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Spatial Variability of Soils of Bobbili Mandal, Vizianagaram District, Andhra Pradesh

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ABSTRACT

The soils of Bobbili mandal, Vizianagaram district were assessed for spatial variability by collecting surface (0-25 cm) and subsurface (25-50 cm) soil samples from 50 representative locations. Three physiographic units namely uplands, midlands and lowlands were indentified based on elevation. The texture of uplands and midlands varied from sandy clay to sandy loams whereas in lowlands it varied from clay to sandy clay. Bulk density of the soils was lower at surface than subsurface with higher values in coarse textured soils. The water holding capacity followed the reverse trend with higher mean values at subsurface than surface with more values recorded in fine textures than coarse textures in all landforms. The soils were found to be strongly acidic to moderately alkaline, non-saline to critical for germination with low organic carbon. Lowlands recorded higher CEC values compared to uplands and midlands.

Key words : CEC, Soil physical properties, Soil reaction, Soil texture, Surface and subsurface soils.

Soil is a variable key natural resource and the management of soil properties determines crop productivity and sustainability. Availability of nutrients is influenced by their distribution in soil and other physico-chemical characteristics of soils. The physical and physico-chemical characteristics of different soils vary in space and time due to variations in topography, climate, physical weathering process, vegetation cover, microbial activities and several other biotic and abiotic variables (Paudel and Sah, 2003). The soil properties like texture, soil reaction, organic carbon, cation exchange capacity, per cent base saturation etc. influence the behaviour of soil and hence its productivity (Sumithra *et al*., 2013). Sound knowledge about soil characters is very much relevant for identifying constraints in crop husbandry for attaining sustained productivity and facilitating the agro-technology transfer. Hence the present study was conducted at Bobbili mandal of Vizianagaram, a coastal district of Andhra Pradesh to find out the spatial variability of the soils of the mandal for better land use planning.

MATERIAL AND METHODS

Bobbili mandal of Vizianagaram district, Andhra Pradesh, is situated between 18^{o}34'and 18^{o}56' North latitude and 83^{0}22'and 83^{0}36' East longitude with elevation varying from 107 - 178 m above the mean sea level. The mean annual rainfall of the area was 1037 mm, the mean annual maximum and minimum temperature were 39.02 ^{o}C and 29.04 ^{o}C, respectively. The drainage pattern is sub - dendritic with ephemeral streams going from West to East. The soils of the study area were divided into three physiographic units viz., uplands, transitional soils and low lands based on elevations and drainage (Fig.1). Major crops of the area were rice and sugarcane.

Fifty sampling locations representing different physiographic forms of Bobbili mandal, were selected and at each site, surface (0-25 cm) and sub surface (25-50 cm) samples were collected. Soil samples were dried under shade, powdered and ground with a wooden hammer and passed through a 2 mm sieve to obtain a uniform representative sample and stored in labelled air tight polythene bags for analysis. The texture of the soils was determined by Bouyoucos Hydrometer method (Piper, 1966), bulk density by clod method (Black and Hartge, 1986) while water holding capacity was estimated by Keen Raczkowski's method (Sankaram1966). The physico-chemical properties like pH and electrical conductivity were determined in 1 : 2.5 soil : water suspension using pH meter and conductivity meter, respectively. Organic carbon content was estimated by Walkley and Black method (Jackson, 1973) whereas, CEC was estimated as per the procedure outlined by Bower *et al*. (1952).

RESULTS AND DISCUSSION

The data related to characteristic properties of different physiographic units of Bobbili mandal are presented in tables 1 to 3.

Physical properties of soils

The maximum sand contents at surface and subsurface were recorded by upland soils (64.36 and 61.12 %) followed by midlands (60.96 and 60.05%) and low lands (41.34 and 38.42%), respectively. Out of the three soil fractions, the silt content was found to be the lowest in all the three landforms viz. uplands (7.17 and 8.54%), midlands (6.80 and 8.47%) and lowlands (8.25 and 9.81%) at surface and subsurface, respectively. The clay content at surface as well as subsurface followed a reverse trend of sand with maximum values recorded in lowlands (50.12 and 51.79 %) followed by midlands (32.24 and 31.47 %) and uplands (28.44 and 30.33 %), respectively. Overall, as per USDA textural triangle the soils in uplands were relatively coarser with 55 per cent of samples falling under loams. In midlands, loams occupied 44 percent while no loams were observed in low lands, which revealed that soils were more finer at lower levels of topography. In a toposequence, the soil texture could chiefly be attributed to the transportation of finer particles down the slope through run-off and their deposition in lower physiographic position (Taha and Nanda, 2003). The texture of uplands and midlands varied from sandy clay to sandy loam, while in lowland soils it varied from clay to sandy clay. The data revealed a wide textural variation, which might be due to the variations in topographic position, nature of parent material, in situ weathering of clay and age of soils.

In lowlands, lower values of bulk density (1.38 and 1.41 Mg m^{-3}) were observed compared to midlands (1.50 and 1.54 Mg m^{-3}) and uplands (1.50 and 1.52 Mg m^{-3}). The bulk density of surface soils were higher than subsurface layers, which might be due to compaction of finer particles in lower depths caused by overhead weight of the surface soils. The critical observation of lower bulk density with finer texture could be attributed to the higher clay content with more surface area and porosity than coarse textured soils (Pravin *et al*., 2013). This can be evidenced by the significant negative correlation (r = -0.759) between clay and bulk density. The soil organic matter also has negative relation (r= -0.283) as it binds mineral particles into granular structure responsible for increased porosity and low bulk density. The water holding capacity was comparatively higher in lowlands (38.15 to 54.67 per cent at surface and 39.79 to 55.31 per cent at subsurface) than uplands (11.50 to 44.68 and 13.54 to 44.85 per cent) and midlands (14.57 to 45.66 and 14.20 to 43.98 per cent). Black soils exhibit high water holding capacity due to high percentage of swell-shrink group of clay minerals (smectite), which have large surface area to retain more quantity of water (Satish *et al*., 2008).

The mean pH values of lowland soils at both surface and subsurface were higher compared to midlands and upland soils. The soils with fine texture in all physiographic units registered high pH values, which can be evidenced by the significant positive correlation with clay (r = 0.597**). The upland soils were strongly acidic to moderately alkaline (5.1 to 8.4) at both surface and subsurface. In midlands, the pH of the surface soils varied from medium acidic to moderately alkaline (5.9 - 8.4) and at subsurface it varied from neutral to moderately alkaline (6.6 - 8.4). The lowland soils were neutral to moderately alkaline (7.3 to 8.4 and 7.5 to 8.4) at both surface and subsurface, respectively. The acidic nature of the soils might be due to acidic parent material and high prevailing rainfall which induces loss of soluble salts under relatively elevated and sloppy areas (Roopa and Mallikarjun, 2011). The neutral to alkaline pH of some soils might be attributed to the location of soils in plains with slopes of <1% and continuous addition of bases through irrigation water or fertilizer material. Overall, 98 per cent of the surface and all subsurface samples were non saline (EC 0-2 dS m^{-1}), which could be due to high precipitation and less evaporation demand (Srinivasan and Poongothai, 2013). The remaining two per cent of the samples were found to record EC values more than 2.00 dS m^{-1}, which is critical for the germination of the salt

Table 1. Characteristic properties of upland soils of Bobbili mandal.

Soil characteristics	Surface (0-25 cm)		Subsurface (25-50 cm)	
	Range	Mean	Range	Mean
Sand (%)	47.20-80.90	64.36	46.70-75.40	61.12
Silt (%)	4.20-10.90	7.17	5.20-12.10	8.54
Clay (%)	12.20-41.70	28.44	14.10-43.70	30.33
BD (Mg m^{-3})	1.44-1.58	1.50	1.47-1.57	1.52
WHC (%)	11.5-44.68	27.79	13.54-44.85	30.51
pH	5.3-8.2	7.1	5.1-8.4	7.3
EC (dS m^{-1})	0.05-0.52	0.17	0.03-0.44	0.17
OC (%)	0.11-0.66	0.35	0.03-0.35	0.18
Exchangeable cations				
Ca^{2+} cmol (p^+) kg^{-1}	4.45-20.00	11.16	5.10-23.60	12.92
Mg^{2+} cmol (p^+) kg^{-1}	1.20-9.96	5.07	2.40-10.61	5.17
Na^+ cmol (p^+) kg^{-1}	0.34-2.06	0.84	0.32-1.52	0.93
K^+ cmol (p^+) kg^{-1}	0.25-0.61	0.38	0.20-0.41	0.37
CEC cmol (p^+) kg^{-1}	9.22-28.54	19.96	11.31-34.14	21.80
PBS	80.50-93.60	86.55	80.90-96.40	88.10

BD = bulk density; WHC= water holding capacity; EC= electrical conductivity;
OC = organic carbon; CEC= cation exchange capacity; PBS= per cent base saturation

Table 2. Characteristic properties of midland soils of Bobbili mandal.

Soil characteristics	Surface (0-25 cm)		Subsurface (25-50 cm)	
	Range	Mean	Range	Mean
Sand (%)	48.10-75.30	60.96	49.50-76.40	60.05
Silt (%)	4.50-11.20	6.8	5.40-12.80	8.47
Clay (%)	16.60-46.70	32.24	17.60-43.40	31.47
BD (Mg m^{-3})	1.41-1.59	1.50	1.46-1.62	1.54
WHC (%)	14.57-45.66	32.13	14.20-41.66	31.31
pH	5.9-8.4	7.5	6.6-8.4	7.7
EC (dS m^{-1})	0.03-1.49	0.36	0.04-1.28	0.34
OC (%)	0.12-0.54	0.34	0.03-0.35	0.15
Exchangeable cations				
Ca^{2+} cmol (p^+) kg^{-1}	6.00-29.20	14.09	7.20-29.60	15.05
Mg^{2+} cmol (p^+) kg^{-1}	1.60-6.00	3.40	1.60-8.62	4.57
Na^+ cmol (p^+) kg^{-1}	0.43-2.06	0.78	0.54-2.28	0.84
K^+ cmol (p^+) kg^{-1}	0.20-1.84	0.56	0.20-1.94	0.52
CEC cmol (p^+) kg^{-1}	13.05-34.52	21.08	15.71-37.50	23.36
PBS	81.20-96.10	88.85	83.60-96.20	89.29

BD = bulk density; WHC= water holding capacity; EC= electrical conductivity;
OC = organic carbon; CEC= cation exchange capacity; PBS= per cent base saturation

Table 3. Characteristic properties of lowland soils of Bobbili mandal.

Soil characteristics	Surface (0-25 cm)		Subsurface (25-50 cm)	
	Range	Mean	Range	Mean
Sand (%)	34.70-54.80	41.34	30.50-48.50	38.42
Silt (%)	3.50-11.70	8.25	4.90-12.40	9.81
Clay (%)	36.80-56.80	50.12	41.40-59.40	51.79
BD (Mg m^{-3})	1.31-1.54	1.38	1.32-1.54	1.41
WHC (%)	38.15-54.67	49.07	39.79-55.31	49.99
pH	7.3-8.4	7.9	7.5-8.4	7.9
EC (dS m^{-1})	0.03-2.90	0.68	0.20-2.50	0.66
OC (%)	0.29-0.76	0.46	0.08-0.44	0.22
Exchangeable cations				
Ca^{2+} cmol (p^+) kg^{-1}	14.40-26.00	21.30	15.20-28.00	21.21
Mg^{2+} cmol (p^+) kg^{-1}	2.00-16.90	8.23	2.93-16.99	10.57
Na^+ cmol (p^+) kg^{-1}	0.65-4.00	1.66	0.54-2.17	1.39
K^+ cmol (p^+) kg^{-1}	0.41-3.20	1.03	0.36-3.48	0.85
CEC cmol (p^+) kg^{-1}	21.10-42.60	35.25	22.40-44.60	37.04
PBS	86.40-95.80	91.22	89.10-96.50	91.78

BD = bulk density; WHC= water holding capacity; EC= electrical conductivity;
OC = organic carbon; CEC= cation exchange capacity; PBS= per cent base saturation

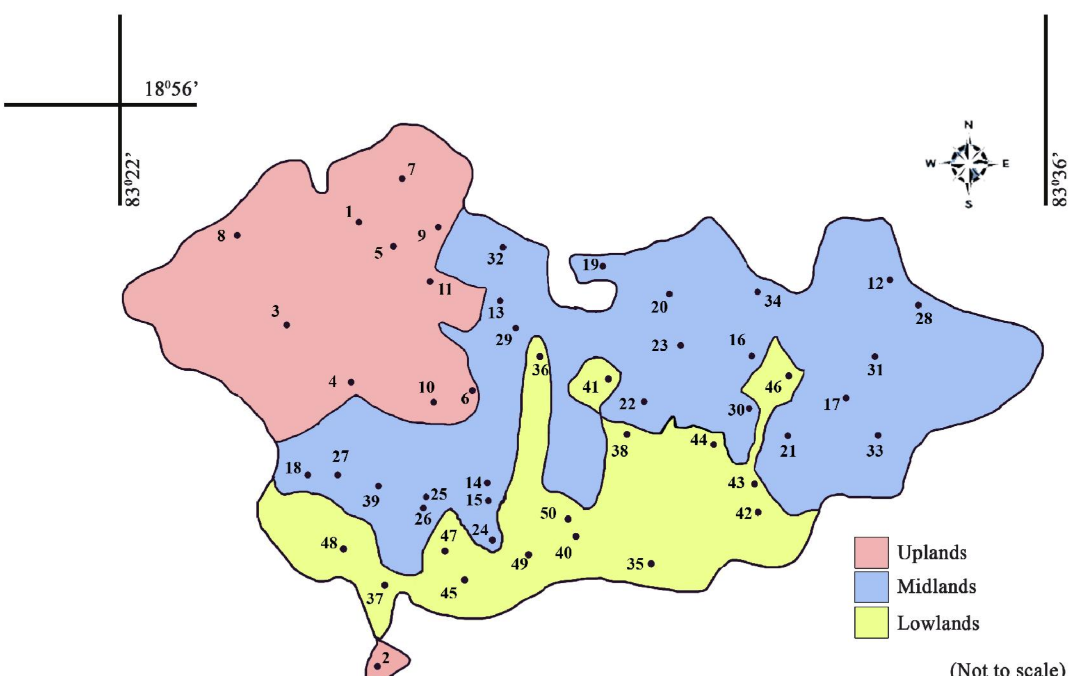

Fig. 3.2 Location of soil sample sites in different physiographic units

sensitive crops. The mean EC of the lowland soils was higher than transitional soils and uplands.

The results related to organic carbon according to the criteria, given by Ramamoorthy and Bajaj (1969) revealed that among the surface samples 82 per cent were low (< 0.5 %), 16 per cent were medium (0.5 to 0.75 %) and 2 per cent were high (>0.75 %) in organic carbon content, while all subsurface samples were low in organic carbon content (< 0.5 %). The surface soils have recorded higher mean organic carbon contents as compared to the subsurface soils, which could be attributed to the addition of crop residues and manures to the surface horizons.

Electro-chemical properties

Data revealed that the contents of exchangeable cations were in the order of Ca^{2+} > Mg^{2+} > Na^{+} > K^{+} in all the soils. The exchangeable calcium was found to be the most dominant cation on exchange complex both at surface and subsurface in all the landforms. Soils usually contain less Mg^{2+} than Ca^{2+} because Mg^{2+} ions are not adsorbed as strongly as Ca^{2+} by clay and organic colloids. Further Mg^{2+} ions are more susceptible to leaching than Ca^{2+} ions (Pasricha and Sarkar, 2012). The low value of exchangeable monovalents compared to divalent could be due to preferential leaching of monovalents than divalent (Thangaswamy *et al*., 2005). The exchangeable potassium was low compared to other cations which might be due to slow weathering of mica and fixation of released potassium.

The mean CEC values of lowland soils at both surface and subsurface (35.25 and 37.04 cmol (p^{+}) kg^{-1}) were higher compared to midlands (21.08 and 23.36 cmol (p^{+}) kg^{-1}) and uplands (19.96 and 21.80 cmol (p^{+}) kg^{-1}, respectively). The low CEC in the soils might be due to loamy texture and low colloidal content. This could also be due to the presence of low CEC minerals like illite and kaolinite. The dependence of cation exchange capacity of soils on clay content was found to be very high ($r = 0.883^{**}$). Hence, clay soils have recorded more cation exchange capacity than coarse textured soils both at surface and subsurface. The low CEC in the soils might be due to loamy texture and low colloidal content. Similar findings were reported by Gangopadhyay *et al*. (1998). The per cent base saturation was maximum in lowlands at both surface and subsurface (86.40-95.80 and 89.10-96.50) followed by midlands (81.20-96.10 and 83.60-96.20) and uplands (80.50-93.60 and 80.90-96.40). The PBS was high in clay soils and it decreased with decrease in clay content. This could be attributed to textural variations and difference in the status of organic matter. The relatively high base saturation in some soils could be attributed to the recycling of basic cations through vegetation.

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