed by the block plantations and orchard. Agricultural crops recorded with high pH and bulk density, low organic carbon and nitrogen. In all the land use systems the organic carbon, available nutrients and CEC decreased with increase in depth. There is a significant correlation between organic carbon and all other. (Soil properties *viz.* CEC, available N, P_2O_5 and K_2O)

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