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Effect of soil physical properties in sugarcane growing tracts of prudential sugar factory zone in Chittoor District, Andhra Pradesh

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Abstract

The present study was formulated to study the effect of soil physical properties in sugarcane tracts of prudential sugar factory zone in Chittoor district of Andhra Pradesh. Two hundred and seventy (270) geo-referenced (GPS based) composite surface soil samples (0-15cm) were collected from 8 mandals of Prudential sugar factory zone results revealed that the texture of soils varied from sandy loam to sandy clay loam. The physical constants viz., bulk density ranged from 1.07 to 1.63 Mg m⁻³, particle density varied from 2.0 to 2.77 Mg m⁻³, porosity ranged between 36.33 and 58.25 per cent, water holding capacity ranged from 29.76 to 53.91 per cent and volume expansion varied from 1.15 to 21.01 per cent, respectively.

Keywords: Sugarcane, soil colour, soil texture and physical constants

Introduction

Sugarcane (*Saccharum officinarum* L.) is cultivated in the tropical and subtropical regions of the world in between latitudes of 37°N and 31°S. Sugarcane is the main sugar producing crop that contributes more than 75 per cent to the total sugar pool at the global level. India, being the world's second largest producer after Brazil, is producing nearly 15 and 25 per cent of global sugar and sugarcane, respectively. Indian sugar industry is playing a lead role in global sugar market contributing significantly to the socio-economic development of the nation. Area coverage, production and productivity of sugarcane in India are 5.0 million ha, 3.4 lakh million tonnes and 69.4 tonnes ha⁻¹, respectively. About 597 sugar mills, 309 distilleries and 213 cogeneration plants and numerous pulp, paper and chemical making units are operating in this subcontinent. The industry is gradually transforming into sugar complexes by producing sugar, bioelectricity, bio-ethanol, bio-manure and chemicals contributing about 1.1 per cent to the national GDP. Area coverage, production and productivity of sugarcane in Andhra Pradesh are 1.22 million ha, 0.9 lakh million tonnes and 75.7 tonnes ha⁻¹, respectively while sugarcane production in Chittoor district is to an extent of 26,000 ha with a productivity of 79.05 t ha⁻¹. Continuous use of higher doses of chemical fertilizers without organic manures by farming community leads to soil deterioration. Hence this was proposed to know the soil physical properties of prudential sugar factory zone in Chittoor district of Andhra Pradesh.

Material and Methods

The study area (Chittoor district) is under semi arid climate and located in southern agro climatic zone of A.P. Prudential sugar factory zone is a part of Chittoor district and it consists of eight mandals viz., Nindra, Nagari, Narayanavanam, K.V.B.Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur. Prudential sugar factory zone lies in between 13° 11' 24" and 13° 53' 49.2" North latitudes and 79° 11' 49.2" and 80° 11' 24" East longitudes. Two hundred and seventy soil samples were collected at depth of 0-20 cm from sugarcane growing areas in Nindra, Nagari, Narayanavanam, K.V.B.Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur mandals of Prudential sugar factory zone by following random sampling technique during the month of November, 2017. The exact sample location was recorded by using hand held GPS.

The collected soil samples were analysed for soil physical properties as per the procedure.

Particle size distribution (mechanical composition) of the soils was determined by the Bouyoucous hydrometer method as described by Baruah and Barthakur (1997) [1]. Based on particle size distribution, textural classification was given using the *nomograph* (textural diagram) of USDA. The physical constants such as bulk density, particle density, water holding capacity pore space and volume expansion in the soil samples were determined by following Keen Raczkowski's method as described by Sankaram (1966) [9].

Results and Discussion

Physical characteristics

Soil Texture

Critical scanning of the data presented in Table 1 and depicted in Fig. 1 revealed that texture in the sugarcane growing soils of different villages in various mandals of study area ranged from loamy sand to sandy clay loam. The sand, silt and clay contents in the sugarcane growing soils ranged from 54.88 to 89.44, 0.30 to 25.88 and 5.66 to 32.84 per cent, respectively. The mean sand, silt and clay contents in the above soils were 76.3, 8.07 and 15.62 per cent, respectively.

The texture in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur varied from loamy sand to sandy clay loam. The clay content in the Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur mandals varied from 8.13 to 32.84, 8.25 to 28.87, 11.16 to 22.27, 5.66 to 26.00, 9.84 to 28.87, 8.16 to 28.87, 9.36 to 28.87 and 11.16 to 28.87 per cent, respectively (Fig. 1), with a mean clay contents of 17.38, 16.69, 14.94, 13.36, 15.73, 13.86, 14.66 and 16.67 per cent, respectively.

The variation in soil texture might be due to variation in topographic position, nature of parent material, *in situ* weathering, translocation of clay and age of the soils. It is known fact that the coarse textured and medium textured soils are well suited for the cultivation of sugarcane crop. Leelavathi *et al.* (2009) [4] reported that the texture of groundnut growing soil in Chittoor district were loamy sand to sandy clay loam. Devi and Naidu (2015) [2] reported soil texture in sugarcane growing soils of eastern mandals of Chittoor district in Andhra Pradesh is ranged from sand to clay loam.

Bulk Density (Mg m^{-3})

From the data presented in Table 2 and depicted in Fig. 2, it could be noticed that bulk density in sugarcane growing soils of Prudential sugar factory zone was ranged from 1.07 to 1.63 Mg m^{-3} with a mean value of 1.37 Mg m^{-3} . The bulk density in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur varied from 1.16 to 1.62, 1.09 to 1.62, 1.07 to 1.62, 1.14 to 1.62, 1.14 to 1.63, 1.12 to 1.62, 1.16 to 1.62 and 1.16 to 1.59 Mg m^{-3} , respectively. The mean bulk density values in sugarcane growing soils of above mandals were 1.37, 1.35, 1.38, 1.39, 1.37, 1.37, 1.40 and 1.33 Mg m^{-3} , respectively. The CV was 11.64 percent for bulk density in the Prudential sugar factory zone.

The low bulk density values could be attributed to loosely packing of coarse textured and medium textured soils in the different mandals of Chittoor district. The lower bulk density

values in some of the soils obtained from the study area might be due to well aggregated and structured soils. Similar findings were reported by Devi and Naidu (2015) [2], Leelavathi *et al.* (2009) [4].

Particle Density (Mg m^{-3})

It is evident from the data presented in Table 2 and depicted in Fig. 3, it could be noticed that particle density of sugarcane growing soils in Prudential sugar factory zone is ranged from 2.0 to 2.77 Mg m^{-3} with a mean value of 2.46 Mg m^{-3} . The particle density in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram, Puttur varied from 2.07 to 2.64, 2.0 to 2.64, 2.08 to 2.77, 2.05 to 2.64, 2.03 to 2.66, 2.01 to 2.64, 2.03 to 2.64 and 2.05 to 2.64 Mg m^{-3} , respectively. The mean particle density values in sugarcane growing soils of above mandals were 2.51, 2.44, 2.52, 2.47, 2.42, 2.44, 2.50 and 2.41 Mg m^{-3} , respectively. The coefficient of variation (CV) was 7.33 per cent for particle density in the Prudential sugar factory zone. The particle density showed more or less uniform values in the study area. Reddy and Naidu (2016) [8] observed more or less uniform particle density in the soils of Chennur mandal in Kadapa district of Andhra Pradesh.

Soil Pore Space (%)

The data presented in Table 2 and depicted in Fig. 4 indicated that, the soil porosity of sugarcane growing soils in different villages of various mandals in the study area of Chittoor district was ranged from 36.33 to 58.25 per cent with a mean value of 46.89 per cent. The porosity in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur varied from 36.33 to 56.32, 40.74 to 54.21, 43.08 to 48.69, 40.10 to 54.21, 40.05 to 58.25, 38.73 to 56.32, 40.96 to 56.32 and 40.23 to 54.21 per cent, respectively. The mean porosity values in sugarcane growing soils of above mandals were 46.41, 46.40, 46.61, 45.56, 47.94, 46.52, 46.55 and 45.02, respectively. The CV was 8.33 per cent for soil porosity in the Prudential sugar factory zone.

The little trend of variation in porosity of the sugarcane grown soils was mainly due to the arrangement of solid particles and these particles lied close together. Similar variation in porosity was reported by Lakshmi *et al.* (2016) [3] and Prakash and Rao (2002) [6].

Water Holding Capacity (%)

The data presented in Table 2 and depicted in Fig. 5 indicated that the water holding capacity in sugarcane growing soils in Prudential sugar factory zone ranged from 29.76 to 53.91 per cent with a mean value of 40.42 per cent. The water holding capacity in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur varied from 30.21 to 50.62, 30.66 to 50.62, 31.63 to 47.94, 30.66 to 50.62, 29.87 to 50.62, 29.83 to 53.91, 29.76 to 50.62 and 30.66 to 50.62, per cent respectively. The mean water holding capacity values in sugarcane growing soils of above mandals were 40.65, 41.56, 40.89, 39.63, 40.94, 40.67, 38.84 and 38.46 per cent, respectively. The CV was 12.57 per cent for water holding capacity in the Prudential sugar factory zone.

The retention of the considerable amount of moisture in the soils studied could be ascribed to the presence of optimum amount of clay content in the soils. The little variation observed in the water holding capacity of soils might be due to variation in the clay content of the study area (Table 4.2). Similar variation in water holding capacity was observed by Thangasamy *et al.* (2005) in sivagiri micro-watershed of Chittoor district. Similar findings were also reported by Rao *et al.* (2008) [7] and Leelavathi *et al.* (2009) [4] in soils of Ramachandrapuram mandal and Yerpedu mandal of Chittoor district, respectively.

Volume Expansion (%)

The data on volume expansion presented in Table 2 and depicted in Fig. 6. The volume expansion in sugarcane growing soils of Prudential sugar factory zone was ranged

from 1.15 to 21.01 per cent with a mean value of 7.46 per cent. The volume expansion in sugarcane growing soils of various mandals in Prudential sugar factory zone of Chittoor district viz., Nindra, Nagari, Narayanavanam, K.V.B. Puram, Vijayapuram, Pichatur, Nagalapuram and Puttur was varied from 2.27 to 17.63, 3.29 to 15.43, 3.82 to 11.5, 1.66 to 15.43, 1.80 to 21.01, 1.49 to 21.01, 1.15 to 15.43 and 2.35 to 21.01 per cent, respectively. The mean volume expansion values in sugarcane growing soils of above mandals were 7.73, 7.34, 6.08, 7.03, 7.83, 7.37, 6.94 and 7.89 per cent, respectively. The CV was 55.24 per cent for volume expansion in the Prudential sugar factory zone. The volume expansion indicates the presence of shrinking and swelling type of clay minerals. This variation in volume expansion was due to presence of significant amount of smectite type of clay. Similar results were reported by Leelavathi *et al.* (2009) [4].

Table 1: Texture in sugarcane growing soils (0-20 cm depth) of various mandals in Prudential sugar factory zone of Chittoor district

S. No	Mandal	Sand (%)	Silt (%)	Clay (%)
1.	Nindra			
	Range	72.61	10.12	17.38
	Mean	54.88-88.84	0.30-25.88	8.13-32.84
2.	Nagari			
	Range	74.07	9.24	16.69
	Mean	56.70-88.24	1.20-18.57	8.25-28.87
3.	Narayanavanam			
	Range	76.50	8.58	14.94
	Mean	63.89-88.24	0.60-14.04	11.06-22.27
4.	K.V.B. Puram			
	Range	79.28	7.36	13.36
	Mean	66.00-89.44	0.30-15.88	5.66-26.00
5.	Vijayapuram			
	Range	75.63	8.64	15.73
	Mean	56.70-88.24	1.20-15.88	9.84-28.87
6.	Pichatur			
	Range	79.57	6.57	13.86
	Mean	56.70-88.84	0.90-18.57	8.16-28.87
7.	Nagalapuram			
	Range	80.53	4.81	14.66
	Mean	56.70-88.24	0.90-15.88	9.36-28.87
8.	Puttur			
	Range	77.02	6.33	16.67
	Mean	56.07-87.04	0.30-25.88	11.16-28.87
9.	Overall mean	76.34	8.07	15.62
10.	Overall range	54.88-89.44	0.30-25.88	5.66-32.84
11.	C.V. (%)	11.85	79.31	37.10

Table 2: Physical characteristics in sugarcane growing soils (0-20 cm depth) of various mandals in Prudential sugar factory zone of Chittoor district

S. No	Mandal	Bulk density (Mg m ⁻³)	Particle density (Mg m ⁻³)	Pore space (%)	Water holding capacity (%)	Volume expansion (%)
1.	Nindra					
	Range	1.16-1.62	2.07-2.64	36.33-56.32	30.21-50.62	2.27-17.63
	Mean	1.37	2.51	46.41	40.65	7.73
2.	Nagari					
	Range	1.09-1.62	2.0-2.64	40.74-54.21	30.66-50.62	3.29-15.43
	Mean	1.35	2.44	46.4	41.56	7.34
3.	Narayanavanam					
	Range	1.07-1.62	2.08-2.77	43.08-48.69	31.63-47.94	3.82-11.5
	Mean	1.38	2.52	46.61	40.89	6.08
4.	K.V.B. Puram					
	Range	1.14-1.62	2.05-2.64	40.1-54.21	30.66-50.62	1.66-15.43
	Mean	1.39	2.47	45.56	39.63	7.03
5.	Vijayapuram					
	Range	1.14-1.63	2.03-2.66	40.05-58.25	29.87-50.62	1.8-21.01
	Mean	1.37	2.42	47.94	40.94	7.83
6.	Pichatur					
	Range	1.12-1.62	2.01-2.64	38.73-56.32	29.83-53.91	1.49-21.01
	Mean	1.37	2.44	46.52	40.67	7.37

7.	Nagalapuram					
	Range	1.16-1.62	2.03-2.64	40.96-56.32	29.76-50.62	6.94-15.43
	Mean	1.4	2.5	46.55	38.84	6.94
8.	Puttur					
	Range	1.16-1.59	2.05-2.64	40.23-54.21	30.66-50.62	2.35-21.01
	Mean	1.33	2.41	45.02	38.46	7.89
9.	Overall range	1.07-1.63	2.0-2.77	36.33-58.25	28.76-53.91	1.15-21.01
10.	Overall mean	1.37	2.46	46.59	40.42	7.16
11.	C.V. (%)	11.64	7.33	8.33	12.57	55.24

Fig 1: Range of clay content in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Fig 2: Range of bulk density in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Fig 3: Range of particle density in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Fig 4: Range of porespace in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Fig 5: Range of water holding capacity in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Fig 6: Range of volume expansion in sugarcane growing soils of various mandals in Prudential sugar factory zone in Chittoor district of Andhra Pradesh

Conclusion

The results lead to a conclusion that the texture in the sugarcane growing soils varied from loamy sand to sandy clay loam. Majority of the soils were sandy loam (51.85%) in texture while rest of them were (24.44%) loamy sand and sandy clay loam (23.70%) in texture. The soil colour varied from pale red to very dark gray (2.5 YR 7/2 to 10 YR 3/1) with hue varied from 2.5 YR to 10 YR, value ranged from 3 to 7 and chroma varied from 1 to 6. The bulk density in sugarcane growing soils ranged from 1.07 to 1.63 Mg m^{-3} with an average value of 1.37 Mg m^{-3} whereas the particle density of the soils varied from 2.0 to 2.77 Mg m^{-3} with a mean value of 2.46 Mg m^{-3} . The porosity in sugarcane growing soils ranged from 36.33 to 58.25 per cent with a mean value of 46.89 per cent while water holding capacity of soils varied from 29.76 to 53.91 per cent with a mean value of 40.42 per cent. Volume expansion of samples ranged from 1.15 to 21.01 per cent with a mean value of 7.46 per cent. The results obtained in the study area revealed that soil test based fertilizer applications and integrated use of organics in combination with inorganic fertilizers not only helps in achieving sustainable yields but also helps in doubling the farmers income.

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