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Assessment of physico-chemical properties of black cotton soils from different blocks of Guntur District, Andhra Pradesh, India

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Abstract
The present investigation was carried at Sam Higginbottom University of Agriculture Technology and Sciences to assess the Physicochemical properties of black cotton soils from different blocks of Guntur district, Andhra Pradesh, India. A total of twenty-seven soil samples were collected randomly from different depths, i.e., 0-15cm,15-30 cm, and 30-45cm. The study area consists of mostly black cotton soil. These soils were moderate to strongly alkaline in reaction and non-saline. On the soil complex, the dominant cation is calcium. The overall fertility status of the soils was low, medium, and high in nitrogen, phosphorus, and potassium respectively. The calcium and magnesium ranges are high in these clay soils. The sulfur is sufficient in these clay soils. As the soils were calcareous and strongly alkaline, there is a need for the application of any acid-forming amendment (S containing amendments) and organic materials to alleviate the nutrient deficiency and improve productivity.

Keywords: Physico-chemical properties, Alkaline, Water retaining capacity, Black cotton soils

1. Introduction
Soil is the backbone of our food security. Without healthy soils, farmers wouldn’t be able to provide us with feed, fiber, food, and fuel. Our farmers need to understand the components which make up the soil in which their crops grow. Adequate crop growth and its production mainly depend on the appropriate nutrition, if there is a nutrient deficiency in the soil it affects the growth rate of plants.

Nitrogen occupies the first position in the plant requirement among the nutrient elements, followed by phosphorus and potassium (Samuel and Ebenezer, 2014; Solanki and Chavda, 2012) [19, 24]; Potassium is a major nutrient that plays a major role in different physiological processes of plants helping plants to resist against diseases and improving physical characteristics of the plant. Magnesium is necessary for the synthesis of chlorophyll pigment in green plants and its deficiency causes the loss of healthy green color of leaves (Mahajan and Billore, 2014) [13, 20]. Calcium ion is the key element in reducing the soil salinity erosion content and as well as phosphorous loss through flowage. Phosphorus is the most important element because the growth of plants depends on the availability of Phosphorous content in the soils. Soil fertility and nutrient management are important factors that have a direct impact on crop yield and quality.

To identify the fertility status of the selected area, various soil samples were collected from pre-determined locations and were analyzed for Physico-chemical properties (pH and electrical conductivity) chemical characteristics including fertility parameters like available nitrogen, phosphorous, potassium, sulfur, and exchangeable basic cations constituting calcium, magnesium.

2. Materials and Methods
2.1 Study area
The location of the Guntur district lies between 16^0 30'67” N latitude and 80^0 43'65" E longitude. It covers a geographical area of 11,391 sq km. (Fig.1). The Krishna River forms the northeastern and eastern boundary of the district, separating Guntur District from Krishna District. It is located near the Bay of Bengal and is surrounded by many suburban areas. Guntur district experiences a tropical climate in summer. And the dry and cold climate in winter. The maximum temperature is 32 ^{0}C and the minimum temperature is 20 ^{0}C. The average annual temperature is 28.5 ^{o}C.

When compared with winter, the summers have much more rainfall. In a year, the average rainfall recorded is 906 mm.

2.2 Sample collection

Soil samples were collected from three different blocks of the Guntur district of Andhra Pradesh. They are Pedakurapadu Krosuru, Sattenpalli. Soil samples were collected with the help of Khurpi, spade, and meter scale. In each block, three villages were selected for sampling and were samples collected randomly from different depths i.e., 0-15cm,15-30cm, and 30-45cm. A total of twenty-seven soil samples were collected.

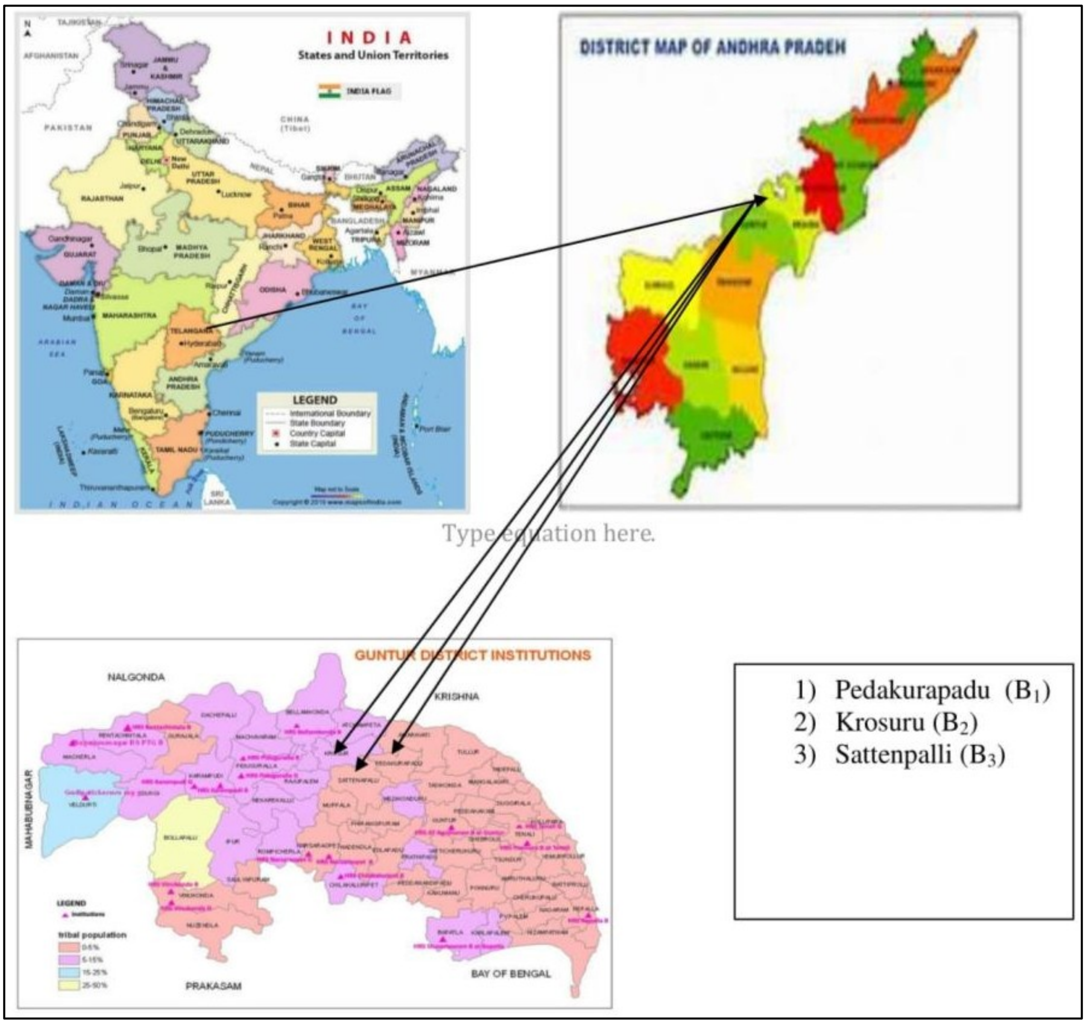

Fig 1: Map of the study area

2.3 Soil analysis

The pH was determined in 1:2 soil water suspensions using digital pH meter (Jackson, 1958). The EC was determined in 1:2 soil water suspensions using digital EC meter (Wilcox, 1950) [30]. The soil was distilled with alkaline potassium permanganate as suggested by (Subbiah and Asija 1956) [25] and the ammonia evolved was determined. P in the soil extract is determined colorimetrically using a Photoelectric Colorimeter after developing molybdenum blue colour (Olsen *et al*., 1954) [18]. The procedure was based on extraction with 1N NH4OAC (pH 7.0) and K was determined by Flame Photometer (Toth and Prince, 1949) [27]. The same procedure used for the estimation of K. Exchangeable calcium and magnesium was determined by 1N Neutral Ammonium Acetate Saturation Method or EDTA method as laid out by Cheng and Bray (1951). Available sulphur was estimated by the turbidimetric method as put forth by Bardsley and Lancaster (1960) [2].

3. Results and Discussion

3.1 pH and EC (ds m^{-1})

Table 1. depicted the statistical accumulation on pH and EC of various farmer's fields which was found to be significant differences due to depth and site. The pH ranges from 8.01 to 8.79. The highest mean value is recorded 8.79 in B3V2 and the least mean value 7.50 in B2V3. The EC ranges from 0.37 to 0.81 ds m^{-1}. The highest mean value is recorded at 0.81 ds m^{-1} in B2V1 and the least mean value of 0.37 ds m^{-1} in B3V2. Higher values were recorded in deeper layers. A similar trend was observed by Dhale and Jagdish Prasad, (2009) [9] in the black soil of Jalna district, Maharashtra.

3.2 Organic carbon and organic matter

Table 2. depicted the statistical accumulation on Organic Carbon and Organic matter of various farmer's fields which was found to be significant differences due to depth and site. The Organic carbon ranges from 0.35 to 0.70%. The highest mean value is recorded 0.70% in B2V1 and the least mean value 0.35% in B3V2. The OM ranges from 0.60 to 1.16%. The highest mean value is recorded at 1.16 in B1V1 and the least mean value 0.67% in B2V2. When depth-wise values were considered, lower values were recorded in deeper layers. Nayak *et al.* (2002) observed a similar organic carbon range (0.11 to 0.82 percent) in black soils of the Indo- Gangetic

plains of West Bengal.

3.3 Available Nitrogen, Phosphorus, and Potassium

Table 3. depicted the statistical accumulation of Nitrogen (kg ha^{-1}) and Potassium (kg ha^{-1}) of various farmer's fields and depths which were found to be significant differences due to depth and site but phosphorus showed nonsignificance due to depth and significance due to site. The N ranges from 168 to 277.66(kg ha^{-1}). The highest mean value is recorded 277.66 in B2V1 and the least mean value 168. Similar trends were observed by Bharmbe *et al.* (1999) [4] in Vertisols of the Majalgao canal command area. The Phosphorus ranges from 11 to 60.3(kg ha^{-1}) 3. The highest mean value is recorded 60.33(kg ha^{-1}) in B1V1 and the least mean value 11(kg ha^{-1}) in B3V1. Satish (2003) [21] and Varaprasad Rao *et al.* (2008) [28] reported medium availability of phosphorus in soils of Chebrolu Mandal, Guntur district, and Ramachandrapuram Mandal, Chittoor districts of Andhra Pradesh, respectively. The Potassium ranges from 505 to 984.33(kg ha^{-1}). The highest mean value is recorded at 984.33 in B1V1 and the least mean value 479(kg ha^{-1}) in B2V3. Similar observations of high potassium content were reported by Bandyopadhyay *et al.* (2004) [1] and Dhale and Jagdishprasad (2009) [9] in black soils of Maharashtra. The available Nitrogen, Phosphorus, and Potassium content were high values at the surface than in lower layers.

3.4 Exchangeable Calcium and Magnesium

Table 4. depicted the statistical accumulation of exchangeable calcium [cmol (p+) kg^{-1}] showed no significant difference was found at depth and a significant difference was found at villages. Very low values were recorded in all the sites. This may be due to the leaching of calcium as hydrogen is added to the soil by the decomposition of organic matter as well as due to heavy rainfall. The highest mean value of 27.7 cmol (p+) kg^{-1} was recorded at B3V3. And the lowest mean value of 22.76 cmol (p+) kg^{-1} was recorded at B3V2. Magnesium showed No significant difference in both depth and site. Very low values were recorded in all the sites. This may be due to the leaching of magnesium as hydrogen is added to the soil by the decomposition of organic matter as well as due to heavy rainfall. The highest mean value of 9.9 cmol (p+) kg-1 was recorded in B1V1. The maximum exchangeable magnesium of 11.73 cmol (p+) kg-1 was recorded in B1V3 while the minimum value was recorded as 6.4 cmol (p+) kg-1 in B3V3. Similar results were observed by Naga Raju Kola and Babu Rao Gudipudi (2020) [16]. Soil Chemistry of Erravagu Sub-basin of Guntur District, Andhra Pradesh 2020

3.5 Available Sulphur

Table 5. depicted the available sulfur (ppm) in soils from various villages and at different profile depths. A significant difference was found. Medium values of available sulfur were recorded in all the sites. The highest mean value was recorded at B2V1 as 36.66 ppm. Low values may be attributed to the leaching of sulfur. The available sulfur was found to decrease with an increase in depth. The maximum available sulfur was recorded in B2V1 which was 36.33 ppm. While the minimum value was recorded in B3V1 as 9.33 ppm. Similar trends were observed in Inceptisol of Chittoor district, Andhra Pradesh (Basavaraju *et al*, 2005) [3] and (Varaprasad Rao *et al.* 2008) [28].

3.6 Correlation Coefficient (R) Between Physicochemical Properties of Black Cotton Soils of Guntur District, Andhra Pradesh, India

The electrical conductivity showed the significant negative correlation with pH (-0.71 @ CD P = 0.01). The available nitrogen showed the significant positive correlation with EC (0.711 @ CD = 0.01). The available nitrogen showed non-significant and negative correlation with pH (-0.334). The available Phosphorus showed the significant positive correlation with% organic carbon (0.549 @ CD P = 0.05). The available Potassium showed the positive correlation with both% organic carbon (0.576 @ CD P = 0.05) and Phosphorus (0.970 @ CD P = 0.01). The exchangeable calcium showed the significant positive correlation with available nitrogen (0.820 @ CD P = 0.01). The exchangeable magnesium showed the significant positive correlation with Phosphorus (0.764 @ CD P =0.01) and Potassium (0.716 @ CD P = 0.01). The available sulphur showed the positive correlation with both available Nitrogen (0.801@ CD P = 0.01) and exchangeable Calcium (0.540 @ CD P = 0.05).

Table 1: Soil pH and Soil EC (dS m-1) at different depths (cm)

villages	pH			EC		
	0- 15cm	15-30cm	30- 45cm	0-15cm	15-30cm	30- 45cm
B1 V1	7.8	8.1	8.2	0.73	0.79	0.85
B1 V2	8.36	8.43	8.53	0.39	0.43	0.47
B1 V3	8.25	8.51	8.62	0.63	0.67	0.7
B2 V1	8.3	8.42	8.51	0.77	0.82	0.86
B2 V2	8.4	8.61	8.71	0.43	0.46	0.48
B2 V3	7.9	7.95	8.2	0.63	0.69	0.75
B3 V1	8.45	8.67	8.81	0.53	0.57	0.61
B3 V2	8.62	8.82	8.91	0.33	0.37	0.42
B3 V3	8.74	8.81	8.82	0.43	0.47	0.5
Range	7.8- 8.74	7.95- 8.82	8.2- 8.91	0.33- 0.77	0.37- 0.79	0.43- 0.86
Mean	8.31	8.48	8.59	0.54	0.58	0.62
	F- test	S.Ed. (±)		F- test	S.Ed. (±)	
	s	0.080423		s	0.024704	
	S	0.094383		s	0.054379	

Table 2: Soil Organic carbon (%) and Soil Organic matter (%) at different depths (cm)

villages	Organic carbon (%)			Organic matter		
	0- 15cm	15-30cm	30- 45cm	0- 15cm	15- 30cm	30- 45cm
B1 V1	0.72	0.68	0.63	1.24	1.17	1.08

B1 V2	0.5	0.49	0.45	0.86	0.84	0.77
B1 V3	0.47	0.39	0.38	0.81	0.67	0.65
B2 V1	0.39	0.35	0.32	0.67	0.6	0.55
B2 V2	0.48	0.45	0.42	0.82	0.77	0.72
B2 V3	0.46	0.42	0.39	0.79	0.72	0.67
B3 V1	0.45	0.41	0.38	0.77	0.7	0.65
B3 V2	0.56	0.54	0.52	0.96	0.93	0.89
B3 V3	0.51	0.48	0.39	0.87	0.82	0.67
Range	0.39- 0.72	0.35-0.68	0.32- 0.63	0.67- 1.24	0.60- 1.17	0.55- 1.08
Mean	0.50	0.46	0.44	0.86	0.80	0.73
	F-test	S.Ed. (±)		F- test	S.Ed. (±)	
	s	0.02117		S	0.0365	
	s	0.031265		s	0.0539	

Table 3: Available NPK (kg ha-1) at different depths (cm)

villages	Available Nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available Potassium (kg ha^{-1})		
	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm	0-15cm	15-30cm	30-45cm
B1 V1	238	225	217	63	60	58	996	987	970
B1 V2	201	189	175	53	51	67	932	927	918
B1 V3	220	212	207	48	47	45	900	893	887
B2 V1	289	275	269	17	17	15	604	597	593
B2 V2	238	233	225	19	18	16	585	578	565
B2 V3	207	201	193	18	17	14	503	497	479
B3 V1	204	193	182	13	11	9	513	507	495
B3 V2	180	169	157	17	15	13	617	659	647
B3 V3	209	197	183	23	21	19	653	647	635
Range	180-289	169-275	157-269	13 - 63	11-60	9-67	503-996	497-987	479-970
Mean	220.66	210.44	200.88	30.11	28.56	28.44	700.33	699.11	687.66
	F-test	S.Ed. (±)		F-test	S.Ed. (±)		F-test	S.Ed. (±)	C.D.at 0.05%
	S	5.710		NS	0.5379		s	4.0339	
	S	10.601		S	6.5735		s	62.599	

Table 4: Exchangeable calcium and Magnesium [cmol (p+)kg-1]

villages	Exchangeable calcium [cmol (p+)kg-1			Exchangeable magnesium [cmol (p+)kg-1		
	0- 15cm	15- 30cm	30- 45cm	0- 15cm	15- 30cm	30-45cm
B1 V1	22.5	27.5	26	10.5	9.9	9.3
B1 V2	24.7	23.5	24.1	12.3	11.7	11.2
B1 V3	27.8	24.3	26.1	11.3	10.5	10.3
B2 V1	34.5	32.7	33.2	9.5	8.7	8.3
B2 V2	26.3	24.3	23.2	10.2	9.8	9.3
B2 V3	25.8	24	24.5	7.2	6.8	7.1
B3 V1	24.9	23.5	23.2	7.9	7.8	7.7
B3 V2	23.7	22.5	22.1	6.8	6.7	6.6
B3 V3	28.9	27.4	26.8	6.5	6.3	6.4
Range	23.7- 34.5	22.5- 32.7	22.1- 33.2	6.5- 12.3	6.3- 11.7	6.4-11.2
Mean	26.56	25.52	25.46	9.13	8.68	8.46
	F-test	S.Ed. (±)		F-test	S.Ed. (±)	
	NS	0.3577		NS	0.1959	
	S	1.0605		NS	0.6306	

Table 5: Available Sulphur (ppm)

villages	Available Sulfur (ppm)		
	0-15cm	15-30cm	30-45cm
B1 V1	29	25	23
B1 V2	26	24	21
B1 V3	25	22	19
B2 V1	39	37	33
B2 V2	37	34	31
B2 V3	30	27	23
B3 V1	12	9	7
B3 V2	18	15	12
B3 V3	21	19	9
Range	12-39	9-37	7-33
Mean	26.33	23.55	19.77
	F-test	S.Ed. (±)	
	S	1.8997	
	S	2.9239	

Table 6: Correlation coefficient (r) between physicochemical properties of black cotton soils of Guntur district, Andhra Pradesh, India

	pH	EC	%OC	N	P	K	Ca	Mg	S
pH	1								
EC	-0.721**	1							
%OC	-0.252	-0.061	1						
N	-0.334	0.710**	-0.287	1					
P	-0.431	0.190	0.549*	-0.004	1				
K	-0.268	0.129	0.576*	-0.014	0.970**	1			
Ca	-0.070	0.592*	-0.456	0.820**	-0.131	-0.090	1		
Mg	-0.297	0.149	0.096	0.286	0.764**	0.716**	-0.007	1	
S	-0.475	0.446	-0.165	0.801**	0.112	0.056	0.540*	0.407	1

* Significant at (0.05) 5% level; ** Significant at(0.01) 1% level.
EC= Electrical Conductivity, OC=Organic Carbon, N=Available Nitrogen, P=Available Phosphorus, K=Available Potassium, Ca=Exchangeable Calcium, M= Exchangeable Magnesium, S= Available Sulphur.

4. Conclusion

It is concluded that the study area consists of black cotton soil. These soils were moderate to strongly alkaline in reaction and non-saline. On the soil complex, the dominant cation is calcium. The overall fertility status of the soils was low, medium, and high in nitrogen, phosphorus, and potassium respectively. The calcium and magnesium ranges are high and sulfur is sufficient in these clay soils. These analyses may help the farmers to maintain proper nutrient management and as the soils were calcareous and strongly alkaline, there is a need for the application of any acid-forming amendment (S containing amendments) and organic materials to alleviate the nutrient deficiency and improve productivity.

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