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Physical and Chemical Properties of Soil in Upland and Lowland Agro-Ecosystem of Garhwa District, Jharkhand

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Abstract The cultivated land of Jharkhand consists of 2 unique agro-ecosystems i.e. upland and lowland due to undulating Terrain. However, differences in physical and chemical properties of soil of these agro-ecosystems have been rarely reported. Further, rise in mean average temperature and lowering rainfall amount has been reported in western part of the state (Palamu, Latehar and Garhwa district) due to climate change. This might also affect physical and chemical properties of the soil. Therefore, physical and chemical characterization of upland and lowland soil of Garhwa district was carried out in this study with view to provide soil information for better soil management. The result found significant differences in physical and chemical properties between upland and lowland soil. Lowland soil had significantly low sand and high silt and clay content as compared to upland soil. Therefore, bulk density and filed capacity was also higher in lowland (BD 1.63±0.11 Mg m^{-3}, FC 21.24±2.17%) as compared to upland soil (BD 1.53±0.07 Mg m^{-3}, FC 19.68±2.07%). Upland soils (pH 5.0–7.6) were more acidic than that of lowland (pH 6.3–7.9 soils in most of the blocks. The soil of lowland was relatively higher in available nitrogen and soil organic carbon as compared to upland soil, while lower in available phosphorus and potassium.

Keywords Physical, Chemical, Soil, Upland, Lowland.

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Introduction

Soil is medium for plant growth and maintaining its quality and productivity is crucial for sustaining agro-ecosystem. Soil also directly and indirectly affects water quality and the global climate through regulation of water flow and nutrient cycling (Delgado and Gomez 2016). However, a soil property is affected by biotic, climatic and topographic factor and these factors often cause heterogeneity in soil properties at the spatial and temporal scales (Yavitt et al. 2009). The special variability of soil also affects strategies for soil nutrient and moisture management and choice of crops for the success of agricultural production. Thus, characterizing spatial heterogeneity of soil properties in different agro-ecosystem can contribute well to the understanding of the structure and function of soil as well as better crop production. Jharkhand state is spread over 7.97 million hectare geographical area which is consists of both plateau and sub-plateau region with highly undulating Terrain. The area suitable for agriculture is about 2.85 million hectare ; with two unique upland and lowland agro-ecosystem. The upland area comprises about 1.34 million hectare and the lowland about 1.06 million hectare (Day and Sarkar 2011). Most of the upland areas are covered by forest, open scrubs, fallow lands, settlements and agricultural lands. Upland agro-ecosystem are gentle sloppy to sloppy land at upper portion in the topo-sequence and generally immediately adjacent to the homestesd. These soils are mainly used for vegetable, maize and rice seedling growing. While low lands are lower portion in the topo-sequence. The lowland agro-ecosystem remains mono-cropped with rice and for follow up crops. The major constraint for agriculture in this region is that more than 80% cultivated area is under rainfed condition (Day and Sarkar 2011). Therefore, proper management of soil become important planning for ensuring better crop production. Further, the north-western region of Jharkhand especially Palamu, Garhwa and Latehar districts, are becoming warm and dry with extended dry spell and climate extremes (Tirkey et al. 2018, Gupta and Kumar 2018). The change in weather and climatic parameters will have severe impact on soil characteristics and agriculture production in this region. However, information on chemical and physical properties of soils of lowland and upland agro-ecosystem in this region is lacking. Therefore, characterization of soil in a particular agro-ecosystem becomes necessary for sustainable land use planning and demarking bench line for tracking change in the future. Characterization of soil especially physical and chemical properties at district level is required for better crop planning (Amenla et al. 2010). For more accurate crop planning in terms of choice of crops, varieties, and crop rotation chemical and physical properties of soil play important role. Therefore, present study was undertaken to characterize the physical and chemical properties of soil of the upland and lowland agro-ecosystem of the Garhwa district.

Materials and Methods

Study area

Garhwa district is located in the north-western part of the State. It is spread over 3°60′ N to 24°39′N and 83°22′E to 84°00′E at altitude from 160 to 295 m above mean sea level. The climate of the region is sub-humid to sub-tropical with an average rainfall of 1237.3 mm. It is located in the western plateau sub-zone (zone V) of Jharkhand State and often becomes a rain-shadow area. Minimum and maximum temperature reached up to 3.9ºC and 45ºC during the winter and summer seasons respectively. The district has about 0.42 million hectare geographical area with 25.96% net shown, out of which 8.23% is irrigated. The soils of the district occurring in different landforms have bean characterized and mapped on 1 : 250,000 scale (Haldar et al. 1996) and three soil orders namely Entisols, Inceptisols and Alfisols were observed out of which Alfisols in dominant soils covering 54.5% of total geographical area followed by Entisols (29.7%) and Inceptisols (14.7%) of the district.

Soil sampling and analysis

Representative soil samples (0—15 cm depth) were randomly collected from upland and lowland cultivated agricultural land in 8 blocks (Bhawnathpur, Dhuraki, Garhwa, Majhiyaon, Meral, Nagar-untari and Ranka) of Garhwa district during 2015. Total 32 composite soil samples, 2 from both the topography (upland and lowland agro-ecosystem) in each block were brought for the analysis in the laboratory of Department of Agro-Meteorology and Soil Physics, Birsa Agricultural University, Ranchi. Soil samples were air dried, processed and used for analysis. Total 5 soil physical parameters (soil texture, bulk density, soil water retention, field capacity and permanent wilting point) and 5 chemical parameters (pH, organic carbon, available nitrogen, available phosphorus and available potassium) were determined by standard protocols. Separate undisturbed soil core were collected for determining bulk density of soils. Soil texture was determined by hydrometer as described by (Bouyoucos 1927). The USDA textural triangle was consulted for determination of textural class of the soils. Soil water retention at field capacity and permanents wilting point (0.033 and 1.5 M Pa) were determined with the help of Pressure plate apparatus (Richard 1949). Water retained between 0.033 and 1.5 M Pa was considered to be available moisture storage of the soil (Peterson et al. 1971) and it was done by subtracting moisture remained at 1.5 M Pa from the water retained at 0.033 M Pa. Soil pH was determined in soil-water suspension of 1 : 2.5 (w/v), using glass electrode by digital pH meter (ELICO 1614) as described by Jackson (1973). Available nitrogen (easily mineralizable) was estimated by distillation of soil with alkaline potassium permanganate and determining the ammonia liberated as per method suggested by Subbiah and Asija (1956). Available phosphorus

Table 1. Phisico-chemical properties of upland and lowland soil.

Soil physical properties

Agro-ecosystem	Textural class	Bulk density (Mg m-3)		Field capacity (%)		Permanent wilting point (%)		Available water (%)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Upland	Sandy loam	1.63	0.11	19.68	2.07	9.38	1.52	10.3	0.88
Lowland	Sandy loam	1.53	0.07	21.24	2.17	10.16	1.84	10.98	0.97
CD		0.10	–	N/A	–	N/A	–	N/A	–
p-value		0.03	–	0.16	–	0.36	–	0.16	–

Soil chemical properties

Agro-ecosystem	pH		Ava. Nitrogen (kg/ha)		Ava. Phosphorus (kg/ha)		Ava. Potassium (kg/ha)		Organic carbon (%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Upland	6.38	0.71	421.44	42.87	28.1	11.14	275.16	92.79	0.44	0.03
Lowland	6.81	0.85	434.29	63.84	18.58	03.96	234.31	92.00	0.47	0.02
CD	N/A	–	N/A	–	8.82	–	N/A	–	N/A	–
p-value	0.14	–	0.91	–	34.91	–	0.37	–	0.07	0.531

was extracted with Bray-P1 extractant (0.03 NH_4F in 0.025 HCL solution) and was determined (Bray and Krutz 1945) as described by Jackson (1973) on a double beam digital spectrophotometer (Spectra Scan UV 2600). Available K was determined by Flame photometer after extraction of soil with 1 N NH_4OAc (pH 7.0) soil and solution ratio was maintained at 1.5 (w/v) as described by Jackson (1973). Organic carbon of the soil was estimated by chromic acid wet digestion method as outlined by Walkley and Black (1934). Analysis of variance was (ANOVA) was done at 95% confidence level for comparing difference in the mean of soil physical and chemical parameters of upland and lowland soil.

Results and Discussion

Soil physical properties

The soil of the agro-ecosystem was significantly different in sand, silt and clay content (Table 1 and Fig. 1). Lowland soil had significantly low sand and high silt and clay content as compared to upland soil. Therefore, soil texture varied from sandy clay loam to sandy loam in lowland system while loamy sand to sandy loam in upland system (Table 1). Percentage of sand, silt and clay was 68.10±6.70, 21.33 ± 5.04 and 10.58 ± 3.93 respectively in upland soil, while it was 60.80 ±5.28, 27.16 ± 3.46 and 12.16 ± 4.84 respectively in lowland soil (Fig. 1). It was earlier also observed that higher sand and lower silt and clay content in upland soil as compared to lowland soil in western plateau (zone V) as well as other agro-climatic zone of the Jharkhand. Similar difference indistribution of soil particles in upland and lowland soil has also been observed else where (von Haden and Mathew 2016, Raj et al. 2017). Soil texture influence other physical properties of the soil, therefore, soil bulk density and water holding capacity was also different in the upland and lowland soil. The bulk density of lowland soil (1.53 ± 0.07 Mg m^{-3}) was significantly lower than upland soil (1.63 ± 0.11 Mg m^{-3}) (Table 1). It was due to higher clay and lower sand content in lowland soil as compared to upland soil. Due to high clay content and bulk density, the water retention at field capacity, permanent wilting point was higher in lowland soil, resulting into high soil water availability to crop (10.98 ± 0.97%) as compared to upland soil (10.3 ± 0.88%), however, difference was insignificant (Table 1). Lowland soils retained more available water than the upland soils in all the blocks. Similar results on water retention parameters with respect to topography and texture have been reported by Verma et al. (2001) and von Haden and Mathew (2016). The result indicated that, upland soils had relatively coarser soil texture and low water

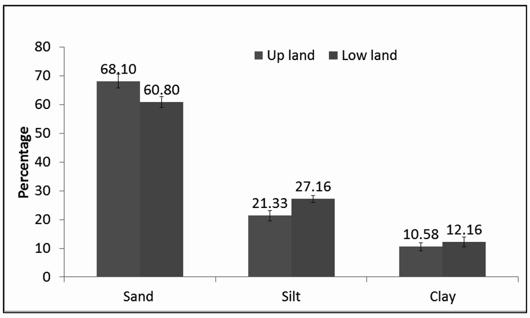

Fig. 1. Percentage distribution (mean) of sand, silt and clay in upland and lowland soil. p value of ANOVA for sand, silt and clay is 0.03, 0.01 and 0.48 respectively at 95% level.

retention, therefore, less water requiring crops like pulses, oilseeds and maize are grown successfully. On the other hand, lowland soils exhibited medium texture and also having more available water, these lands are cultivated for high water requiring crops like paddy (dry seeding and transplanted).

Soil chemical properties

Variation in chemical properties of soil was observed between lowland and upland soil. Upland soils were more acidic than that of lowland soils in most of the blocks. Soil pH varied from 5.0–7.6 (6.38 ± 0.71) in upland soil, while it varied from 6.3–7.9 (6.81 ± 0.85) in lowland soil (Table 1). The pH of acidic soil has been reported to increase because of flooding (Fageria et al. 2011). In the present study, the lowland agro-ecosystem remain flooded for longer duration due to cultivation of rice, while, upland remain aerobic around the year. Therefore, soil pH of lowland soil might be higher than upland soil. Soils of both upland and lowland were low in organic carbon content, while medium in available N, P and K content. However, upland and lowland soil showed differences in these parameters. The soil of lowland was relatively higher in available nitrogen and soil organic carbon as compared to upland soil, while lower in available phosphorus and potassium. The mean value of available N, P, K and soil organic carbon was 421.44±42.87 kg ha^{-1}, 28.1±11.14 kg ha^{-1}, 275.16±92.79 kg ha^{-1} and 0.44±0.07% respectively in upland soil, while it was 434.29±63.84 kg ha^{-1}, 18.58 ± 3.96 kg ha^{-1}, 234.31± 92.02 kg ha^{-1} and 0.47±0.06% respectively in lowland soil (Table 1). Zhang et al. (2014) also reported high soil pH and soil organic carbon content in lowland soil as compared to upland soil in different agro-climatic zone of Jharkhand. Similarly, higher value of pH, organic carbon and available N has been reported in lowland as compared to upland soil by von Haden and Mathew (2016) and Raj et al. (2017). Von Haden and Mathew (2016) also reported lower available P in low land soil as compared to upland soil. The differences in chemical properties of upland and lowland soil are mainly attributed to prolonged aerobic and anaerobic condition in these agro-ecosystems respectively (Fageria et al. 2011).

Conclusion

There was difference in physical and chemical properties of upland and lowland soil of Garhwa district. Lowland soil was physically and chemically richer than upland soil. However, both soils are medium in fertility status. The result indicated that, upland soils had relatively coarser soil texture and low water retention, therefore, less water requiring crops may be suitable. Further, upland soil is less fertile than lowland soil, therefore upland soil need suitable nutrient management.

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