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Research Article

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Evaluation of some sugarcane growing red, red laterite and black soils of Medak district of Telangana

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Summary

A reconnaissance soil survey was undertaken in sugarcane growing soils of Medak district of Telangana to assess the characteristics of soils, evaluate the land by identifying potentials and limitations to suggest suitable management options in the perspective of developed land use decision for effective utilization of resources. Soil samples (128 surface and 128 subsurface) were collected at a depth of 0-15cm and 15-30cm and analyzed for morphological, physical, physico-chemical and available major nutrient status. All the surface and subsurface soils well developed structural variation and exhibited granular to sub angular blocky structure in surface and sub angular blocky to angular blocky in subsurface horizon. The textural classes of the district are sandy loam, sandy clay loam, sandy clay to clay loam and clay. The consistence of soils varied from loose to hard, very friable to firm, non-sticky, non- plastic to very sticky, very plastic in dry, moist and wet conditions, respectively. The pH ranges between extremely acidic to moderately alkaline in reaction and EC was non-saline. The organic carbon content ranged from low to high in surface soils and low to medium in subsurface soils. The soils are low to medium in available N, medium to high in P and K in surface soils. Major soil constraints include texture, erosion, slope, depth, drainage and low organic carbon, low availability of N and micronutrients. If the improvements could be done, there is scope that the area under marginally suitable may be converted to moderately suitable to highly suitable for the cultivation of different crops.

Key words : Sugarcane growing red, Red laterite, Black soils, Available macronutrients, Constraints, Management

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Introduction

The population in India is increasing steadily and as well the demand for sugar and other sweetening agents raising because of changing food habits. There is less scope to increase the area under sugarcane to meet the requirements due to several reasons. This envisages the adoption of better crop production and protection technologies for increased production per unit area and time apart from varietal improvement. 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 at the cost of forests have reduced to 20 per cent 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 per cent and 13.25 per cent, of Asian and Worlds sugar production, respectively.

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} (Center for Monitoring Indian Economy, 2014-15). 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 (112,077 sq km or 112.077 lakh ha or 11.207 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. The present investigation is aimed to assess the surface characteristics of sugarcane growing soils of Medak district in the perspective of developed land use decision for effective utilization of resources. The information available on the sugarcane growing soils is very meager. The present study is taken upto determine the soil physical, physico-chemical and available nutrient status for surface and subsurface soils by identifying potentials and limitations to suggest suitable management options.

Resource and Research Methods

Location and description of the study area:

Medak district of Telangana state 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. They are: Andol-Jogipet (Aodol-Jogipet, Hathnura and Pulkal revenue mandals), Dubbak (Dubbaka, Daulatabad, Mirdoddi and Tupran), Gajwel (Gajwel, Jagdevpur, Mulug and Wargal), Medak (Kulcharam, Medak and Papannapet), Narsapur (Jinnaram, Kowdipalli, Narsapur and Sivampel), Narayankher (Kalher, Kangti, Manur and Narayankher), Ramayampet (Chegunta, Ramayampet, Shankarampet (A) and Yeldurti),Sadasivpet (Kohir, Kondapur, Munipally and Sadasivpet), Sangareddi (Ramachandrapuram, Patancheru and Sangareddi), Shankarampet (R) (Alladurg, Regode, Shankarampet (R) and Tekmal), Siddipet (Chinnakodur, Kondapak, Nanganoor and Siddipet), Zaheerabad (Jharasangam, Nyalkal, Raikode and Zaheerabad). The sugarcane crop is cultivated in 10 agricultural divisions of Medak district except Siddipet and Gajwel. The forest cover is 96,267 hectares and the net area sown is 4,23,000 ha with the total cropped area of 5,25,000 ha. There are no major surface irrigation projects worth mentioning except for minor irrigation projects like Ghanpur, Ranapalli, Gangakathwam, Bollampalle, Nallavagu and Pocharam. Manjira, a perennial tributary of river Godavari with its tributaries of Haldi (Pasupuyeru) and Kundlair drains the district. The district is drained by a major river Manjira and three minor rivers, *viz.*, Haldi, Kundlair and Mohedamada and several other ephemeral streams and channel. The drainage pattern is dendritic and parallel to subparallel and dendritic.

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. The Medak district represents a variety of geological formations. 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 unconformable with overlying Basaltic flows of late Cretaceous to early Eocene age with sub-recent to recent alluvium along the stream courses. The rock formations are mainly divided into four geological formations, *i.e.*, Archaean, Mesozoic-lower Tertiary, Pleistocene and Recent alluvium. The main formations in order of age from the oldest to the youngest along with their occurrence in different Mandals are given in Table A. 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 and LUP, 2005).

The pink granite together with its pegmatite and quartz veins was a later intrusion than the greygranite, as indicated by the presence of enclaves of the latter in the former and also the intrusive relation of the former with the latter. The dark minerals of granite include biotite mica and hornblende and other minerals like apatite, zircon etc. The important rock types are granites, grano-diorites and banded gneisses. In some areas, the peninsular gneisses are traversed by a number of dolerite dykes which represent the last phase of igneous activity of the Archaean period. The Deccan Trap formations occur in the northwestern and northern part of the district and cover about 1,40,438 ha (14.5%) area. They are mostly remnants of huge lava flows that poured out from extensive fissures. They form flat-topped hills with step-like trappean topography. The common rock is basalt. Seven Deccan Trap flows with unweathered outcrops and two completely lateralized flows have been differentiated (Dutt, 1981). The basalts are composed of pigeonite-augite andesine-labradorite, brown or green glass altering to palagonite, rarely olivine, and microcrystalline silica and magnetite. The intertrappean overlie granite. The laterites occur in the southwestern and southern part of the district and cover about 84,652 ha (8.7%) area. They occur as caps (50-60 m thick) over Deccan Traps in Zaheerabad and Narayankhed areas. Recent Alluvium occurs all along the rivers and *vagus* like Manjira, Haldi, Kundlair, Peddavagu, Mohedamada, Nakkavagu etc. They are colluvio-alluvial in nature (NBSS and LUP, 2005). Medak is predominantly an agricultural district with a large number of artificial lakes and the river Manjira.

The climate is semi-arid which is comparatively equitable and although it is very hot in May with mercury rising upto 42°C. The temperature dips to 12°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 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 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 methods used for soil sample analysis:

The division wise geo-referenced pedons were selected on the basis of soil heterogeneity and land forms in different locations of sugarcane growing areas of the district. Horizon wise soil samples were collected from the above representative pedons for laboratory analysis. Simultaneously, a total of 128 surface (0-15 cm) and 128 subsurface (15-30 cm) soil samples were collected in every three to five villages of each sugarcane growing mandals. The representative soil samples of the villages were characterized for important physical, physico-chemical properties using standard procedures. Particle size analysis was done according to International Pipette method (Piper, 1966), bulk density (Blake and Hartze, 1986), water holding capacity (Sankaram, 1966), soil pH and EC was determined in 1:2.5 soil water suspensions. organic carbon and free calcium carbonate were determined (Walkly and Black, 1934 and Piper, 1966), respectively. The available nitrogen was determined by kjeldal method, available phosphorus was estimated by spectrophotometer (Olsen method) and potassium by flame emission method (Jackson, 1973). Available sulphur in the soil was extracted using 0.15 per cent $CaCl_2$ solution (Williams and Steinbergs, 1959). The soils were characterized as per keys to soil taxonomy (Soil Survey

Staff, 2010).

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Soil morphology:

Morphological characteristics of the surface and subsurface soils of sugarcane growing areas of Medak district is presented in (Table 1). All the surface and subsurface soils of showed well developed structural variation and exhibited granular to sub angular blocky structure in surface and sub angular blocky to angular blocky in subsurface horizon. The variation in soil structure is a reflection of physiographic position (Singh and Agarwal, 2003) and Rao *et al*. (2008). The black soils developed from basalt and basaltic alluvium had sub angular to angular blocky structure (Singh and Mishra, 1996). The textural classes of the surface and subsurface soils are sandy loam, sandy clay loam, sandy clay to clay loam and clay. These variations are caused by topographic position, nature of parent material, *insitu* weathering, translocation of clay and age of soils. These results are in conformity with the findings of Raju *et al*. (2005) and Ram *et al*. (2010). Similar studies were made by Sitanggang *et al.* (2006); Mini *et al.* (2007) and Rao *et al*. (2008) and reported that, variations in texture were attributed to the topography, parent material characteristics, weathering phenomena and intensity and primarily age and translocation of clay in soils.

The consistence of the surface and subsurface soils was varied from loose to hard, very friable to firm, non-sticky, non-plastic to very sticky, very plastic in dry, moist and wet conditions, respectively (Kumar *et al*., 2001) Vertic properties like surface cracks were developed in the black soils might be due to presence exchangeable cations (Rajeshwar and Mani, 2013b). This soils distinguished by high amounts of swell-shrink clays resulting in deep, wide cracks in the dry seasons. Shrinking of the drying soil mass induces cracks which have a polygonal appearance. Vertically oriented cracks expose large blocks or prisms at the surface part of the soil. The cracks are wide, about 3 to 8 cm and become progressively deeper as the soil dries out. The surface soils show a self-mulching. The swell-shrink soils on wetting develop a characteristic micro relief consisting of low mounds and shallow depressions. Mild to strong effervescences were observed with dilute HCl test in all the surface and subsurface soils of sugarcane growing areas exept Zaheerabad division red laterite soils.

Physical properties:

Physical characteristics of the surface and subsurface soils is presented in (Table 2). The sand, silt and clay content ranges from 10.9 to 77.4 per cent, 4.0 to 23.1 and 15.8 to 77.9 per cent in surface soils, 10.1 to 74.7, 5.1 to 22.2 and 18.2 to 79.8 per cent in subsurface soils, respectively. The clay content was more in subsurface soils than surface soils. In red and red laterite coarse to medium texture was observed and fine texture was found in black soils. The texture of the soils varied from sandy loam to clay. The maximum clay content of 79.8 per cent was recorded in Narayankhed division soils, while minimum clay content 15.8 per cent was noticed in Sangareddy division soil. The maximum silt content of 23.1 per cent was noticed in Ramayampet division surface soils and minimum silt content of 4.0 per cent was noticed in Narayankhed division soils. The maximum sand content of 77.4 per cent was recorded in Sangareddy division soils, while minimum clay content 10.1 per cent was noticed in Sadasivpet division soils. Gravel was

Table A: Geological formations of Medak district

Formation	Age	Occurrence (Mandals)
Archaean gneisses	Lower precambrian	Nangnur, Chinnakodur, Siddipet, Dubbak, Mirdoddi, Ramayampet, Shankarampet (R), Chegunta, Daulatabad, Gajwel, Jagdevpur, Mulugu, Wargal, Tuphran, Shivampet, Yeldurthi, Medak, Papannapet, Shankarampet (A), parts of Kalher, Narayankhed, Regode, Alladurg, Andole, Raikode, Manur, Munipalli, Sadasivpet, Kondapur, Sangareddy, Patancheru, Ramachandrapuram, Jinnaram, Narsapur, Hatnura, Pulkal, Kowdipalli, Kulcharam and Tekmal
Deccan Traps	Mesozoic-lower tertiary	Parts of Zaheerabad, Kohir, Sadasivpet, Munipally, jharasangam, Nyalkal, Raikode, Andale, Alladurg, Regode, Narayankher, Manur, Kangti and Kalher
Laterites	Pleistocene-recent	Parts of Zaheerabad, Kohir, jharasangam, Munipalli and Nyalkal
Alluvium		All the mandals

observed in all the surface and subsurface soils and their distribution varied widely with soil types. The Gravel content ranges from 5.1 to 48.4 per cent in surface soils, 4.0 to 55.6 per cent in subsurface soils, respectively. The maximum Gravel content of 55.6 per cent was recorded in division Zaheerabad soils, while minimum Gravel content of 4.0 per cent was noticed in Narayankhed division soils. The bulk density of sugarcane growing soils of Medak district ranged from 1.32 to 1.65 Mgm^{-3} in surface soils, 1.34 to 1.69 Mgm^{-3} in subsurface soils at different moisture regimes, respectively.

The maximum bulk density content of 1.69 Mgm^{-3} was recorded in Jogipet divisions soils, while minimum Gravel content of 1.32 Mgm^{-3} was noticed in Shankarampet division soils. The bulk density values in surface soil were low when compared to sub surface samples. Lower bulk density values of surface soil might be due to loose and porous nature and organic matter content (Walia and Rao, 1996). The maximum water holding capacity ranges from 19.0 to 51.0 per cent in surface soils, 20.0 to 55.0 per cent in subsurface soils at different moisture regimes, respectively. The maximum water holding capacity of 55.0 per cent was recorded in Jogipet division soils, while minimum water holding capacity of 19.0 per cent was noticed in Zaheerabad division soils. Water holding capacity of the surface

Table 1 : Morphological characteristics of sugarcane growing soils of Medak district

Sr. No.	Division		No. of Villages	No of samples	Depth (cm)	Texture	Structure	Consistency			Efferve-scence	Pores	Roots
								Dry	Moist	Wet			
1.	Medak	3	14	14	0-15	scl toc	m2gr to m3abk	l to vh	fr to fi	ss to vs and vp	nil to ms	ff	mf to cf
				14	15-30	scl-c	f1sbk to m3abk	l to vh	fr to vfi	ss to vs and vp	nil to s	ff	ff to ff
2.	Zaheerabad	5	27	27	0-15	scl-c	f1gr to m3abk	l to vh	fr to fi	ss to vs and vp	nil to ms	ff	mf to cf
				27	15-30	scl-c	f2gr to m3abk	sh to vh	fr to vfi	ss to vs and vp	nil to s	ff	ff to ff
3.	Sangareddy	2	14	14	0-15	sl to c	m1gr to m1sbk	l to h	fr to fi	So and po to s and p	nil to ms	ff	mf to cf
				14	15-30	sl to c	m1sbk to m3 abk	sh to h	fr to vfi	Ss and sp	nil to ms	ff	ff
4.	Sadasivpet	3	13	13	0-15	scl-c	m1sbk to m2 sbk	vh to h	fr to fi	S and p to vs and vp	nil to ms	ff	mf to cf
				13	15-30	scl-c	m1sbk to c3 abk	vh to h	fr to vfi	ss to vs and vp	nil to s	ff	ff
5.	Narayankhed	4	20	20	0-15	sl to c	m1gr to c3abk	l to vh	fr to fi	ss to vs and vp	nil to ms	ff	mf to cf
				20	15-30	sl to c	m1sbk to c3abk	sh to vh	fr to vfi	ss to vs and vp	nil to s	ff	ff
6.	Jogipet	3	15	15	0-15	sl to c	m1gr to c1sbk	l to vh	fr to fi	ss to vs and vp	nil to ms	ff	mf to cf
				15	15-30	sl to c	m1sbk to c3abk	sh to vh	fr to vfi	ss to vs and vp	nil to s	ff	ff
7.	Dubbaka	2	5	5	0-15	sl to scl	f1 gr to m2 sbk	l to sh	fr to fi	So and po	nil to ms	ff	mf to cf
				5	15-30	sl to scl	m2 gr to m2sbk	l to sh	fr to fi	Ss and pp	nil to ms	ff	ff
8.	Narsapur	3	12	12	0-15	sl to cl	f1 gr to m2 sbk	l to sh	fr to fi	ss to s and p	nil to ms	ff	mf to cf
				12	15-30	sl to cl	m2 gr to m3abk	l to sh	fr to fi	ss to vs and vp	nil to ms	ff	ff
9.	Shankarampet	2	7	7	0-15	scl-c	m1sbk to m2 sbk	vh to h	fr to fi	S and p to vs and vp	nil to ms	ff	mf to cf
				7	15-30	scl-c	m1sbk to c3 abk	vh to h	fr to vfi	ss to vs and vp	nil to s	ff	ff
10.	Ramayampet	3	8	8	0-15	cl to c	m3sbk to c3 abk	vh to h	fi to vfi	s and p to vs and vp	ms to s	ff	mf to cf
				8	15-30	cl	m2sbk to c3 abk	vh to h	fi to vfi	Vs and vp to vs and vp	ms to s	ff	ff
	Total			256									

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
Cutans T-Argillans;tn-thin; p-patchy

Table 2 : Physical characteristics of surface and subsurface soils of sugarcane growing areas of the Medak district

Sr. No.	Division/ mandal/ vilages	No. of soil samples	Depth (cm)	Gravel (%)	Particle size distribution (%)			B.D Mgm^{-3}	MWHC (%)
					Sand	Silt	Clay		
1.	Medak	14	0-15	9.0-37.4	12.8-72.3	5.8-19.8	20.8-77.9	1.39-1.52	33.0-51.0
				(15.6)	(30.4)	(14.6)	(54.3)	(1.5)	(44.0)
		14	15-30	5.6-23.6	10.4-66.4	6.5-17.3	26.5-79.1	1.41-1.54	38.0-54.0
				(11.5)	(28.4)	(13.9)	(56.9)	(1.49)	(48.3)
2.	Zaheerabad	27	0-15	9.8-47.7	10.9-65.9	5.8-20.1	26.3-72.3	1.33-1.59	19.0-50.0
				(30.8)	(44.8)	(11.1)	(43.5)	(1.4)	(30.7)
		27	15-30	6.6-55.6	9.6-63.6	6.1-19.4	29.9-73.2	1.34-1.61	21.0-53.0
				(31.3)	(43.4)	(11.3)	(44.9)	(1.4)	(34.2)
3.	Sangareddy	7	0-15	9.6-33.3	15.4-77.4	6.3-18.2	15.8-49.9	1.32-1.51	23.0-49.0
				(19.4)	(54.5)	(10.3)	(34.7)	(1.4)	(35.6)
		7	15-30	9.1-36.6	13.9-74.7	6.1-18.4	19.6-67.2	1.34-1.53	24.0-51.0
				(20.5)	(52.3)	(9.9)	(37.2)	(1.4)	(38.7)
4.	Sadasivpet	13	0-15	9.4-33.1	12.3-69.3	4.8-18.7	25.5-76.5	1.41-1.54	32.0-51.0
				(14.4)	(27.1)	(14.1)	(58.2)	(1.5)	(43.4)
		13	15-30	8.4-35.4	10.1-67.1	5.8-18.6	26.4-79.8	1.42-1.56	40.0-55.0
				(13.2)	(25.3)	(14.3)	(59.9)	(1.5)	(48.1)
5.	Narayankhed	20	0-15	5.1-39.4	11.1-76.4	4.0-22.6	16.1-69.6	1.35-1.58	22.0-48.0
				(16.9)	(39.7)	(12.4)	(47.3)	(9.2)	(37.0)
		20	15-30	4.0-40.3	10.2-73.3	5.1-21.3	20.5-72.9	1.38-1.59	23.0-54.0
				(16.6)	(38.1)	(12.8)	(48.6)	(1.5)	(39.7)
6.	Jogipet	15	0-15	9.4-48.4	12.8-75.8	5.2-19.2	16.8-67.3	1.36-1.65	23.0-47.0
				(32.2)	(51.1)	(25.1)	(56.9)	(15.0)	(49.8)
		15	15-30	6.5-51.5	12.4-74.2	5.6-20.3	18.2-67.9	1.40-1.69	26.0-55.0
				(31.3)	(49.8)	(25.2)	(58.7)	(15.1)	(52.5)
7.	Dubbaka	5	0-15	26.4-48.4	61.9-76.2	5.6-6.3	18.2-31.2	1.33-1.48	18.0-29.0
				(35.2)	(71.3)	(6.1)	(22.2)	(1.4)	(22.0)
		5	15-30	29.1-52.3	59.4-73.4	5.9-6.9	19.5-32.4	1.43-1.51	21.0-32.0
				(38.0)	(69.3)	(6.3)	(23.3)	(1.4)	(25.8)
8.	Narsapur	12	0-15	9.4-38.4	39.6-74.6	5.1-18.6	19.5-45.8	1.33-1.55	19.0-42.0
				(25.5)	(61.6)	(8.1)	(29.7)	(1.4)	(29.6)
		12	15-30	6.6-41.5	38.1-73.2	5.5-17.3	20.6-47.1	1.42-1.57	20.0-49.0
				(26.8)	(59.3)	(8.5)	(31.6)	(1.5)	(32.8)
9.	Shankarampet	7	0-15	9.6-33.6	16.4-61.3	8.4-17.7	28.1-66.6	1.32-1.55	30.0-49.0
				(19.1)	(35.2)	(13.9)	(50.3)	(1.5)	(42.0)
		7	15-30	6.8-35.4	15.2-59.9	8.3-19.6	31.6-67.4	1.36-1.57	33.0-54.0
				(18.8)	(33.7)	(14.1)	(51.7)	(1.5)	(45.4)
10.	Ramayampet	8	0-15	8.9-18.4	16.5-41.2	11.2-23.1	38.7-64.3	1.46-1.61	39.0-47.0
				(11.8)	(25.8)	(18.1)	(55.3)	(1.5)	(42.8)
		8	15-30	6.4-12.6	14.6-42.3	11.1-22.2	40.1-62.5	1.44-1.55	44.0-50.0
				(9.3)	(24.4)	(18.0)	(56.7)	(1.5)	(48.0)
Overall range			0-15	5.1-48.4	10.9 -77.4	4.0-23.1	15.8-77.9	1.32-1.65	19.0-51.0
Mean				(22.1)	(44.1)	(13.4)	(45.2)	(3.6)	(37.7)
			15-30	4.0-55.6	10.1-74.7	5.1-22.2	18.2-79.8	1.34-1.69	20.0-55.0
				(21.7)	(42.4)	(13.4)	(46.9)	(2.8)	(41.3)

The data in parenthesis ( ) indicate the average values

horizons ranged from 21.8 to 49.8 per cent, these differences were due to the variation in the depth and clay, silt and organic carbon content (Rajeshwar *et al*., 2009).

Physico-chemical properties:

Physico-chemical properties of the surface and subsurface soils are presented in (Table 3). All the soil samples studied were extremely acidic to moderately alkaline in reaction. The soil pH in surface and subsurface soils ranged from 4.60 to 8.86 and 4.40 to 8.89, respectively. The lowest pH (4.40) was recorded in Zaheerabad soil which might be due to accumulation of exchangeable H^+, Al^{3+}, Fe and Al oxides, soil organic matter and clay minerals (Deka *et al.,* 2009). The highest pH values (8.89) were noticed in Jogipet division soil. Increase in pH was observed in almost all subsurface soils caused by an increase in $CaCO_3$ with depth. Similar results were observed by Rajeshwar and Mani (2013a and b) and stated that the parent materials, rainfall and topography, were greatly influenced by the characteristics and behaviour of soil environs. The E.C of sugarcane growing soils of Medak district ranges from 0.09 to 0.46 dS m^{-1} in surface soils, 0.11 to 0.45 dS m^{-1} in subsurface soils, respectively. The maximum E.C of 0.46 dS m^{-1} was recorded in division of Narayankhed soils, while minimum E.C of 0.09 dS m^{-1} was noticed in division of Zaheerabad soils. The low amount of soluble salts in surface and subsurface soils could be attributed to loss of bases (Sidhu *et al.,* 1994) due to heavy rainfall. The organic carbon content was found to be low to high (4.1 to 8.3 g kg^{-1} and 3.0 to 7.4 g kg^{-1}) in surface and subsurface soils of all the divisions. Higher organic carbon content was recorded in surface soils as compared to subsurface soils. The soil organic carbon decreased with increase in depth. The general decrease in organic carbon content with depth could be due to organic matter accumulation in the surface soil as a result of nutrient recycling by biomass (Varaprasad Rao *et al.,* 2008 and Rajeshwar and Mani, 2014).

Soil fertility status:

The available macronutrients status of the surface and subsurface soils is presented in (Table 3). The available nitrogen status was found to be low (240.0 to 328.0 kg ha^{-1} and 161.0 to 264.0 kg ha^{-1}) in all the division of surface and subsurface soils. However, available N content of all the above soils was found to be more in surface soils and decreased in sub surface soils which might possibly be due to decreasing organic carbon with depth.These observations are in accordance with the findings of Prasuna Rani *et al*. (1992) and Panwar *et al*. (2011). The semi-arid condition of the area might have favoured rapid oxidation and lesser accumulation of organic matter releasing NO_3-N which could have been lost by leaching (Finck and Venkateswarlu, 1982). The reason for the maximum available nitrogen content observed in the surface could be attributed to the fact that cultivation of crops are mainly confined to the surface horizon (Rhizosphere) only and at regular interval the depleted nitrogen content is supplemented by the external addition of fertilizers during crop cultivation (Rajeshwar and Mani, 2014).

The available phosphorus status was found to be medium to high in surface soils (16.0 to 41.0 kg ha^{-1}) and low to high in subsurface soils (10.0 to 34.0 kg ha^{-1}) in all the division of surface and subsurface soils, respectively. All the surface and subsurface soils showed a decreasing trend with the depth. Decrease in available phosphorus is attributed to decrease in organic matter content with increase in depth. Similar results were reported by Varaprasad Rao *et al*. (2008). The reason for higher P in surface soils might possibly be the confinement of crop cultivation to the rhizosphere and supplementing of the depleted phosphorus through external fertilizers. Similar results were reported by Rajeshwar and Mani (2014). Thangasamy *et al*. (2005) also reported that lower availability of phosphorus was due to the fixations of released P by clay minerals and oxides of Fe and Al. The available potassium was high (261.0 to 457.0kg ha^{-1}) in surface soils of all divisions whereas in subsurface soils it was medium to high (169.0 to 399.0 kg ha^{-1}). In the present study, all the surface and subsurface soil samples showed a consistent and gradual decreases available K with increasing depth. The available K status was more in surface soils which could be attributed to release of labile-K from organic residues, application of K fertilizers and upward translocation of K from lower depths along with capillary rise of ground water. Similar results were reported by Pal and Mukhopadyay (1992).

Major soil constraints :

Soil constraints were identified using soil test data (Table 4) which include texture, erosion, slope, depth, drainage and low organic carbon, low availability of N, P and micronutrients. Similar observations were made

Table 3 : Physico-chemical and available nutrient status of surface and subsurface soils of sugarcane growing areas of the Medak district

Sr. No.	Division	No. of soil samples	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Available macronutrients ($kg\ ha^{-1}$)		
							N	P	K
1.	Medak	14	0-15	7.58 - 7.91	0.24 - 0.27	4.2 - 8.1	243.0 - 305.0	21.0 - 39.0	290.0 - 428.0
				(7.70)	(0.26)	(6.05)	(278.7)	(30.5)	(357.0)
		14	15-30	7.64 - 7.93	0.36 - 0.45	3.6 - 6.9	169.0 - 264.0	19.0 - 34.0	169.0 - 368.0
				(7.75)	(0.27)	(5.24)	(191.3)	(26.1)	(290.1)
2.	Zaheerabad	27	0-15	4.60 - 7.60	0.09 - 0.27	4.4 - 7.4	243.0 - 326.0	16.0 - 39.0	262.0 - 426.0
				(6.38)	(0.18)	(5.8)	(275.1)	(27.6)	(336.7)
		27	15-30	4.40 - 7.70	0.14 - 0.32	3.2 - 6.6	177.0 - 256.0	11.0 - 27.0	182.0 - 314.0
				(6.42)	(0.18)	(4.9)	(201.9)	(19.9)	(241.3)
3.	Sangareddy	7	0-15	7.03 - 7.23	0.22 - 0.24	4.6 - 6.7	263.0 - 322.0	26.0 - 33.0	262.0 - 431.0
				(6.99)	(0.22)	(5.5)	(285.0)	(28.1)	(355.3)
		7	15-30	7.40 - 7.55	0.26 - 0.34	3.9 - 6.1	179.0 - 241.0	16.0 - 24.0	198.0 - 337.0
				(7.24)	(0.22)	(4.6)	(212.7)	(18.9)	(264.4)
4.	Sadasivpet	13	0-15	7.25 - 7.82	0.19 - 0.26	4.8 - 6.9	240.0 - 328.0	18.0 - 41.0	271.0 - 454.0
				(7.50)	(0.22)	(5.7)	(291.4)	(26.1)	(381.9)
		13	15-30	7.60 - 7.90	0.25 - 0.38	3.9 - 5.2	184.0 - 241.0	14.0 - 27.0	196.0 – 399.0
				(7.70)	(0.21)	(4.6)	(199.6)	(17.5)	(307.2)
5.	Narayankhed	20	0-15	5.54 - 8.04	0.16 - 0.45	4.9 - 8.2	245.0 - 314.0	18.0 - 36.0	261.0 - 452.0
				(7.32)	(0.20)	(6.4)	(277.3)	(22.0)	(388.9)
		20	15-30	6.94 - 8.05	0.18 - 0.46	3 - 7.2	174.0 - 213.0	14.0 - 21.0	191.0 - 396.0
				(7.36)	(0.21)	(5.0)	(189.7)	(17.8)	(293.0)
6.	Jogipet	15	0-15	7.00 - 8.34	0.15 - 0.32	4.8 - 8.3	264.0 - 259.0	18.0 - 33.0	268.0 - 457.0
				(7.9)	(0.18)	(6.9)	(278.7)	(25.0)	(370.7)
		15	15-30	7.01 - 8.38	0.16 - 0.39	3.7 - 7.1	161.0 - 211.0	13.0 - 26.0	206.0 - 364.0
				(7.9)	(0.20)	(5.7)	(200.1)	(18.1)	(272.7)
7.	Dubbaka	5	0-15	5.55 - 5.70	0.12 - 0.31	4.4 - 6.0	261.0 - 294.0	24.0 - 31.0	271.0 - 399.0
				(5.6)	(0.21)	(5.1)	(279.8)	(26.8)	(333.0)
		5	15-30	5.69 - 5.70	0.14 - 0.36	3.9 - 5.4	168.0 - 199.0	15.0 - 22.0	194.0 - 312.0
				(5.7)	(0.22)	(4.4)	(188.2)	(19.6)	(226.4)
8.	Narsapur	12	0-15	6.99 - 7.69	0.16 - 0.32	4.1 - 5.8	259.0 - 298.0	16.0 - 28.0	261.0 - 443.0
				(7.4)	(0.22)	(5.2)	(277.9)	(21.5)	(364.7)
		12	15-30	7.01 - 7.73	0.19 - 0.39	3.4 - 4.9	174.0 - 231.0	10.0 - 19.0	232.0 - 381.0
				(7.4)	(0.19)	(4.1)	(196.5)	(15.6)	(295.0)
9.	Shankarampet (A)	7	0-15	7.29 - 7.38	0.22 - 0.23	4.6 - 7.8	263.0 - 305.0	20.0 - 32.0	275.0 - 422.0
				(7.3)	(0.22)	(6.2)	(278.9)	(26.7)	(355.7)
		7	15-30	7.32 - 7.41	0.24 - 0.31	4.1 - 6.4	204.0 - 236.0	15.0 - 26.0	214.0 - 382.0
				(7.4)	(0.24)	(5.0)	(216.4)	(20.3)	(274.4)
10.	Ramayampet	8	0-15	5.88 - 8.13	0.16 - 0.28	5.1 - 7.0	256.0 - 296.0	14.0 - 36.0	261.0 - 448.0
				(7.1)	(0.25)	(5.8)	(276.6)	(24.8)	(367.9)
		8	15-30	6.07 - 8.09	0.20 - 0.32	4.2 - 5.8	164.0 - 234.0	11.0 - 29.0	201.0 - 368.0
				(7.2)	(0.26)	(5.0)	(201.9)	(19.8)	(266.6)
Overall range			0-15	4.60 - 8.86	0.09 - 0.45	4.1 - 8.3	240.0 - 328.0	16.0 - 41.0	261.0 - 457.0
Mean				(7.13)	(0.21)	(5.89)	(280.0)	(25.9)	(361.2)
			15-30	4.40 - 8.89	0.11 - 0.46	3.0 - 7.4	161.0 - 264.0	10.0 - 34.0	169.0 - 399.0
				(7.21)	(0.22)	(4.86)	(199.8)	(19.4)	(273.1)

The data in parenthesis ( ) indicate the average values

by Reddy *et al*. (1998) and Fransis *et al*. (1983). Major soil constraints for crop production and recommendations based on limitations were discussed below.

Soil constraints and management options for sugar cane growing red soils :

Major constraints for crop production in red soils are shallow (pedon 10) to moderately deep with coarse loamy texture, slope, erosion, high coarse fragments, low to medium OC, low availability of N and Zn (pedon 10 and 11). As the rainfall is high during rainy season, runoff and erosion are the main problems. Improved soil management practices by green manuring, application of organic manures such as farmyard manures, composted coir pith; pressmud at 25 t ha^{-1} per year conserves soil moisture and crop rotation with legumes to enhance the crop productivity on these soils. These soils are deficient in nutrients like N followed by Zn. High soil productivity could be achieved by enrichment of organic matter and maintenance of enhanced soil fertility.

Soil constraints and management options for sugar cane growing black soils:

Major constraints for crop production in sugar cane growing soils are very deep soils, calcareous, clayey and poorly drained with slow permeability and low hydraulic conductivity. Leaching of soluble weathering products were limited hence, the contents of available calcium and magnesium were high. The pH was above 8.0 with low to medium availability of N. Soils have swell shrink characteristic and cracks during summer. The moisture retention capacity of the soil was high. The early rainfall enters into the soils through cracks and once the cracks are closed the water stagnation occurs due to slow permeability. As the rainfall is high during rainy season, runoff and erosion are the main problems. Soils are prone to water erosion due to their slow infiltration. Once the soil is thoroughly wetted and the cracks are closed the rate of water infiltration becomes almost zero. These

Table 4 : Comparative evaluation of productivity of soils in the study area along with the management options

Soil type	Suitability	Major limitations	Management suggested
Black soils	Moderately suitable to highly suitable	Drainage, texture, runoff, erosion and high $CaCO_3$, high pH in subsurface horizon	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; 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.
Red soils	Marginally suitable to Moderately suitable	Depth, Slope, Erosion, Texture, Coarse fragments, OC, Low N and low Zn	Application of black soils/ tank silt; pre monsoon sowing of green manures; application of farmyard manure, composted coir pith or press mud at 25 t ha^{-1} per year and crop rotation. Follow site-specific nutrient management;Application of black soils/ tank silt; 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 to overcome the nutrients deficiencies.
Red laterite soils	Marginally suitable to Moderately suitable	Texture, slope, Low WHC, Moderately acidic, coarse fragments, OC, Low N ,Sub surface hardening, insitu crusting, indurate laterite layer, massive and tough	Deep ploughing, sub-soiling or chiseling up to a depth of 50 - 75 cm at 90 cm; Application of black soils/ tank silt; application of Lime (1.0-1.5 t ha^{-1}); application of FYM enriched rock phosphate and zinc sulphate; Green manuring; application of organic manures; application of bio char @ 5 -10; maintenance of surface pH; split application of nitrogen to reduce leaching; use lower rates of less acidifying fertilizers; avoid acidifying fertilizers such as mono ammonium phosphate or sulphate of ammonia; crop rotation with legumes. Follow site-specific nutrient management.

soils need proper surface drainage during rainy season. As the available moisture capacity of the surface and subsurface soils was high, the soils have potential for double cropping. Improved management practices have good potential to enhance productivity on these soils. Some of these soil management suggested are:

Addition of river sand @ 100 t ha^{-1} and application of 100 cart loads of red loam soil ha^{-1} deep ploughing with mould board plough or disc plough during summer can be recommended to enhance the infiltration and percolation. To overcome the problem of water logging during rainy season, the broad bed and furrow system is suggested. Broad bed and furrow system manage the surface drainage during rainy season cropping. The raised beds should be 1.2 m wide and 15 cm high with two furrows of 30 cm width on either side to drain out excess water. The broad bed and furrow system needs a graded slope of land, 0.8 to 2.0 per cent and it should be formed across the slope. The furrows should lead to a main drain at the end of the field. Pre- monsoon sowing of green manures and incorporation at flowering stage will enhance the nitrogen availability and improves the soil physical, chemical and biological environment. Application of farmyard manure or pressmud @ 25 t ha^{-1} $year^{1}$ conserves soil moisture, adds micronutrients, enhances aeration and improves the soil physical properties; crop rotation with legume crops tend to take up more cations in proportion to anions which aids in reduction of soil pH.

Soil constraints and management options for sugar cane growing red laterite soils:

The soil constraints for sugar cane in red laterite soils were light to medium in surface texture, shallow, moderately deep to deep rooting depth and gravelliness with kaolinite clay mineralogy resulting in poor water holding capacity. Surface crusting is common problem in this soil. The low water holding capacity does not permit post-rainy season cropping without irrigation. They are denuded and subject to serious erosion problems. Intensive leaching causes nutrient losses and release of free iron and aluminum oxides. The free iron and aluminum causes toxicity and nutrient imbalances in terms of N, K, P and Zn. Due to low pH of these soils, acidification causes P fixation with Fe or Al ions and hydroxides resulting in deficiency of phosphorus in the form of insoluble compound of $Al_2(H_2PO_4)_3$ and FeH_2PO_4; reduced availability of K, Ca, Mg and toxicity due to high availability of Mn, Fe, B and Mo. Improved management practices have good potential to enhance productivity on these soils. The soil management suggestions given are:

Application of lime is the most effective remedy for soil acidity. It is the only cost-effective option for acidic agricultural soils. Liming may result in substantial crop yield responses for several years, as well as allowing or improving crop production. Recommended quantity of FYM with enriched rock phosphate and zinc sulphate has to be applied to enhance the phosphorus and zinc use efficiency and maintain the soil quality; pre-monsoon sowing of green manures and incorporation at flowering stage will enhance the nitrogen availability and reduce surface crusting problem by creating favourable soil physical environment. Application of organic manures such as farmyard manure, composted coirpith or pressmud @ 25 t ha^{-1} per year conserves soil moisture, adds micronutrients, enhances aeration and improves the physical properties of the soil, therefore, 15-20 tonnes of well decomposed farmyard manure is added while preparing the land a month before sowing the seed.

Maintenance of surface pH above 6.5 is essential in acidic soils for optimum soil productivity. More than one application of 1.0-1.5 t/ha of lime is likely to be required over a number of years. Application of higher rates of lime (2-5 t/ha) to reach the desired surface pH may expose crops to nutrient deficiencies, particularly manganese and zinc. Rising of soil pH decreases the level of available aluminum and manganese in the soil and at the same time increases the availability of phosphorus, magnesium, calcium and molybdenum. To overcome the leaching of nitrogen, split application of nitrogen fertilizers along with phosphorus and Zn for maximizing the crop yield; can be recommended use lower rates of less acidifying fertilizers; application of acidifying fertilizers such as mono ammonium phosphate or sulphate of ammonia to be avoided. Continuous cultivation of legumes crops in acid soils tend to take up more cations in proportion to anions. As a consequence, H^+ ions are excreted from their roots to maintain the electrochemical balance within their tissues. This leads to a rise in soil acidification. Hence, crop rotation with cereals crop is mandatory.

Literature Cited

Blake, G. R. and Hartze, K.H. (1986). Bulk density In: *Methods of soil analysis* part I(Ed A Klute). American Society of

Agronomy Incorporation Wisconsin USA. pp. 377-382.

Centre for Monitoring Indian Economy (2014). Assistant Cane commissioner, Nizam Deccan Sugars Ltd, Sangareddy, Medak 2013-2014. Mandal Wise Plant, Ratoon areas, pp. 1-25.

Deka, Bipul, Baruah, T.C., Dutta, Marami and Karmakar, R.M. (2009). Landscape-soil relationships and pedogenic evaluation of soils in Ghiladhari watershed of the Brahmaputra valley of Assam. *J. Indian Society Soil Sci.,* **57** (3): 245-252.

Dutt, N.V.B.S.(1981). Geology and mineral resources of Andhra Pradesh, Ramesh Printers and Publishers, Hyderabad, India.

Fransis, C., Peter, R., Marion, B., Kell, C.M., Raymond, D. and Priscilla, R. (1983). In resource inventory and base line study methods for developing countries. *American Association of Advancement of Science*, Washington pp. 189-345.

Finck, A. and Venkateswarlu, J. (1982). Chemical properties and fertility management of Vertisols: In: *Vertisols and rice soils on the tropics, Symposia of* 12th *International Congress of Soil Science,* New Delhi, held on 8-16 February.

Jackson, M.L. (1973). *Soil chemical analysis* – Oxford IBH Publishing House, Bombay, pp. 38.

Kumar, S., Padole, L.M. and Patel, N.R. (2001). Pedogenic characterization and productivity of some lateritic soils developed on different geomorphic conditions. *Agropedology,* **11**: 37-44.

Mini, V., Patil, P.L. and Dasog, G.S. (2007). Characterization and classification of soils of Pilot site in coastal agro-ecosystem of North Karnataka. *Agropedology,* **17**(1): 59-67.

National Bureau of Soil Survey and Land use Planning (2005). Soils of Andhra Pradesh for optimizing land use NBSS and LUP (ICAR), Nagpur, India.

Pal, S.K. and Mukhopadyay, A.K. (1992). Distribution of different forms of potassium in profiles of some Entisols. *J. Indian Society of Soil Sci.,* **40**: 371- 373.

Panwar, N.R., Totawat, K.T.S., Shyampura, R.L. and Rathore, A. (2011). Distribution of nutrients in relation to properties of salt affected soils of Southern Rajasthan.*Agropedology,* **21** (1) : 35-39.

Piper, C.S. (1966). *Soil and plant analysis.* Inter Science Publication. Inc. New York, U.S.A.

Prasuna Rani, P., Pillai, R.N., Bhanuprasad, V. and Venkata Subbaiah, G.V. (1992). Clay mineralogy of Alfisols and associated soils of Kavali area under Somasila project in Andhra Pradesh. *J. Indian Society of Soil Sci.,* **4** : 893-896.

Rajeshwar, M., Aariff Khan, M.A. and Ramulu, V. (2009). Characterization and classification of soils of Ganapavaram pilot area of Nagarjuna Sagar Left Canal Command area of Andhra Pradesh. *Internat. J. Tropical Agric.,* **27**: 1-7.

Rajeshwar, M. and Mani, S. (2013a). Soil quality assessment in red laterite soils of Chettinad of Sivagangai district of Tamil Nadu. *An Aisan J. Soil Sci.,* **8** (1): 25-33.

Rajeshwar, M. and Mani, S. (2013b). Soil quality assessment in black soils of Veppanthattai Sivaganga district of Tamil Nadu. *An Asian J. Soil Sci.,* **8**(1): 108-121.

Rajeshwar, M. and Mani, S. (2014). Nutrients status in the surface and subsurface soils of dryland Agricultural Research Station at Chettinad in Sivaganga district of Tamil Nadu. *Asian J. Soil Sciences*, **9** (2): 169-175.

Raju, D.B., Naidu, M.V.S., Ramavatharam, N., Venkaiah, K., Rao, G.R. and Reedy, K.S. (2005). Characterization, classification and evaluation of soils in Chandragiri mandai of chittoor district, Andhra Pradesh. *Agropedology*, **15**: 55-62.

Ram, D., Ram, T. and Subhash, C. (2010). Characterization and classification of flood-prone soils of Eastern plains of Rajasthan for their corrective measures. *J. Indian Society of Soil Sci.,* **58**(2): 228-232.

Rao, A.P.V., Naidu, M.V.S., Ramavatharam, N. and Rao, R.G. (2008). Characterisation, classification of soils of different land farms in Ramachandrapuram mandal of Chittoor district in Andhra Pradesh for sustainable land use planning. *J. Indian Society of Soil Sci.,* **56** (1): 23-33.

Reddy, R.S., Shiva Prasad, C.R., Harinadranath, C.S., Venugopal, K.R., Roy, S.K., Nagaraju, M.S.S., Datta, D., Bhaskar, B.P and Ramesh, M. (1998). Assessment of soil degradation in Andhra Prasad. *J. Indian Society of Soil Sci.,* **46** (2) : 278-283.

Sankaram, A. (1966). *A laboratory manual for agricultural chemsitry*. Published by Jaya Singer, Asia Publishing House, Bombay, pp. 56-57.

Sidhu, P.S., Raj Kumar and Sharma, B.D. (1994). Characterization and classification of Entisols in different soil moisture regimes of Punjab. *J. Indian Society of Soil Sci.,* **42** (4) : 633-640.

Singh, I.S. and Agrawal, H.P. (2003). Characterization and classification of some rice growing soils of Chandauli district of Uttar Pradesh. *Agropedology,* **13**: 11-16.

Singh, V.N. and Mishra, B.B. (1996). Pedogenic characterization of some typical soils of Gandak command area of Bihar for evaluation of land suitability. *J. Indian Soc. Soil Sci.,* **44**:136-142.

Sitanggang, M., Rao, Y.S., Ahmed, N. and Mahapatra, S.K. (2006). Characterization and classification of soils in watershed area of Shikohpur, Gurgaon district, Haryana. *J. Indian Society of Soil Sci.,* **54** : 106–110.

Soil Survey Staff (2010). *Keys to soil taxonomy*. U.S. Dept. Agric., Natural Resources Conservation Service, Washington D.C. Oxford & IBH Publishing Co., New Delhi, India.

Thangasamy, A.,Naidu, M.V.S., Ramavatharam, N. and Raghava Reddy, C. (2005). Characterization, classification and evaluation of soil resources in Sivagiri micro watershed of Chittoor district in Andra Pradesh for sustainable land use planning. *J. Indian Society of Soil Sci.,* **53**(1): 11-21.

Varaprasad Rao, A.P., Naidu, M.V.S., Ramavatharam, N. and Rama Rao, G. (2008). Characterization classification and evaluation of soils on different landforms in Ramachandrapuram Mandal of Chittoor district in Andra Pradesh for sustainable land use planning. *J. Indian Society of Soil Science,* **56** : 23-33.

Walia, C.S. and Rao, Y.S. (1996). Genesis, characteristics and taxonomic classification of some red soils in Bundelkhand region of Uttarpradesh. *J. Indian Society of Soil Sci.,* **44**(3): 476-481.

Walkely, A.J. and Black, C.A. (1934). An estimation of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science,* **37**: 29-38.

Williams, C.H. and Steinbergs, A. (1959). *In: Methods of analysis of soils, plants, waters and fertilizers*. FDCO, New Delh, pp. 58.

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