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RESEARCH ARTICLE :

# Genesis, classification and evaluation of some sugarcane growing black soils in semi arid tropical region of Telangana

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**SUMMARY :** The morphological, physical and physico-chemical characteristics of some sugarcane growing black soils of Medak district of Telangana State have been studied for proper appraisal of their productivity potential and their rational use. The soils were formed at nearly level and plain topography on granitic gneiss parent material mixed with calcareous murram. The soils are deep to very deep. The textural class of fine earth fraction was clay loam and clayey and had angular blocky structure. The colour varied from very dark grayish brown (10 YR3/2) to dark yellowish brown (10YR 4/4) under dry condition. The clay content ranged from 38.7 to 71.4 per cent in surface and 37.2 to 76.2 per cent in subsurface horizons. The silt clay ratio was found to be less than 0.5 indicating the moderate weathering. The soil pH was neutral to strongly alkaline in range (6.5 to 9.2) and non saline in nature. The organic carbon content was medium to high (4.3 to 8.4 g $kg^{-1}$) in surface horizons. The soils are moderately calcareous with $CaCO_3$ ranges from 1.3 to 7.8 per cent with high in cation exchange capacity. The exchangeable bases were in the order of $Ca^{+2} > Mg^{+2} > Na^{+} > K^{+}$ on the exchange complex. The CEC / clay ratios soils were high (0.58 to 0.86). It indicates the presence of smectitic type of clay minerals. The soils have been classified as Typic Haplusterts and Vertic Haplustepts based on the morphological, physical, physico-chemical, and chemical properties. The study area classified into 'III swef' land capability sub-class due to the limitations of drainage, texture, erosion and soil fertility limitations. The soils were moderately suitable to highly suitable for cultivation of sugarcane.

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## BACKGROUND AND OBJECTIVES

Land is a finite natural resource and there is little scope to increase the areas under cultivation. The efforts made in the past to bring new areas under cultivation which results the reduction forests to 20% of total geographical area of the country. For decades, advancement in agricultural practices has been a necessity due to ever increasing demand caused by growing population. Sugarcane (*Saccharum officinarum* L) is being cultivated is India is an area of 42.45 lakh ha in the states of Karnataka, Maharashtra, Madhya Pradesh, Telangana, Andhra Pradesh, Tamil Nadu, Goa and Kerala with total sugar production of 192.67 lakh tones. India is one of the largest producers of sugar and shares about 41.11 % and 13.25 % of Asian and Worlds sugar production, respectively. The population in India is increasing steadily and as well the demand for sugar and other sweetening agents because of changing food habits. There is no scope to increase the area under sugarcane to meet the requirements. This envisages the adoption of better crop production and protection technologies for increased production per unit area and time apart from varietal improvement. Sugarcane is cultivated in the Medak district in an area of 22076 hectares producing 1721 thousand tonnes with an average productivity of 74.41 t $ha^{-1}$.

Telangana state being under a semi-arid tropical monsoon climate, has a number of soil types which are found in all types of climates, occupying 3.5 per cent (114,840 sq km or 114.84 lakh ha or 11.484 m.ha) of the country's geographical area. Hence their management varies from place to place besides the crop variation. Maintaining the soil with high productivity on sustainable basis is important to meet basic needs of the people. Hence delineating the sugarcane growing soils for their fertility helps in understanding the soil related constraints and their intensity which is essential to develop site specific management strategies.

Classification of sugarcane growing soils in a taxonomic perspective provides information on the nature and its potential production capabilities. The characterization and classification of soils helps in determining the soil potential, identifying constraints and giving detailed information on different soil properties of the sugarcane growing areas. The present investigation is aimed to assess the characteristics of soils and land resources to comprehend the potential capability of sugarcane growing soils of Medak district in the perspective of developed land use decision for effective utilization of resources.

## RESOURCES AND METHODS

**Location and brief description of the study area :**

Medak district of Telangana state is extending over an area of 9,519 $km^2$. It forms a part of Deccan Plateau under Godavari basin and lies between North Latitudes $17^0$ 27' and $18^0$ 18' and East longitudes $77^0$ 28' and $79^0$ 10' falling in topographical sheet nos. 56 F, G, J and K of Survey of India. It is bounded by the Nizamabad district on the north, Karimnagar district on the north and north-east, Warangal and Nalgonda district on the east, Hyderabad and Rangareddy district on the south and Bidar district (Karnataka) on the west. It is divided into three revenue divisions, *viz.*, Sangareddy, Medak and Siddipet with 46 revenue mandals/tehsil and 1223 villages in the district. The district is divided into 12 agricultural divisions.

Based on the morphological characteristics and physiography, four geo-referenced pedon were selected in Medak district such as Aroor (Pedon 1), Budera (Pedon 2), Andole (Pedon 3) and Pulakurty (Pedon 4). Physiographically, the district forms part of South Deccan Plateau. It is an ancient plateau exposed for long ages to denudation. Sheet-wash and retreat of hill slopes are the major geomorphic processes responsible for sculpturing of the present day landforms under semi-arid conditions. The plateau has two erosional surfaces with altitudes of 150-600 m and 300-900 m above MSL. It has been divided into three physiographic regions, *viz.,* granite and granite-gneiss landform, basalt landform and laterite landform. The important rock types are Peninsular Gneissic complex, Dharwar super group associated with Younger intrusive of Achaean age separated unconformably with overlying Basaltic flows of late Cretaceous to early Eocene age with sub-Recent to Recent alluvium along the stream courses. The Archaean or Peninsular gneisses occur all over the district in 6, 86,853 ha area (70.7%). They are partially metamorphosed igneous rocks. They remained stable as a "Shield" area for a very long time. The rocks are composed of grey or pink feldspars, quartz and muscovite mica (NBSS&LUP, 2005).

The climate is semi-arid. The mean annual rainfall is 870 mm of which 76 per cent is received during the southwest monsoon (June to September), 14 per cent during the northeast monsoon (October to December) and 8 per cent during the premonsoon period (March to May). The rainfall is highest in the month of August. The climate of Medak district is comparatively equitable and although it is very hot in May with mercury rising up to $42^o$ C. The temperature dips to $12^o$C in winters during the months of December and January. The mean maximum and minimum temperature vary from 40° to

26°C. Mean humidity varies from 65 per cent in July to 74 per cent in December. The soil moisture content is dry for more than 90 cumulative days or 45 consecutive days in the months of summer solstice. The soil moisture and temperature regimes of the study area are Ustic and Isohyperthermic, respectively. The natural vegetation existing in the study area are grasses, shrubs, thorny bushes such as *Cynodon dactylon, Cyprus rotundus, Butea frondosa, Dalbergia latifolia, Azadirachta indica, Tectona grandis, Terminalia tomertose and Acacia spp. Prosopis juliflora, Cacia sp*, broad leaf weeds such as *Selotia, Parthenium, Eucalyptus, Euforbia* sps., *etc.* The principal crops cultivated are Rice, Maize, Sugarcane, cotton, redgram, Greengram, Blackgram, Groundnut and potato.

**Collection and processing of soil samples :**

The geo-referenced black soil pedons were selected on the basis of soil heterogeneity and land forms in different locations of sugarcane growing areas of the district. The profiles were dug up to parent rock and studied for their morphological characteristics (Soil Survey Division Staff, 1993). Soil samples were collected from each horizon of four representative pedons for laboratory analysis. The samples were air dried and ground to pass through 2 mm sieve. Relevant physical and chemical properties were determined by following standard analytical procedures. The Soil pH, EC (1:2.5 soil water suspension); exchangeable cations (Jackson1973); cation exchange capacity (Chapman, 1965); organic carbon (Walkly and Black, 1934); free CaCO3 (Piper 1966); bulk density (Blake and Hartze 1986); moisture retention at 33 and 1500 kPa (Richards,1954); COLE (Soil Survey Staff, 2010); water holding capacity and volume expansion (Sankaram,1966); gravel by gravimetry method (Govindarajan and Koppar,1975); Soil texture by International Pipette Method (Piper,1966). The soils were characterized and classified as per Keys to Soil Taxonomy (Soil Survey Staff, 2010).

## OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

**Morphological properties :**

Major part of the study area is coming under nearly level to gently sloping. The details of the morphological properties of the soils were presented in Table 1. The drainage condition of the pedon 1, 2, 3 and 4 was poorly drained with irregular $CaCO_3$ concretions. Soil depth of the pedons 1, 3 and 4 were very deep (>150 cm) and deep soils were found in nearly level to very gently sloping plain. The pedon 2 was moderately deep (75-100 cm), The variation of depth in relation to physiography, mainly because of non-availability of adequate amount of water for prolonged period on upland soils associated with removal of finer particles and their deposition at lower pediplain have resulted in shallow soils in uplands and deeper soils in lowland physiographic units. The results obtained in the present study are in agreement with the findings of Ramprakash and Seshagiri Rao (2002). All the pedons were characterized as A- B-C horizons. The thickness of the surface horizons varied from 14.0 (pedon 2) to 27.0cm (pedon 4) cm and sub surface horizons ranged from 17.0 (pedon 2) to 40.0 cm (pedon 3). Pedon 1, 3 and 4 showed slicken sides (Bss). The surface horizon was designated as 'Ap' horizon at all the location because of the ploughed and disturbed condition due to cultivation. Similar observation was made by Rajeshwar *et al* (2009) and Ashok kumar and Jagadish Prasad (2010) to represent ploughed condition of the soils.

The 'B' horizon of soils (pedon 1, 9 and 12) exhibited prominent, well-formed distinct slickensides. Hence the symbol 'ss' (sub-ordinate distinction) was suffixed to the master horizon symbol 'B'. Similar type of designation was represented by Chinchmalatpure *et al.* (2005); Ashok kumar and Jagadish Prasad (2010); Rajeshwar and Mani (2015). The boundary between the sub-horizons of 'Bss' horizon was described as diffuse because of the presence slickensides and the clay content was high enough for clay textural class. Similar finding was noticed by Balapande *et al.* (2007). The soil colour varying from very dark grayish brown (10 YR3/2) to dark yellowish brown (10YR 4/4) under dry condition and very dark gray (10 YR3/1) to dark yellowish brown (10YR 4/4) under moist condition. The dark colour appears due to the presence of iron and manganese oxide in combination with the organic complex (Srinivasan *et al.*, 1969) and parent material, topography, high clay content, clay-humus complex, smectite type of clay, moisture *etc.*, were the factors responsible for the dark colour of the soils (Santsingh,1987).

The surface horizons and subsurface horizons had

**Table 1 : Morphological characteristics of Sugarcane growing soil pedons of the Medak district**

| Pedon | Location | Horizon | Depth (cm) | Colour | | Texture | Structure | Consistency | | | Effervescence | Pores | Roots | Boundary | Cutans | Other features |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dry | Moist | | | Dry | Moist | Wet | | | | | | |
| | **Sadasivpet division** | | | | | | | | | | | | | | | |
| 1. | Aroor | Very-Fine Smectitic Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° N 17° 37'42.34" Longitude° E 77° 53'10.33" Altitude 539 m) | | | | | | | | | | | | | | |
| | | Ap | 0-25 | 10YR3/2 | 10YR3/2 | c | m1abk | sh | fi | vs&vp | ms | ff | mf | cs | | Gilgai relief; |
| | | BA | 25-52 | 10YR3/2 | 10YR3/1 | c | m2abk | h | vfi | vs&vp | ms | ff | cf | gs | | surface cracks |
| | | Bss1 | 52-79 | 10YR3/2 | 10YR3/2 | c | m2abk | h | vfi | vs&vp | ms | ff | - | cd | | (5-8 cm wide); |
| | | Bss2 | 79-115 | 10YR4/2 | 10YR3/2 | c | m2abk | h | vfi | vs&vp | s | ff | - | cd | | slickensides; |
| | | Bss3 | 115-155 | 10YR4/2 | 10YR3/2 | c | m2abk | h | fi | vs&vp | vs | ff | - | cd | | sub surface hard |
| | | C | 155+ | Mixed with calcareous murram | | | | | | | | | | | | pan with high B.D |
| 2. | Budera | Fine Smectitic Superactive Non calcarious Isohyperthermic Vertic Haplustepts (Latitude ° N 17° 38'37.18" Longitude ° 77° 50'35.00"Altitude 585 m) | | | | | | | | | | | | | | |
| | | Ap | 0-14 | 10YR3/2 | 10YR3/1 | cl | f1sbk | sh | fr | s&p | ms | ff | mf | cs | - | subsurface |
| | | Bw1 | 14-41 | 10YR3/2 | 10YR3/1 | cl | m1sbk | h | fr | vs&p | ms | ff | ff | cw | - | cracks(3-4cm) |
| | | Bwss1 | 41-58 | 10YR4/2 | 10YR4/1 | cl | m1sbk | h | fr | vs&p | ms | ff | ff | cw | - | &slickensides |
| | | Bwss2 | 58-79 | 10YR4/2 | 10YR4/2 | cl | m1sbk | h | fi | vs&p | ms | ff | - | cw | | |
| | | BC | 79-100 | 10YR4/4 | 10YR4/4 | cl | m1sbk | h | fi | s&p | ms | ff | - | cw | | |
| | **Jogipet division** | | | | | | | | | | | | | | | |
| 3. | Andole | Fine Smectiti Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17° 49'34.54" Longitude° 78° 05'07.31" Altitude 492 m) | | | | | | | | | | | | | | |
| | | Ap | 0-25 | 10YR3/2 | 10YR3/2 | c | m2sbk | h | fi | vs&vp | ms | ff | mf | cs | - | Gilgai relief |
| | | BA | 25-65 | 10YR3/2 | 10YR3/2 | c | c2abk | h | fi | vs&vp | ms | ff | ff | cs | - | surface cracks |
| | | Bss1 | 55-85 | 10YR3/2 | 10YR3/2 | c | c2abk | h | vfi | vs&vp | ms | ff | ff | cd | - | (5-8 cm wide) |
| | | Bss2 | 85-117 | 10YR3/2 | 10YR3/2 | c | c2abk | h | vfi | vs&vp | ss | ff | - | cd | - | and subsurface |
| | | Bss3 | 117-145 | 10YR3/2 | 10YR3/2 | c | c2abk | h | vfi | vs&vp | ss | ff | - | cd | -- | cracks (3-5cm) |
| | | Bss4 | 145-178 | 10YR3/2 | 10YR3/2 | c | c2abk | h | vfi | vs&vp | ss | ff | - | cd | | slickensides conca |
| | **Narayankhed division** | | | | | | | | | | | | | | | |
| 4. | Pulkurty | Very- Fine Smectitic, Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17°56'45.77" Longitude° 77°42'43.82" Altitude 527 m) | | | | | | | | | | | | | | |
| | | Ap | 0-27 | 10YR3/2 | 10YR3/2 | c | m2sbk | h | fi | vs&vp | - | ff | cf | cs | | Gilgai relief |
| | | BA | 27-55 | 10YR3/2 | 10YR3/2 | c | c2abk | h | fi | vs&vp | ms | ff | cf | cs | | surface cracks |
| | | Bss1 | 55-87 | 10YR3/2 | 10YR3/2 | c | c2abk | h | fi | vs&vp | ms | ff | ff | cs | | (5-7 cm wide); |
| | | Bss2 | 88-124 | 10YR3/2 | 10YR3/2 | c | c2abk | h | fi | vs&vp | s | ff | - | cd | | slickensides; |
| | | Bss3 | 124-150 | 10YR3/2 | 10YR3/2 | c | c2abk | h | fi | vs&vp | s | ff | - | cd | | sub surface hard pan with high B.D. |

Soil texture : ls – Loamy sand ,sl- Sandy loam, scl –Sandy clay loam, sc- Sandy clay, cl- Clay loam and c- Clay
Soil Structure : c-coarse, m- medium , f- fine , 1- weak, 2- moderate,3 - strong, gr- granular ,abk- angular blocky, sbk- sub-angular blocky
Soil Consistence : l- loose, sh- slightly hard, h- hard ,vh- very hard ,vfr-very friable ,fr- friable , fi- firm, vf- very firm, so – non sticky, ss –slightly sticky, s- sticky,vs- very sticky, po- non plastic, ps – slightly plastic, p-plastic, vp- very plastic
Pores : Size f-fine, m-medium, c-coarse; Quantity f-few, c-common, m-many
Roots : Size f-fine, m-medium, c-coarse; Quantity f-few, c-common, m-many
Effervescence : m-mild ,ms-moderately strong s-strong vs-very strong
Boundary : c- clear , d- diffuse, s- smooth ,w- wavy, g- gradual, a- abrupt

blocky structure (sub-angular and angular) and the peds were medium to coarse in size with strong grade (strength). The pedality of black soils was more strongly developed because of the high clay content, CEC, BSP and dominance of montmorillonite type of clay. Stronger pedality of soils at lower topographic positions might be due to finer fractions (Shyampura *et al.,* 1994). The textural class of fine earth fraction was clay loam (pedon 2) to clay (pedon 1, 3 and 4) throughout the depth. The uniformity in texture was due to the argillopedoturbation operating in the black soil profiles (Buol *et al.*, 1998); Marathe *et al*. (2003) and Balapande *et al.* (2007). The horizons of soils exhibited sticky to plastic to very sticky to very plastic, firm and hard to very hard in wet, moist and dry conditions, respectively, which might be due to high clay content. Similar observations made by Sarkar *et al.* (2001) in soils of lower outlier of Chhotanagpur plateau and Rajeshwar and Mani (2013).

Vertic properties like surface cracks ranging from 3-8 cm wide, slickensides, microknolls and microridges were developed in the soil pedons (1, 3 and 4). The soil pedons (1, 2, 3 and 4) had shown a prominent gilgai

**Table 2 : Physical characteristics of Sugarcane growing soil pedons of the Medak district**

| Pedon | Location | Horizon | Depth (cm) | Gravel (%) | Particle size distribution (%) | | | B.D (Mg m-3) | Pore space (%) | W.H.C (%) | Volume expansion (%) | COLE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sand | Silt | Clay | | | | | |
| | **Sadasivpet division** | | | | | | | | | | | |
| 1 | Aroor | Very-Fine Smectitic Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° N 17° 37'42.34" Longitude° E 77° 53'10.33" Altitude 539 m) | | | | | | | | | | |
| | | Ap | 0-25 | 11.50 | 20.1 | 19.8 | 59.6 | 1.56 | 55.0 | 48.0 | 23.1 | 0.14 |
| | | BA | 25-52 | 10.50 | 19.0 | 18.4 | 62.1 | 1.59 | 53.0 | 51.0 | 23.7 | 0.16 |
| | | Bss1 | 52-79 | 9.00 | 17.3 | 17.3 | 63.9 | 1.61 | 50.0 | 49.0 | 25.5 | 0.18 |
| | | Bss2 | 79-115 | 9.50 | 16.8 | 17.2 | 64.3 | 1.65 | 48.0 | 46.0 | 26.4 | 0.19 |
| | | Bss3 | 115-155 | 8.30 | 16.4 | 20.0 | 61.1 | 1.68 | 46.0 | 45.0 | 28.4 | 0.21 |
| | | C | 155+ | Mixed with calcareous murram | | | | | | | | |
| 2 | Budera | Fine Smectitic Superactive Non calcarious Isohyperthermic Vertic Haplustepts (Latitude ° N 17° 38'37.18" Longitude ° 77° 50'35.00"Altitude 585 m) | | | | | | | | | | |
| | | Ap | 0-14 | 12.30 | 41.2 | 18.6 | 38.7 | 1.43 | 46.0 | 32.0 | 23.10 | - |
| | | Bw1 | 14-41 | 14.00 | 42.3 | 17.3 | 40.1 | 1.52 | 52.0 | 38.0 | 26.24 | - |
| | | Bwss1 | 41-58 | 14.50 | 43.2 | 18.6 | 37.2 | 1.50 | 55.0 | 36.0 | 27.13 | - |
| | | Bwss2 | 58-79 | 17.00 | 42.5 | 17.9 | 39.3 | 1.61 | 61.0 | 38.0 | 29.14 | - |
| | | BC | 79-100 | 17.60 | 39.9 | 17.2 | 42.1 | 1.62 | 62.0 | 39.0 | 29.10 | - |
| | **Jogipet division** | | | | | | | | | | | |
| 3 | Andole | Fine Smectiti Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17° 49'34.54" Longitude° 78° 05'07.31" Altitude 492 m) | | | | | | | | | | |
| | | Ap | 0-25 | 10.9 | 28.2 | 16.5 | 54.2 | 1.51 | 45.0 | 44.0 | 22.8 | 0.13 |
| | | BA | 25-65 | 10.4 | 25.4 | 16.9 | 57.6 | 1.50 | 48.0 | 47.0 | 23.7 | 0.14 |
| | | Bss1 | 55-85 | 11.1 | 23.2 | 17.4 | 58.9 | 1.54 | 51.0 | 49.0 | 25.8 | 0.16 |
| | | Bss2 | 85-117 | 12.6 | 20.1 | 18.0 | 61.7 | 1.58 | 52.0 | 51.0 | 26.8 | 0.18 |
| | | Bss3 | 117-145 | 12.3 | 19.0 | 17.7 | 63.1 | 1.58 | 52.0 | 48.0 | 30.4 | 0.18 |
| | | Bss4 | 145-178 | 12.5 | 18.8 | 19.6 | 61.4 | 1.60 | 55.0 | 53.0 | 30.1 | 0.17 |
| | **Narayankhed division** | | | | | | | | | | | |
| 4 | Pulkurty | Very- Fine Smectitic, Calcareous Superactive Isohyperthermic Typic Haplustrets (Latitude ° 17° 56'45.77" Longitude° 77° 42'43.82" Altitude 527 m) | | | | | | | | | | |
| | | Ap | 0-27 | 10.0 | 10.3 | 17.5 | 71.4 | 1.49 | 45.0 | 46.0 | 23.5 | 0.14 |
| | | BA | 27-55 | 9.4 | 8.2 | 18.1 | 73.4 | 1.55 | 48.0 | 47.0 | 24.6 | 0.15 |
| | | Bss1 | 55-87 | 8.9 | 6.3 | 18.4 | 75.1 | 1.62 | 51.0 | 49.0 | 26.8 | 0.17 |
| | | Bss2 | 88-124 | 10.1 | 4.3 | 19.5 | 75.7 | 1.66 | 53.0 | 51.0 | 28.6 | 0.19 |
| | | Bss3 | 124-150 | 10.5 | 3.6 | 20.1 | 76.2 | 1.66 | 53.0 | 52.0 | 30.1 | 0.20 |

Sand (0.02-2.0 mm); Silt (0.002- 0.02mm) and Clay (<0.002mm) formation due to wide deep surface cracks, the surface soil could have been sloughed off during rainy season and swelling pressures developed in the lower layers pushed the peds upward which leads the development of slickensides in the deeper horizons and mounds and depressions on the surface. Similar observations were made by Subbaiah and Manickam (1992); Ashok kumar and Jagadish Prasad (2010). Pressure faces were common in sub-surfaces horizon of pedon 1, 3 and 4 and slickensides were observed from 52 and 55 cm of depth, respectively and their thickness is more than 40 cm. Moderately strong to violent effervescences were observed with dilute HCl. Many calcium carbonate nodules (calcrets) were formed in lower horizons of the pedons of 1, 2, 3 and 4. The colour of $CaCO_3$ concretions vary from pale brown to light grayish white, small to bigger size (0.2 mm to 8.0 cm diameter), hard irregular outlined found in surface layers. The soft and easily separable lime nodules developed a zone of accumulation below 150 to 178 cm (Pedon 1, 3 and 4). The uniform distribution of lime concretions (and pebbles) in surface and subsurface horizon of black soils are observed. It may

**Table 3 : Ratios of fine earth fractions of pedons (Particle size-analysis)**

| Pedon | Location | Horizon | Depth (cm) | Sand+ Silt | Silt + Clay | Sand / Silt | Silt / Clay | Sand /(Sand + Silt) | Sand /(Silt + Clay) |
|---|---|---|---|---|---|---|---|---|---|
| | **Sadasivpet division** | | | | | | | | |
| 1 | Aroor | Very-Fine Smectitic Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° N 17 ° 37'42.34" Longitude ° E 77 ° 53'10.33" Altitude 539 m) | | | | | | | |
| | | Ap | 0-25 | 39.9 | 79.4 | 1.02 | 0.33 | 0.50 | 0.25 |
| | | BA | 25-52 | 37.4 | 80.5 | 1.03 | 0.30 | 0.51 | 0.24 |
| | | Bss1 | 52-79 | 34.6 | 81.2 | 1.00 | 0.27 | 0.50 | 0.21 |
| | | Bss2 | 79-115 | 34.0 | 81.5 | 0.98 | 0.27 | 0.49 | 0.21 |
| | | Bss3 | 115-155 | 36.4 | 81.1 | 0.82 | 0.33 | 0.45 | 0.20 |
| | | C | 155+ | Mixed with calcareous murram | | | | | |
| 2 | Budera | Fine Smectitic Superactive Non calcarious Isohyperthermic Vertic Haplustepts (Latitude ° N 17 ° 38'37.18" Longitude ° 77 ° 50'35.00" Altitude 585 m) | | | | | | | |
| | | Ap | 0-14 | 59.8 | 57.3 | 2.22 | 0.48 | 0.69 | 0.72 |
| | | Bw1 | 14-41 | 59.6 | 57.4 | 2.45 | 0.43 | 0.71 | 0.74 |
| | | Bwss1 | 41-58 | 61.8 | 55.8 | 2.32 | 0.50 | 0.70 | 0.77 |
| | | Bwss2 | 58-79 | 60.4 | 57.2 | 2.37 | 0.46 | 0.70 | 0.74 |
| | | BC | 79-100 | 57.1 | 59.3 | 2.32 | 0.41 | 0.70 | 0.67 |
| | **Jogipet division** | | | | | | | | |
| 3 | Andole | Fine Smectiti Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17 ° 49'34.54" Longitude ° 78 ° 05'07.31" Altitude 492 m) | | | | | | | |
| | | Ap | 0-25 | 44.7 | 70.7 | 1.71 | 0.30 | 0.63 | 0.40 |
| | | BA | 25-65 | 42.3 | 74.5 | 1.50 | 0.29 | 0.60 | 0.34 |
| | | Bss1 | 55-85 | 40.6 | 76.3 | 1.33 | 0.30 | 0.57 | 0.30 |
| | | Bss2 | 85-117 | 38.1 | 79.7 | 1.12 | 0.29 | 0.53 | 0.25 |
| | | Bss3 | 117-145 | 36.7 | 80.8 | 1.07 | 0.28 | 0.52 | 0.24 |
| | | Bss4 | 145-178 | 38.4 | 81.0 | 0.96 | 0.32 | 0.49 | 0.23 |
| | | C | 90+ | Weathered granite- gneiss | | | | | |
| | **Narayankhed division** | | | | | | | | |
| 4 | Pulkurty | Very- Fine Smectitic, Calcareous Superactive Isohyperthermic Typic Haplustrets (Latitude ° 17 ° 56'45.77" Longitude ° 77 ° 42'43.82" Altitude 527 m) | | | | | | | |
| | | Ap | 0-27 | 27.8 | 88.9 | 0.59 | 0.25 | 0.37 | 0.12 |
| | | BA | 27-55 | 26.3 | 91.5 | 0.45 | 0.25 | 0.31 | 0.09 |
| | | Bss1 | 55-87 | 24.7 | 93.5 | 0.34 | 0.25 | 0.26 | 0.07 |
| | | Bss2 | 88-124 | 23.8 | 95.2 | 0.22 | 0.26 | 0.18 | 0.05 |
| | | Bss3 | 124-150 | 23.7 | 96.3 | 0.18 | 0.26 | 0.15 | 0.04 |

be probably due to the localized movement of the sub-soil as described by Murthy *et al.* (1982). Sub surface hard pan with high bulk density was observed in sugarcane growing black soil pedon 1 and 4 where the penetration and proliferation roots are very few within 20-40 cm depth due to decades of cultivation practices of shallow ploughing and migration of finer clays to deeper layers resulted in sub soil hard pan to some extent.

**Physical properties :**

The clay content varied from 37.2 per cent (pedon 2) to 76.2 per cent (pedon 4). Increase of clay up to certain depth and a decrease was observed in pedon 1, 7, and 9 due to the illuviation process occurring during soil development (Table 2). Similar observations were also made by Tripathi *et al.* (2006). The clay content was found gradually increased in pedon 4. The increased clay content with depth was an evidence of pedogenic development as their formation and distribution is time dependent (Bhaskar *et al.,* 2009) and also these variations could be attributed to the parent material, topography, *in situ* weathering and / or pedogenesis (Rudramurthy and Dasog, 2001). The silt content varied from 16.5 (pedon 3) to 19.8 (pedon 1) percent, where as in sub surface horizons ranged from 16.9 (pedon 9) to 20.1 (pedon 4) per cent. There was a gradual increase in silt content with depth in pedon 4 and no uniform trend was observed in the distribution pattern of silt content with depth in all other pedons**.** The silt content in most of the pedons showed an irregular trend with soil depth. It might be due to coarse nature of silt than clay, which restricts its movement with percolating water (Sharma *et al.,* 2001).

The sand content varied from 10.3 (pedon 4) to 41.2 (pedon 2) per cent in surface horizon whereas, in subsurface horizon 3.6 (pedon 4) to 43.2 (pedon 2) per cent. A decreasing trend in sand content with depth was observed in pedon 1, 3 and 4 due to the translocation / migration of finer particles into the lower layers and surface erosion. These observations were in agreement with those of Bhaskar and Subbaiah (1995), Sarkar *et al.* (2001) and Monday *et al.* (2003). To confirm the presence or absence of lithological discontinuity among adjacent horizons in different soil pedons, the ratios of fine earth fractions were computed (Table 3). The ratios of sand / silt (0.18 (pedon 4) to 2.45 (pedon 2)), silt / clay (0.25 (pedon 4) to 0.50 (pedon 2)) and sand / (silt + clay) (0.04 (pedon 4) to 0.77 (pedon 2)). The silt clay ratio was found to be less than 0.5 in black soils indicating the moderate weathering (Rajeshwar and Mani, 2013).

The bulk density of the soils ranged from 1.43 Mg $m^{-3}$ (pedon 2) to 1.56 Mg $m^{-3}$ (pedon 1) in surface horizons whereas in subsurface horizons ranged from1.50 Mg $m^{-3}$ in (pedon 2) to 1.68 Mg $m^{-3}$ in (pedon 1). Bulk density increased with increasing depth in all pedons might be due to decrease in organic matter content, more compaction, and less aggregation (Singh and Agarwal, 2005 and Rajeshwar and Mani, 2013) except (pedon 2) showed irregular trend with soil depth. The Bss horizon of pedon 1, 3, and 4 had higher bulk density than the surface and sub-surface horizons which may be due to high clay content resulting in greater compaction in swelling clay soils (Ashok kumar and Jagadish Prasad, 2010). The higher water-holding capacity was recorded and varied from 32 per cent (pedon 2) to 53.0 per cent (pedon 3). The water holding capacity showed increasing trend with soil depth in pedon 4. The other pedons were exhibited an irregular trend with depth. In all the locations these values showed increasing trend with increasing clay content (Rudramurthy and Dasog, 2001). The pore space varied from 45.0 per cent (pedon 12) to 62.0 per cent (pedon 2). A reduction in porosity with depth was observed in pedon 1 due to soil compaction whereas reverse trend was noticed in pedon 9 and 12 (Rajeshwar and Mani, 2013).

The higher volume of expansion was varied from 23.1 per cent (pedon 1) to 30.4 per cent (pedon 3). The volume expansion was high in black soil pedons due to presence smectite type of clay minerals (Rajeshwar and Mani, 2013).The shrinkage and swelling phenomenon was exhibited by black soils, co-efficient of linear extensibility (COLE) was determined and ranged from 0.13 (pedon 3) to 0.21 (pedon 1). The studied black soils fall in the category of very high (greater than 0.09) swell-shrink class (Nayak *et al.,* 2006) might be due to increased amount of clay (Ashok kumar and Jagadish Prasad, 2010 and Rajeshwar and Mani, 2013).

**Physico-chemical properties :**

The pedon wise physico-chemical properties are described in table 3). The pH value of soils (pedon 1, 2, 3 and 4) found to vary from 6.5 (pedon 2) to 8.2 (pedon 1) in surface horizons (neutral to moderately alkaline) whereas in subsurface horizons ranged from 6.7 in pedon

**Table 4 : Physico-chemical characteristics Sugarcane growing soil pedons of the Medak district**

| Pedon | Location | Horizon | Depth (cm) | pH (1:2.5) | EC ($dSm^{-1}$) | OC ($g\ kg^{-1}$) | Exchangeable Cations ($c\ mol\ (p+)\ kg^{-1}$) | | | | Total Ex. Bases | BS (%) | CEC ($cmol\ (p+)\ kg^{-1}$) | Free $CaCO_3$ (%) | ESP (%) | SAR | CEC/Clay ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ca | Mg | Na | K | | | | | | | |
| | **Sadasivpet division** | | | | | | | | | | | | | | | | |
| 1 | Aroor | Very-Fine Smectitic Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° N 17° 37'42.34" Longitude° E 77° 53'10.33" Altitude 539 m) | | | | | | | | | | | | | | | |
| | | Ap | 0-25 | 8.1 | 0.24 | 7.5 | 18.6 | 11.6 | 0.55 | 1.70 | 32.45 | 80.32 | 40.4 | 5.6 | 1.36 | 0.11 | 0.68 |
| | | BA | 25-52 | 8.2 | 0.28 | 5.4 | 21.4 | 12.4 | 0.66 | 1.52 | 35.96 | 84.61 | 42.5 | 7.4 | 1.55 | 0.13 | 0.68 |
| | | Bss1 | 52-79 | 8.3 | 0.33 | 5.1 | 22.4 | 12.5 | 0.73 | 1.53 | 37.13 | 78.83 | 47.1 | 8.3 | 1.55 | 0.14 | 0.74 |
| | | Bss2 | 79-115 | 7.9 | 0.33 | 3.7 | 22.1 | 12.8 | 0.75 | 1.55 | 37.25 | 77.28 | 48.2 | 9.3 | 1.56 | 0.14 | 0.75 |
| | | Bss3 | 115-155 | 8.5 | 0.34 | 1.7 | 22.4 | 13.1 | 0.81 | 1.50 | 37.81 | 76.69 | 49.3 | 11.6 | 1.64 | 0.15 | 0.81 |
| | | C | 155+ | Mixed with calcareous murram | | | | | | | | | | | | | |
| 2 | Budera | Fine Smectitic Superactive Non calcarious Isohyperthermic Vertic Haplustepts (Latitude ° N 17° 38'37.18" Longitude ° 77° 50'35.00"Altitude 585 m) | | | | | | | | | | | | | | | |
| | | Ap | 0-14 | 6.5 | 0.21 | 6.6 | 11.4 | 6.0 | 0.14 | 0.76 | 18.30 | 75.00 | 24.4 | 2.8 | 0.57 | 0.04 | 0.63 |
| | | Bw1 | 14-41 | 6.8 | 0.26 | 4.5 | 12.2 | 6.0 | 0.15 | 0.52 | 18.87 | 66.68 | 28.3 | 3.2 | 0.53 | 0.04 | 0.71 |
| | | Bwss1 | 41-58 | 7.0 | 0.29 | 5.0 | 13.1 | 6.2 | 0.15 | 0.51 | 19.96 | 66.98 | 29.8 | 3.9 | 0.50 | 0.04 | 0.80 |
| | | Bwss2 | 58-79 | 6.7 | 0.31 | 3.5 | 13.2 | 6.4 | 0.20 | 0.55 | 20.35 | 81.08 | 25.1 | 4.7 | 0.80 | 0.05 | 0.64 |
| | | BC | 79-100 | 7.0 | 0.34 | 2.4 | 13.3 | 6.5 | 0.21 | 0.55 | 20.56 | 83.92 | 24.5 | 4.7 | 0.86 | 0.05 | 0.58 |
| | **Jogipet division** | | | | | | | | | | | | | | | | |
| 3 | Andole | Fine Smectiti Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17° 49'34.54" Longitude° 78° 05'07.31" Altitude 492 m) | | | | | | | | | | | | | | | |
| | | Ap | 0-25 | 8.2 | 0.21 | 7.9 | 24.6 | 8.2 | 0.7 | 0.5 | 34.00 | 87.40 | 38.9 | 5.5 | 1.80 | 0.13 | 0.72 |
| | | BA | 25-65 | 8.2 | 0.29 | 5.1 | 21.3 | 11.6 | 0.8 | 0.3 | 34.00 | 87.40 | 38.9 | 6.3 | 2.06 | 0.15 | 0.68 |
| | | Bss1 | 55-85 | 8.4 | 0.28 | 4.5 | 20.4 | 10.9 | 0.9 | 0.3 | 32.50 | 79.08 | 41.1 | 6.5 | 2.19 | 0.18 | 0.70 |
| | | Bss2 | 85-117 | 8.4 | 0.34 | 3.3 | 19.1 | 11.3 | 1.2 | 0.3 | 31.90 | 75.06 | 42.5 | 6.6 | 2.82 | 0.24 | 0.69 |
| | | Bss3 | 117-145 | 8.9 | 0.36 | 3.3 | 18.3 | 12.3 | 1.0 | 0.2 | 31.80 | 70.51 | 45.1 | 7.8 | 2.22 | 0.20 | 0.71 |
| | | Bss4 | 145-178 | 9.2 | 0. 40 | 2.9 | 18.1 | 8.4 | 1.3 | 0.3 | 28.10 | 60.69 | 46.3 | 9.9 | 2.81 | 0.28 | 0.75 |
| | **Narayankhed division** | | | | | | | | | | | | | | | | |
| 4 | Pulkurty | Very- Fine Smectitic, Calcareous Superactive Isohyperthermic Typic Haplustrets (Latitude ° 17° 56'45.77" Longitude° 77° 42'43.82" Altitude 527 m) | | | | | | | | | | | | | | | |
| 12 | | Ap | 0-27 | 7.9 | 0.16 | 8.4 | 25.2 | 16.3 | 0.81 | 0.80 | 43.11 | 76.71 | 56.2 | 7.8 | 1.44 | 0.14 | 0.79 |
| | | BA | 27-55 | 8.1 | 0.18 | 6.7 | 26.6 | 18.5 | 0.86 | 0.60 | 46.56 | 82.85 | 60.2 | 8.4 | 1.43 | 0.14 | 0.82 |
| | | Bss1 | 55-87 | 8.0 | 0.20 | 4.8 | 29.2 | 19.6 | 0.89 | 0.60 | 50.29 | 83.54 | 64.7 | 8.6 | 1.38 | 0.14 | 0.86 |
| | | Bss2 | 88-124 | 8.2 | 0.22 | 4.6 | 30.5 | 20.1 | 1.11 | 0.60 | 52.31 | 80.85 | 64.2 | 10.1 | 1.73 | 0.17 | 0.85 |
| | | Bss3 | 124-150 | 8.4 | 0.23 | 3.6 | 30.9 | 20.6 | 1.13 | 0.50 | 53.13 | 82.76 | 65.2 | 11.2 | 1.73 | 0.18 | 0.86 |

2 to 9.2 in pedon 3 (neutral to strongly alkaline). The pH increased with depth in the pedon 3 might be due to increase in bases with depth and their complete downward leaching. The distribution was irregular in pedon 1, 2 and 4 which might be due to downward movement of bases and they get adsorbed at different layers irregularly (Rajeshwar and Mani, 2013). The EC was non saline, values found to vary from 0.16 dS $m^{-1}$ (pedon 4) to 0.24 dS $m^{-1}$ (pedon 1) in surface horizons whereas in subsurface horizons ranged from 0.18 dS $m^{-1}$ in (pedon 4) to 0.40 dS $m^{-1}$ in pedon 3. The EC gradually increased with depth might be due to the leaching of electrolytes to the lower depth and also due to foraging of nutrient ions by the vegetation in the surface layer (Renukadevi, 2003).

The organic carbon content found to vary from 6.6 g $kg^{-1}$ (pedon 2) to 8.4 g $kg^{-1}$ (pedon 4) in surface horizons whereas in subsurface horizons ranged from 1.7 g $kg^{-1}$ in pedon 1 to 6.7 g $kg^{-1}$ in pedon 4. The organic carbon content relatively higher in surface horizons than sub-surface horizons in all the pedons and it decreased with depth except pedon 2. This was attributed to the addition of farmyard manure and plant residues to surface horizons which resulted in higher organic carbon content in surface horizons than that of lower horizons. These observations are in accordance with results of Rajeshwar *et al.* (2009).

The $CaCO_3$ content was varying from 2.8 per cent (pedon 2) to 7.8 per cent (pedon 4) in surface horizon and 3.2 per cent (pedon 2) to 11.6 per cent (pedon 1) in subsurface horizon. The content was relatively higher in deeper layers than in surface layers might be due to the downward movement of it along with percolating water (pedogenic and lithogenic) in soils of semi-arid regions ( Pal *et al.*,2000). Increase in the calcium carbonate content down the depth was attributed to the leaching of bicarbonate from upper layer during rainy season and their subsequent precipitation as carbonate in the lower layer (Maji *et al.*, 2005).

## Exchangeable properties :

The cation exchange capacity was higher and varied from 24.4 c mol ($p^+$) $kg^{-1}$ (pedon 2) to 56.2 c mol ($p^+$) $kg^{-1}$ (pedon 4) in surface layers and 24.5 c mol ($p^+$) $kg^{-1}$ (pedon 2) to 65.2 c mol ($p^+$) $kg^{-1}$ (pedon 4) in sub surface layers. The high CEC of the black soils was attributed to the high clay content and smectitic clay mineralogy (Pal and Deshpande, 1987). The CEC/clay ratios were found to vary from 0.58 (pedon 7) to 0.86 (pedon 12). The CEC values are indicating that the black soils are less weathered .Higher values of CEC/clay ratio indicate the less weathered nature of the soils with weatherable primary minerals (Buol *et al.*, 1998). Soil exchange complex was dominated with Ca in all the pedons compared to other exchangeable cations and varied from 11.4 c mol ($p^+$) $kg^{-1}$ (pedon 2) to 25.2 (pedon 4) in surface layers and 12.2 (pedon 2) to 30.9 (pedon 4) in sub surface layers. In general, exchangeable Ca content increased with depth in pedons 2 and 4 and decreased with depth in pedon 3. There was no regular pattern of distribution with depth was noticed in pedon 1.

The Mg was varied from 6.0 c mol ($p^+$) $kg^{-1}$ (pedon 2) to 16.3 c mol ($p^+$) $kg^{-1}$(pedon 4) in surface layers and 8.4 c mol ($p^+$) $kg^{-1}$ (pedon 3) to 20.6 c mol ($p^+$) $kg^{-1}$(pedon 4) in sub surface layers. Pedons 1, 2 and 4 showed increasing trend with soil depth. The exchangeable Na varied from varied from 0.7 c mol ($p^+$) $kg^{-1}$ (pedon 3) to 0.81 c mol ($p^+$) $kg^{-1}$ (pedon 4) in surface layers and 0.8 c mol ($p^+$) $kg^{-1}$ (pedon 3) to 1.13 c mol ($p^+$) $kg^{-1}$ (pedon 4) in sub surface layers. The exchangeable Na content increased with depth in pedons 1 and 7 and in the rest of the pedons, the depth wise distribution was irregular**.**

The K in soils varied from 0.5 c mol ($p^+$) $kg^{-1}$ (pedon 3) to 0.80 c mol ($p^+$) $kg^{-1}$ (pedon 4) in surface layers and 0.2 c mol ($p^+$) $kg^{-1}$ (pedon 3) to 1.6 c mol ($p^+$) $kg^{-1}$ (pedon 1) in sub surface layers. The pedon 4 shows that the exchangeable K content decreased with depth. The remaining pedons showed inconsistent pattern with depth. The exchangeable bases in soil pedons were in order of $Ca^{+2} > Mg^{+2} > Na^+ > K^+$ on the exchange complex. From the distribution of $Ca^{+2}$ and $Mg^{+2}$, it is evident that $Ca^{+2}$ shows the strongest relationship with all the species, comparing these ions ($Ca^{+2}$, $Mg^{+2}$, $K^+$ and $Na^+$) it was clear that $Mg^{+2}$ was present in low amount than $Ca^{+2}$ because of its higher mobility. These results are in conformity with findings of Thangasamy *et al.*, (2005). The base saturation percentage was higher in black soil pedons ranged from 75.0 per cent (pedon 2) to 87.4 per cent (pedon 3) in surface layers and 60.69 per cent (pedon 3) to 87.40 per cent (pedon 3) in sub surface layers might be due to the dominance of smectitic type of clays and moderate to strongly alkaline reaction (Singh and Agarwal, 2005 and Gabhane *et al.*, 2006). The SAR ranged from 0.04(pedon1) to 0.14 (pedon 4) in surface layers and 0.04 (pedon 2) to 0.28 (pedon 3) in sub surface layers .The pedons 1 and 4 found to follow an increasing trend with the increase in depth. All other pedons exhibited an irregular distribution pattern with the increase in depth.

## Soil classification :

Sugar cane growing soils of Medak district were classified based on morphological, physical, physico-chemical, chemical and meteorological data, according to revisions of USDA Soil Taxonomy (2010). At the highest category (order), the presence or absence of diagnostic horizons which are indications of pedogenic processes are considered. At sub-order level, the moisture and temperature regimes were used. At lower categories (great group, family *etc.*) mineralogy, texture, soil chemical properties and drainage are considered. The soils of the study area were characterized and classified into two soil orders *viz.*, Vertisols and Inceptisols.

The pedons 1, 3 and 4 were classified under Vertisols because of the following features. A layer of 25 cm or more thick, with an upper boundary with in 100 cm of the mineral soil surface; clayey texture, more than 30 per cent clay in fine earth fraction throughout the depth;

**Table 5 : Available nutrient status of Sugarcane growing soil pedons of the Medak district**

| Pedon | Location | Horizon | Depth (cm) | Available macronutrients (kg ha$^{-1}$) | | | Available S (mg kg$^{-1}$) | Available micronutrients (mg kg$^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | N | P | K | | Zn | Cu | Mn | Fe | B |
| | **Sadasivpet division** | | | | | | | | | | | |
| 1 | Aroor | Very-Fine Smectitic Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° N 17° 37'42.34" Longitude° E 77 ° 53'10.33" Altitude 539 m) | | | | | | | | | | |
| | | Ap | 0-25 | 289 | 41.8 | 401 | 44.6 | 0.86 | 2.63 | 7.69 | 8.94 | 1.85 |
| | | BA | 25-52 | 210 | 24.1 | 383 | 31.1 | 0.73 | 2.32 | 7.25 | 7.05 | 1.12 |
| | | Bss1 | 52-79 | 189 | 19.6 | 281 | 26.2 | 0.54 | 2.60 | 6.65 | 5.52 | 0.56 |
| | | Bss2 | 79-115 | 168 | 15.2 | 241 | 16.2 | 0.51 | 1.89 | 5.24 | 4.85 | 0.39 |
| | | Bss3 | 115-155 | 101 | 10.2 | 222 | 13.3 | 0.36 | 1.48 | 5.44 | 3.27 | 0.42 |
| | | C | 155+ | Mixed with calcareous murram | | | | | | | | |
| 2 | Budera | Fine Smectitic Superactive Non calcarious Isohyperthermic Vertic Haplustepts (Latitude ° N 17° 38'37.18" Longitude ° 77 ° 50'35.00" Altitude 585 m) | | | | | | | | | | |
| | | Ap | 0-14 | 277 | 21.03 | 310 | 30.56 | 0.88 | 0.94 | 12.36 | 15.8 | 1.94 |
| | | Bw1 | 14-41 | 184 | 20.62 | 281 | 18.52 | 0.80 | 0.86 | 10.60 | 11.6 | 1.86 |
| | | Bwss1 | 41-58 | 152 | 14.80 | 267 | 15.47 | 0.42 | 0.66 | 10.25 | 14.4 | 1.51 |
| | | Bwss2 | 58-79 | 96 | 11.23 | 210 | 10.75 | 0.36 | 0.39 | 9.57 | 12.6 | 1.36 |
| | | BC | 79-100 | 92 | 8.11 | 181 | 9.23 | 0.31 | 0.38 | 10.98 | 11.1 | 1.22 |
| | **Jogipet division** | | | | | | | | | | | |
| 3 | Andole | Fine Smectiti Calcareous Superactive Isohyperthermic Typic Haplusterts (Latitude ° 17° 49'34.54" Longitude° 78° 05'07.31" Altitude 492 m) | | | | | | | | | | |
| | | Ap | 0-25 | 296 | 42.1 | 415 | 48.56 | 1.36 | 1.05 | 10.60 | 10.2 | 1.99 |
| | | BA | 25-65 | 253 | 39.3 | 395 | 31.98 | 0.69 | 1.02 | 10.23 | 8.1 | 1.84 |
| | | Bss1 | 55-85 | 165 | 29 | 336 | 24.52 | 0.48 | 0.96 | 9.63 | 5.2 | 1.74 |
| | | Bss2 | 85-117 | 168 | 18.91 | 358 | 19.23 | 0.37 | 0.62 | 9.51 | 6.2 | 1.58 |
| | | Bss3 | 117-145 | 96 | 18.52 | 321 | 9.65 | 0.34 | 0.61 | 8.86 | 6.6 | 1.41 |
| | | Bss4 | 145-178 | 88 | 16.4 | 294 | 6.23 | 0.23 | 0.61 | 5.45 | 5.2 | 1.23 |
| | **Narayankhed division** | | | | | | | | | | | |
| 4 | Pulkurty | Very- Fine Smectitic, Calcareous Superactive Isohyperthermic Typic Haplustrets (Latitude ° 17°56'45.77" Longitude° 77° 42'43.82" Altitude 527 m) | | | | | | | | | | |
| | | Ap | 0-27 | 289 | 58.94 | 404 | 51.21 | 0.96 | 2.34 | 13.8 | 9.5 | 1.89 |
| | | BA | 27-55 | 178 | 27.66 | 384 | 26.25 | 0.72 | 2.14 | 11.1 | 9.1 | 1.74 |
| | | Bss1 | 55-87 | 165 | 20.02 | 348 | 18.29 | 0.52 | 2.51 | 6.5 | 8.3 | 1.68 |
| | | Bss2 | 88-124 | 129 | 16.56 | 334 | 15.52 | 0.41 | 1.63 | 5.2 | 8.2 | 1.51 |
| | | Bss3 | 124-150 | 113 | 16.21 | 256 | 10.31 | 0.36 | 1.61 | 4.8 | 4.9 | 1.42 |

gilgai micro-relief (micro-knolls and micro-ridges) on the surface; distinct intersecting slickensides in lower horizons; cracks of greater than 1 cm width which remained open and close periodically to the surface from a depth of more than 40 cm and Absence of lithic or paralithic contact, duripan, petrocalcic horizon within 50 cm from the surface. Based on these characters, the soils were grouped under order "Vertisols". The pedon 2 was classified under the order Inceptisols based on the presence of cambic subsurface horizon due to the following features. A texture of loamy very fine sand or finer; absence of rock structure in one half or more of its volume. In these pedons the subsurface horizons were recognized as cambic horizons (Thangasamy *et al.*, 2005). As the moisture regime is Ustic, the pedons 1, 3 and 4 were classified as Usterts at sub order level. The pedons 1, 3 and 4 were further placed under the Haplusterts at great group level (Walia and Rao,1997 and Singh *et al.*, 1998) and Typic Haplusterts at sub group level because these pedons had deep cracks that remained open for more than 150 cumulative days most years (Surekha *et al.*,1997). The pedon 2 was classified as Haplustepts at great group level and Vertic Haplustepts at sub group level because of the base saturation is more than 60 per cent at a depth between 0.2 to 0.6 m from the soil surface and due to presence of cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years.

The pedon 1 and 4 had clay content more than 60 per cent on weighted average in fine earth fraction. Hence, it was qualified for "Very fine" particle size class. The pedon 3 had clay content less than 60 per cent on weighted average in fine earth fraction which is qualified for "fine" particle size class and showed relative dominance of smectite mineral. Hence the clay mineralogical class of these pedons was "smectitic" (Rajeshwar and Mani, 2015). The pedon 2 had showed clay content more than 35 per cent on weighted average in fine earth fraction and it was qualified for "fine" particle size class (Ramprakash and Rao,2002). The difference between mean summer and winter temperatures was less than $6^0$ C and the mean annual soil temperature was more than $22^0$ C. Therefore, the study area was classified as "iso- hyperthermic" temperature regime (Sehgal, 1996).

**Pedogenesis :**

Eastern Ghats (south) of Deccan trap had been divided into three landforms *viz.,* granite and granite - gneiss, dharawars, and cuddapahs and kurnools (Reddy *et al.,* 1996). In the very gently sloping lands and valleys, the finer factions and calcium carbonate were accumulating with weathered granitic gneiss. Hence, the parent material for the development of these black soils was weathered granite - gneiss at higher elevations and it was mixed with calcareous murram in very gently sloping lands, plains and valleys. The black soils (pedon

**Table 6 : Land capability classification of Sugarcane growing soil pedons of Medak District based on soil characteristics**

| Physiographic unit | Location | Topography | | Physical soil characteristics | | | | | Pedon development | Soil fertility factors | | | LCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Slope | Erosion | Drainage | Texture | Sur.coarse fragments | Sub.sur.coarse fragments | Soil Depth | | CEC | BS | OC | |
| Pedon 1 | Aroor | II | II | IV | III | II | II | I | I | I | III | II | IIIwef |
| Pedon 2 | Budera | III | II | III | II | II | II | II | I | I | I | III | IIIwef |
| Pedon 3 | Andole | II | II | IV | III | II | II | I | I | I | I | II | IIIwef |
| Pedon 4 | Pulkurty | II | II | IV | III | II | II | I | I | I | I | II | IIIwef |

**Table 7 : Soil-site characteristics for land evaluation of sugarcane growing Soils of Medak District**

| Physiographic unit | Location | Climate | | | | Land form characteristics | | | Physico-chemical characteristics(weighted averages) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rain fall (mm) | Max.temp (oC) | Min. temp (oC) | RH (%) | Slope (%) | Erosion | Drainage | Depth (cm) | Sur.coarse fragments (vol %) | Texture | pH (1:2.5) | OC (g kg$^{-1}$) | CEC (Cmol (p+)/kg) | B.S (%) |
| Pedon 1 | Aroor | 855 | 40.0 | 26.2 | 74.0 | 1-3 | Moderate | Poor | 155 | 11.5 | c | 8.1 | 7.5 | 40.4 | 80.32 |
| Pedon 2 | Budera | 980 | 40.0 | 26.2 | 74.0 | 1-3 | Moderate | Poor | 100 | 12.3 | cl | 6.5 | 6.6 | 24.4 | 75.00 |
| Pedon 3 | Andole | 855 | 40.0 | 26.2 | 74.0 | 1-3 | Moderate | Poor | 178 | 10.4 | c | 8.2 | 7.9 | 38.9 | 87.40 |
| Pedon 4 | Pulakurty | 855 | 40.0 | 26.2 | 74.0 | 1-3 | Moderate | Poor | 150 | 10.0 | c | 7.9 | 8.4 | 56.2 | 76.71 |

1 and 3) were derived from weathered granite-gneiss mixed with calcareous murram whereas pedon 4 was derived from weathered basalt mixed with calcium carbonate nodules. Similar occurrence of black soils on granite-gneiss was reported earlier by Paramasivam and Gopalaswamy (1993); Subbaiah and Manickam (1992);Vijay Kumar *et al.* (1994). The black soils (pedon 1, 2, 3 and 4) were developed on nearly level to very gently sloping lands with slope per cent varying between 1 and 3. Many scientists in different locations also reported formation of black soils on lower elements of topography. Similar results were reported by Nagelschmidt *et al.* (1940) in deccan state of India*;* Curi and Franzmeir (1984) in central plateau of Brazil; Nagassa and Gebrekidan (2003) in Bako soils of Ethiopia and Gabhane *et al.* (2006) in Vidarbha region. The soils of the study area might have been formed during Archean period about 3800 million years back (Rao *et al.*, 1995). Digar and Barde (1982) reported that it was during Archean period, the black soils were developed during Cenozoic era, which included tertiary and quaternary period (Coulombe *et al.*, 1996).

**Soil forming processes :**

The black soils of sugarcane growing area (pedon 1, 3 and 4), prominent or distinct slickensides were noticed in the lower layers. Slickensides were originated due to sliding of one soil mass over the other due to swelling and expansion of clay minerals in wet season. They were seen as polished smooth surfaces in dry period when profile was opened up to the deeper layers. The pedogeneic process was nothing but argillo pedoturbation. Similar reports were earlier given by Mermut *et al.* (1996) and Maji *et al.* (2005). In the black soil locations, narrow to wide cracks were noticed revealing the shrinking nature of the clay minerals in dry period. The soil particles particularly clay which were loose on the surface, due to slight disturbance, wind and / or rain migrate to the

**Table 8 : Actual and potential soil suitability for sugarcane growing Soils of Medak District**

| Pedon No | Location | Max. temp © | Min.Temp © | RH © | Slope (t) | Drainage (w) | Texture (s) | Depth (s) | $CaCO^3$ (s) | EC (n) | ESP (n) | pH (n) | BSP (f) | CEC (f) | OC (f) | Actual suitability | Potential Suitability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pedon 1 | Aroor | S1 | S1 | S1 | S1 | S3 | S3 | S1 | S1 | S1 | S1 | S2 | S1 | S1 | S1 | S2 | S1 |
| Pedon 2 | Budera | S1 | S1 | S1 | S1 | S2 | S1 | S1 | S2 | S1 | S1 | S2 | S1 | S1 | S2 | S2 | S1 |
| Pedon 3 | Andole | S1 | S1 | S1 | S1 | S3 | S3 | S1 | S1 | S1 | S1 | S2 | S1 | S1 | S1 | S2 | S1 |
| Pedon 4 | Pulakurty | S1 | S1 | S1 | S1 | S3 | S3 | S1 | S1 | S1 | S1 | S1 | S1 | S1 | S1 | S2 | S1 |

Soil Suitability class: $S_1$ - Highly suitable; $S_2$ - Moderately suitable ; $S_3$ - Marginally suitable

Not Suitability class: $N_1$- Temporarily not suitable $N_2$ - Permanently not suitable AS - Actual Suitability PS - Potential Suitability

**Table 9 : Comparative evaluation of productivity of soils in the study area along with the management options**

| Soil type | Pedon | Location | Suitability | Major limitations | Management suggested |
|---|---|---|---|---|---|
| **Black soils** | | | | | |
| | 1 | Aroor | Moderately suitable to highly suitable | Drainage, texture, runoff, erosion and $CaCO_3$, high pH, sub surface hard pan | Addition of river sand at 100 t $ha^{-1}$; application of 100 cart loads of red loam soil; summer deep ploughing; furrow system to manage the surface drainage; raised beds should be 1.2 m wide and 15 cm hight with two furrows of 30 cm width on either side to drain out excess of water; pre monsoon sowing of green manures; application of farmyard manures, composted coir pith or press mud at 25 t $ha^{-1}$ per year and crop rotation. Follow site-specific nutrient management. |
| | 2 | Andole | Moderately suitable to highly suitable | Drainage, texture, runoff, erosion and high $CaCO_3$, high pH in subsurface horizon | |
| | 3 | Pulakurty | Moderately suitable to highly suitable | Drainage, texture, runoff, erosion and high $CaCO_3$, high pH, sub surface hard pan | |
| | 4 | Budera | Moderately suitable to highly suitable | Slope, medium OC and N and Low Zn | Pre monsoon sowing of green manures; application of farmyard manures, composted coir pith or press mud at 25 t $ha^{-1}$ per year and crop rotation. Follow site-specific nutrient management. |

deeper layers along the sides of the cracks. This type of mechanical migration of inorganic particles in the profile was described as lessivage (Buol *et al.*, 1998). The 'B' horizon in the pedon 2 was exhibiting features of altered horizon and thereby resulted in structural / colour 'B' horizon (cambic horizon, a sub-surface diagnostic horizon). The colour of the soil was darker in dry and moist conditions due to release of iron oxides from weathering of rocks and minerals and their accumulation in the solum.

**Land capability classification :**

Land capability classification is an interpretive grouping of soils mainly based on the inherent soil characteristics, external land features and environmental factors that limits the use of land. The classification of units provide information on the physiography, colour, texture, structure of soil, type of clay mineral, consistence, permeability, depth of soil and soil reaction. Based on soil properties, soils were classified into land capability classes III with 'III swef' land capability sub-class due to the limitations of drainage, texture, erosion and soil fertility limitations Table 6). Similar interpretation was also made by Sarkar *et al.* (2002) and Rajeshwar and Mani (2013).

**Soil site suitability evaluation for sugarcane :**

Soil site suitability evaluation for any crops forms an essential part of every land use planning programme. The soils of the study area were evaluated for their suitability for growing sugar cane by the following criteria outlined by Naidu *et al*. (2006). Important parameters *viz.*, maximum and minimum temperature, relative humidity, slope, erosion, drainage, texture, coarse fragments, depth, soil reaction, EC, $CaCO_3$, organic carbon, CEC, ESP and BSP were taken into consideration for evaluating the suitability of crops (Table 7). The land suitability order and classes were assigned to the soils as per the guidelines given in the Frame Work of Land Evaluation (FAO, 1976).

The land is given a suitability rating depending on how well its properties meet the requirement of the crop. If all the properties match well with the crop requirements, the land is considered highly suitable: otherwise less suitable (moderate and marginal) and even not suitable depending upon the deviation of the land properties from the optimal growth requirement of the crops. The studied sugar cane growing soils vary in their suitability, according to the criteria for the determination of land suitability classes (Table 8).

The suitability for sugarcane cultivation in black soil pedons (1,2,3 and 4) were found moderately suitable to highly suitable with limitation of poor drainage, texture, runoff, erosion and $CaCO_{3,}$ high pH, sub surface hard pan, Slope, medium OC and N and Low Zn (Table 9) with slow permeability and low hydraulic conductivity. In the black soil area, improved management practices have good potential to enhance productivity on these soils. If the improvements could be done such as addition of river sand @ 100 t $ha^{-1}$ and application of 100 cartloads of red loam soil; deep ploughing the field with mould board plough or disc plough during summer to enhance the infiltration and percolation will help to enhance moderately suitable to highly suitable for the cultivation of sugarcane.

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