Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 409-416
Received: 16-01-2018
Accepted: 17-02-2018

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Land use options and site suitability for sugarcane growing red soils, red laterite soils and black soils of Medak district of Telangana

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Abstract
A reconnaissance soil survey was undertaken in sugarcane growing soils of Medak district of Telangana to evaluate the soil suitability characteristics for developing the strong soil resource database for proper appraisal of their productivity potential and their rational use. This study was an embodiment with an objective of land use options and crop suitability of some sugarcane growing red soils, red laterite soils and black soils. Land capability classification was done based on the inherent soil characteristics, external land features and environmental factors. The red and red laterite soils of sugarcane cane growing area fall under one land capability class with three subclasses, *viz.*, 'III stef' and 'III tsdef' due to the limitations of slope, texture, soil depth, coarse fragments and soil fertility. The black soils fall under 'III swef' land capability sub-class due to the limitations of drainage, texture, erosion and soil fertility. Four fertility capability units were identified in the study area. The conditions modifiers identified in the study area were'd' dryness, 'v' high clay content, 'b' basic reaction, and 'h' acid but not Al-toxic. The condition modifier'd' dominated in its occurrence followed by the condition modifier 'h', 'v' and 'b'. The land evaluation for crop suitability indicated that the black soils were moderately suitable to highly suitable, red soils were marginally to moderately suitable and red laterite soils are marginally suitable for cultivation of sugarcane. Soil productivity can be improved by maintenance of enhanced soil fertility, addition of organic matter, proper drainage facilities, reduced sub surface crusting and erosion control practices.

Keywords: Land use options; Crop suitability of some Red Soils; Red Laterite soils and Black Soils of sugarcane growing area

1. Introduction
Telangana state being under semi-arid tropical monsoon climate has a number of soil types which are to be managed on a sustainable basis is the need of the hour. Among the district of Telangana state, Medak has the considerable area under sugarcane cultivation. The sugar cane cultivated in the district in an area of 22076.0 hectares (Nizam Deccan Sugars Ltd, 2013-14).
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 (Appendix I). Each of above factor have definite role to play in behavior of soil and its management. The land capability classification consists of three categories namely i) capability classes' ii) capability sub-classes and iii) capability units. In all eight capability classes, class I, II, III and IV were suitable for cultivation and class- V, VI, VII were unsuitable for cultivation but suitable for permanent vegetation (grazing). The capability sub classes are based on kind of dominant limitation such as wetness or excess water (w), climate (c), soil(s), erosion (e) and topography (t). The capability unit includes soils which are sufficiently uniform in their characteristics. Potential and limitations and require fairly uniform conservation treatments and management practices.
Soil site suitability studies provide information on the choice of crops to be grown on best suited soil unit for maximizing crop production per unit land, labour and inputs. For planning and effective utilization of soil resources, the information relating to soil site and characteristic for cultivation of crops is necessary. Each plant species require specific soil-site condition for its optimum growth. For rationalizing land use, the soil site suitability for different crops needs to be determined. These suitability models provide guidelines to decide the policy of growing most suitable crops depending on the capacities of each soil unit (Sehgal, 1986) [11]. It has become imperative that the land resources need to be intensified in terms of their suitability for

different agricultural uses with a view to maximize production of food, fuel and fiber.

The concept of soil Fertility Capability Classification (FCC) system was developed as an attempt to bridge the gap between sub-disciplines of soil classification and soil fertility especially to interpret Soil Taxonomy and additional soil attributes in a way that is directly relevant to the plant growth. Soil fertility parameters are mostly found in topsoil and have been listed to form the FCC system and this classification system was proposed by Buol *et al*. (1975) and modified by Sanchez *et al*. (1982). The FCC is a classification of soils on the basis of fertility constraints, quantified from condition modifiers.

Most of the studies conducted earlier were only broad based and were conducted as a part of their study of soils of country or state. So, it is essential to understand the land suitability for certain crops at block and district levels which provide the representative information of that region. Considering this fact with a view to assess the site specific constraints and provide potential for development and remediation, the present study is planned to take sugarcane growing area of Medak district as a unit. Approach is in consonance with the land use planning and land resources are systematically accounted and prepared a resource inventory, which act as ready reference reckoned for any planning activity for the development and improvement of sugarcane growing soil and land resources further. The entire study work encompass in accounting of the soil and land resources, which is providing a medium for the crop growth. Systematic study of sugarcane growing soils is essential for their better management and productivity.

Location, climate and brief discussion of the study area

Materials and methods

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. 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.

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 division wise geo-referenced pedons (Table 1) 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 representative fourteen pedons for laboratory analysis. A composite sample of about 1kg was taken through mixing of representative soil samples. The soil samples were air-dried in shade, processed and screened through a 2 mm sieve. Particles greater than 2mm were considered as gravel. After sieving, all the samples were packed in the polythene bags for determination of physical, and physico-chemical and chemical properties by using the standard procedures.

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 the land. The land capability is mainly based on the inherent soil characteristics, external land features and environmental factors. Land capability classification was done keeping in view of soil limitations and other soil related parameters like texture, depth, slope, erosion, drainage, and nature of the substrata (Klingebiel and Montgomery 1961) [3]. The criteria used for land capability classification are presented in table 2 (Sehgal 1996). Each soil pedon was interpreted in relation to soil- site suitability of major crops of the area. The soil related characters viz., topography (t) and drainage (d) are interrelated for assessing the suitability of particular land for different crops (Sys *et al.*1993) [13] to prepare an action plan has been suggested for land use planning.

The suitability of a given piece of land is its natural ability to support a specific purpose. Soil site suitability classification for sugarcane crop was done for the study area by following the framework of land evaluation (FAO, 1976) based on the land suitability structure viz,. Suitable (S) and Non Suitable (NS). Based on the criteria developed by Naidu *et al*. (2006) [5] soil site suitability were assessed for the study area for growing rice, maize, sorghum, pulses, groundnut, soybean and cotton. Soil constraints for crop production were identified based on the laboratory and field analysis of the soil (Table.4)

Results and discussion

Land Capability Classification

Based on soil properties, the red soils, red laterite soils and black soils were classified into land capability classes III. Similar observations were also made by Sarkar *et al.* (2002) [10]. Pedon wise land capability classification of the sugarcane growing soils of Medak district is given in table 3. The red and red laterite soil pedons (2, 3, 4, 5, 6, 8, 10, 11, 13 and 14) were classified into 'III tsef' land capability sub-class due to the limitations of slope, texture, soil depth, erosion and soil

fertility whereas the pedon 10 classified as 'III tsdef' capability sub-class due to the limitations of slope, texture, soil depth, severe erosion, coarse fragments and soil fertility limitations. The pedon 1, 7, 9 and 12 classified into 'III swef' land capability sub-class due to the limitations of drainage, texture, erosion and soil fertility limitations. Similar interpretation was also made by Rajeshwar and Mani, (2013) [7, 8].

Soil Site Suitability Evaluation for Sugarcane

The studied sugar cane growing soils vary in their suitability, according to the criteria for the determination of land suitability classes (Table 5 and 6). The suitability for sugarcane cultivation in black soil pedons (1, 7, 9 and 12) were found moderately suitable to highly suitable with limitation of poor drainage 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 cart loads 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.

Soil site suitability in red soils indicated that study area was found marginally to moderately suitable (pedon 8, 10, 11, 13 and 14) for sugar cane cultivation. However fertility related constraints can be managed through appropriate fertilizer management practices. Slope, texture, depth, fertility, erosion and surface crusting were the major limitations. Therefore to realize the full potential, these soils should be properly managed, supplemented with organic manures and inorganic fertilizers and to be provided with assured irrigation. If these improvements could be done, the marginally suitable land could be converted to the moderately suitable lands and moderately suitable lands become highly suitable for Sugar cane cultivation.

Regarding suitability for sugarcane cultivation in the red laterite soils (pedon 2, 3, 4, 5 and 6) it was marginally suitable. Slope, texture, sub surface hardening and in-situ crusting, depth, high coarse fragments, low pH, CEC and OC content were the major fertility related problems. Therefore to realize the full potential, these soils should be properly managed, supplemented with organic manures and inorganic fertilizers and to be provided with assured irrigation. 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.

Fertility capability classification

The concept of soil fertility capability classification (FCC) system was developed as an attempt to bridge the gap between sub-disciplines of soil classification and soil fertility, especially to interpret soil taxonomy and additional soil attributes in a way that is directly relevant to plant growth. FCC is a classification of soils on the basis of fertility constraints, quantified from condition modifiers (Buol *et al.*, 1975; Sanchez *et al.*, 1982). The sugar cane growing soils of the Medak district were classified for their fertility capability and found that 2 types and 3 substrata types and 4 modifiers were present in these soils (Table 7). Combining all these parameters, fertility capability units were derived for representing area of each soil pedons based on the analytical results type, substrata type and condition modifiers were identified for each pedon and the results are discussed here under.

The conditions modifiers identified in the study area are

d - Ustic moisture regime: dry > 90 consecutive days in 20 – 60 cm depth

v - Vertic condition, very sticky and plastic with clay > 35 per cent.

b - Basic reaction with soil pH more than 7.3 or free $CaCO_3$ within 50 cm.

h- Acid but not Al-toxic or pH in between 5.0 and 6.0

Prime (**`**) symbol denotes presence of gravel 15-35% up to 50cm depth

Double Prime (``) symbol denotes presence of gravel >35% up to 50cm depth

Based on the results six fertility capability units were identified and the description for each FCC unit is presented below

1. L`d – Loamy surface and subsurface with dryness as limitation
2. L``d – Loamy surface and subsurface with dryness as limitation
3. LC` dh– Loamy surface and clayey subsurface with dryness and deficient in bases as limitation
4. SC``dh– Sandy clay surface with dryness and deficient in bases as limitation
5. Cdvb – Clayey surface and subsurface. Dry soils with vertic properties and basic reaction.
6. CLdv – Clayloamy surface and subsurface and dry soils with vertic properties

The condition modifier'd' dominated in its occurrence followed by the condition modifier 'v', 'h' and 'b'. (Table 15)

The fertility capability class of 'Cdvb' was assigned to pedon 1, 9 and 11 of black soils. The 'v' modifier indicates high clay content. Hence, tillage will be difficult when too dry or too moist; low infiltration rates; poor hydraulic conductivity; good water-holding capacity; runoff if sloping and difficult to till. But the soils have high productivity potential if proper crop and nutrient management practices are adopted. The pedon 7 black soil was comes under the FCC unit 'CL` dv' indicating clayey surface and subsurface. The major limitations for crop production were Ustic condition low infiltration rates; poor hydraulic conductivity and good water-holding capacity.

The pedons (8 and 11) of red soils were comes under the FCC unit 'L` d' indicating loamy surface and subsurface. The major limitations for crop production were Ustic condition and presence of gravels >15to 35% up to 50cm depth which limits the availability of WHC and nutrients. The pedons (10, 13 and 14) of red soils were comes under the FCC unit 'L`` d' indicating loamy surface and subsurface. The major limitations for crop production were Ustic condition and presence of gravels 35% up to 50cm depth which limits the availability of WHC and nutrients.

Sandy clay surface and clayey subsurface was found in red laterite soil pedons (2, 4, 5 and 6) were classified under FCC as 'SC``dh'. As per the fertility capability unit the soils had Ustic moisture condition, susceptible to severe soil degradation from erosion exposing undesirable subsoil; high priority should be given to erosion control; poor water holding capacity with high infiltration rate and presence of gravels >35% up to 50cm depth which limits the crop production. The pedon 3 of red laterite soils was comes under the FCC unit 'LC``dh' indicating loamy surface and sandy clay subsurface. The major limitations for crop production were Ustic condition, susceptible to severe soil degradation

from erosion exposing undesirable subsoil; high priority should be given to erosion control; poor water holding capacity with high infiltration rate and presence of gravels >35% up to 50cm depth which limits the crop production.

Major soil constraints and recommendations for crop production

The soil constraints identified (Table 8) using soil test data were slope, shallow depth, coarse and fine texture, erosion, drainage and low organic carbon, low and high pH, low CEC, low availability N, P and micronutrients content in the soils. Similar observations were made by Reddy *et al*. (1998) [9], Fransis *et al*. (1983) [2] and Rajeshwar and Mani (2013) [7, 8].

Sub surface hardening and gravelly hardened in-situ as crust was observed in red laterite soil pedons, which leads the impedance to root penetration and proliferation. Shallow root system makes the plant susceptible to drought during dry spells. In the second horizon of all red laterite soil pedons, mottles with evidence of enrichment of sesquioxide were observed. Major soil constraints for crop production and recommendations based on limitations for each soil types of study area were discussed in table 5. The suitability for sugarcane cultivation in black soil pedons (1, 7, 9 and 12) was found moderately suitable with limitation of poor drainage with slow permeability, sub surface hardening and low hydraulic conductivity.

If the improvements could be done such as deep ploughing, addition of farm yard manures and addition of black soil/tank silt in red and red laterite soils, the area under marginally suitable for cultivation may be converted to moderately suitable and highly suitable for cultivation of sugarcane. In the black soil area, improved management practices have good potential to enhance productivity on these soils. If improved technologies such as addition of river sand @ 100 t ha^{-1} and application of 100 cart loads of red loam soil; deep ploughing the field with mould board plough or disc plough during summer which will enhance the infiltration and percolation will help to enhance moderately suitable to highly suitable for the sugarcane cultivation.

Table 1: Geo-referenced location points of Sugarcane growing pedons in the Medak district

Pedon	Location of Pedon	Latitude ° N	Longitude ° E	Altitude (m)
1	Aroor	17 ° 37’42.34”	77 ° 53’10.33”	539
2	Paidigumma	17 ° 32’39.17”	77 ° 44’14.26”	651
3	Burdipad	17 ° 43’43.50”	77 ° 33’38.09”	602
4	Kuppanagar	17 ° 44’31.90”	77 ° 41’38.59”	626
5	Basanthpur	17 ° 47’40.52”	77 ° 32’50.03”	615
6	Kothur	17 ° 43’52.78”	77 ° 36’15.96”	611
7	Budera	17 ° 38’37.18”	77 ° 50’35.00”	585
8	Mamdipally	17 ° 36’12.54”	78 ° 08’59.68”	514
9	Andole	17 ° 49’34.54”	78 ° 05’07.31”	492
10	Kaudloor	17 ° 57’04.04”	78 ° 00’36.82”	489
11	Antharam	17 ° 51’52.75”	78 ° 11’17.34”	539
12	Pulakurty	17 ° 56’45.77”	77 ° 42’43.82”	527
13	Mudguntal	18 ° 03’34.95”	77 ° 49’20.43”	484
14	Ramakkapet	18 ° 11’10.10”	78 ° 37’47.53”	509

Table 2: Land Capability Classification – Quantification of the Criteria

Charecteristics	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI	Class-VII	Class-VIII
Topograhy(t)								
Slope (%)	0-1	1-3	3-8	8-15	Upto 3	15-30	30-50	>50
Erosion	Nill	Slight	Moderate	Severe	Nil	Severe	Very severe	extreme
Wetness(w)								
Flooding	Nil (F0)	Nil (F0/F1)	slight F1)	moderate (F3)	Mod.to severe (F0/F4)	Nil, severe (F0/F4)	Nil to very severe (F0/F4)	---------
Drainage(1)	Well	Mod. Well	Imperfect	Poor	V.Poor	Excessive	Excessive	Excessive
Permeability	Moderate	Mod. Rapid	Rapid slow	V.rapid, v slow	--------	--------	----------	--------
Infiltration rate (cm/hr)	2-3.5	1-2.0, 3.0-5.0	0.5-1, 5.0-10.0	<0.5, >10.0	2.0			
Physical soil characteristics (s)								
Surface texture	loam	sil& cl	sl& c	scl	s, c(m)	ls -cl	1s, s, c	1s, s, c(m)
Sur.coarse frag (%)	1-3	3-15	15-40	40-75	15-75	75+		
Sur. stoniness (%)	<1	1-3	3-5	5-8	8-15	15-40	40-75	>75
Sub surface coarse fragments (%)	<15	<15	15-35	35-50	50-75	50-75	50-75	>75
Soil depth (cm)	>150	150-100	100-50	50-25	-	25-10	25-10	<10
Pedon development	Cambic/Argillic) hor.A-(B)-C	A-B-C $A-B_t-C$	Stratified A-C;A-B-C	Salic (z)/Calcic (k) hor.A-Bz-C/A-Bk-C	Az-C, $A-B_Z$- C	Gypsic (y) hor. A $-C_y$	A-C(stony	R (bouldry)
Fertility (f)								
CEC(cmol(p+)/kg)	40-16	16-12	16-12	12-8				
Base saturation (%)	80+	80+	80-50	50-35	50-35	35-15	<15	
OC (0-15cm) (%)	>1.0	0.75-1.0	0.5-0.75	0.3-0.5	<0.3			
Salinity EC(dS m^{-1})	<1.0	1-2	2-4	4-8	8-15	15-35	35+	
Gypsum (%)	0.3-2.0	2-5	5-10	10-15	15-25	>25		

Table 3: 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	Paidigummal	III	III	I	V	III	IV	III	II	IV	IV	III	IIIstef
Pedon 3	Burdipad	III	III	I	IV	III	III	III	II	IV	IV	IV	IIIstef
Pedon 4	Kuppanagar	III	III	II	IV	III	III	III	II	IV	III	III	IIIstef
Pedon 5	Basanthpur	III	III	II	V	III	IV	III	II	IV	III	III	IIIstef
Pedon 6	Kothur	III	III	I	V	III	III	II	II	IV	IV	IV	IIIstef
Pedon 7	Budera	III	II	III	II	II	II	II	I	I	I	III	IIIwef
Pedon 8	Mamdipally	III	IV	I	III	III	III	III	II	I	III	III	IIIstef
Pedon 9	Andole	II	II	IV	III	II	II	I	I	I	I	II	IIIwef
Pedon 10	Kaudloor	III	VI	I	III	III	III	IV	V	IV	III	IV	IIItsdef
Pedon 11	Antharam	II	IV	I	III	III	III	III	II	I	III	III	IIIstef
Pedon 12	Pulkurty	II	II	IV	III	II	II	I	I	I	I	II	IIIwef
Pedon 13	Mudguntal thanda	II	IV	I	III	III	III	III	II	I	IV	III	IIIstef
Pedon 14	Ramakkapet	II	IV	I	III	III	III	III	II	I	III	III	IIIstef

Table 4: Soil site suitability criteria (crop requirements) for Sugarcane

Soil-site characteristics			Rating			
		Unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Climatic regime	Mean temperature in growing season	°C	30-34	26-29 35-38	25-20 39-40	<20 >40
	Mean minimum temperature in growing season	°C	10-20	21-30	9-5	<5
	Mean RH (%)in	Growing season	70-85	60-70/85- 90	60-50/>90	<50
		Ripening stage	55-76	75-90	<55/>90	-
Land quality	Land characteristics					
Oxygen availability to roots	Soil drainage	Class	Well drained	Mod. / Imperfectly drained	Poorly drained	V. Poorly/ Excessively drained
	Depth of water	m	>1.0	1.0-0.5	<0.5	
Nutrient availability	Texture	Class	l, cl, sil, sicl, sc, scI	c(m/k), sl	c+(ss)	
	pH	1:2.5	7.0-8.0	6.0-6.9 8.1-9.0	4.0-5.9/ 9.1-9.5	<4.0/ >9.5
	CEC	c mol (p+)/kg	>20	10-20	10-5.0	<5
Rooting conditions	Effective soil depth	cm	>100	100-75	75-50	<50
	Stonnines	%	<15	15-35	35-50	>50
Soil toxicity	Salinity (EC saturation extract)	dS/m	<2.0	2.0-4.0	4.0-9.0	>9
	Sodicity (ESP)	%	<10	10-15	15-25	>25
Erosion hazard	Slope	%	<3	3-5	5-8	>8

Clay (m/k)= mixedlkaolinitic; Clay (ss)= shrink-swell clays
(NBSS&LUP2005)

Table 5: 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	Paidigummal	855	40.0	26.2	74.0	3-8	Severe	Well	67	35.6	gsc	6.0	4.9	8.8	50.11
Pedon 3	Burdipad	980	40.0	26.2	74.0	3-8	Severe	Well	95	24.2	scl	5.8	5.5	11.2	41.07
Pedon 4	Kuppanagar	980	40.0	26.2	74.0	3-8	Severe	Well	81	31.2	scl	5.6	5.7	8.9	53.48
Pedon 5	Basanthpur	980	40.0	26.2	74.0	3-8	Severe	Well	70	35.0	sc	5.1	5.5	7.7	36.10
Pedon 6	Kothur	980	40.0	26.2	74.0	3-8	Severe	Well	105	29.2	sc	5.4	4.9	11.5	35.21
Pedon 7	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 8	Mamdipally	855	40.0	26.2	74.0	3-8	Severe	Well	95	15.6	sl	6.6	5.3	14.4	74.58
Pedon 9	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 10	Kaudloor	855	40.0	26.2	74.0	3-8	Severe	Well	41	24.6	gsl	6.5	4.3	7.8	62.50
Pedon 11	Antharam	855	40.0	26.2	74.0	3-8	Severe	Well	90	23.0	sl	6.9	5.9	16.1	85.09
Pedon 12	Pulakurty	855	40.0	26.2	74.0	1-3	Moderate	Poor	150	10.0	c	7.9	8.4	56.2	76.71
Pedon 13	Mudguntal thanda	855	40.0	26.2	74.0	3-8	Severe	Well	65	22.5	sl	6.8	6.6	13.2	83.18
Pedon 14	Ramakkapet	855	40.0	26.2	74.0	3-8	Severe	Well	70	17.9	sl	6.8	6.8	13.2	79.24

Table 6: 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	Paidigummal	S1	S1	S1	S3	S1	S3	S3	S3	S1	S1	S2	S3	S3	S3	S3	S2
Pedon 3	Burdipad	S1	S1	S1	S3	S1	S1	S2	S3	S1	S1	S2	S3	S2	S2	S3	S2
Pedon 4	Kuppanagar	S1	S1	S1	S3	S1	S1	S2	S3	S1	S1	S2	S3	S3	S2	S3	S2
Pedon 5	Basanthpur	S1	S1	S1	S3	S1	S3	S3	S3	S1	S1	S3	S3	S3	S2	S3	S2
Pedon 6	Kothur	S1	S1	S1	S3	S1	S3	S1	S3	S1	S1	S3	S3	S3	S3	S3	S2
Pedon 7	Budera	S1	S1	S1	S1	S2	S1	S1	S2	S1	S1	S2	S1	S1	S2	S2	S1
Pedon 8	Mamdipally	S1	S1	S1	S3	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S3	S2
Pedon 9	Andole	S1	S1	S1	S1	S3	S3	S1	S1	S1	S1	S2	S1	S1	S1	S2	S1
Pedon 10	Kaudloor	S1	S1	S1	S3	S1	S2	N1	S3	S1	S1	S2	S1	S3	S3	S3	S2
Pedon11	Antharam	S1	S1	S1	S3	S1	S2	S2	S2	S1	S1	S2	S1	S1	S2	S3	S2
Pedon 12	Pulakurty	S1	S1	S1	S1	S3	S3	S1	S1	S1	S1	S1	S1	S1	S1	S2	S1
Pedon 13	Mudguntal thanda	S1	S1	S1	S3	S3	S2	S3	S2	S1	S1	S3	S3	S2	S2	S3	S2
Pedon 14	Ramakkapet	S1	S1	S1	S3	S1	S2	S3	S2	S1	S1	S2	S2	S2	S2	S3	S2

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 7: Fertility capability classification –soil sample coding for Sugarcane growing Soils of Medak District

Pedon	Location	Type/ Substrata	Check list for modifiers									Modifiers	FCC unit
			d	e	i	v	k	b	n	s	h		
1.	Aroor	C	*	-	-	*	-	*	-	-	-	dvb	Cdvb
2.	Paidigummal	SC	*	-	-	-	-	-	-	-	*	dh	SC``dh
3	Burdipad	LC	*	-	-	-	-	-	-	-	*	dh	LC``dh
4.	Kuppanagar	SC	*	-	-	-	-	-	-	-	*	dh	SC``dh
5.	Basanthpur	SC	*	-	-	-	-	-	-	-	*	dh	SC``dh
6.	Kothur	SC	*	-	-	-	-	-	-	-	*	dh	SC``dh
7.	Budera	CL	*	-	-	*	-	-	-	-	-	dv	CLdv
8.	Mamdipally	L	*	-	-	-	-	-	-	-	-	d	L`d
9.	Andole	C	*	-	-	*	-	*	-	-	-	dvb	Cdvb
10.	Kaudloor	L	*	-	-	-	-	-	-	-	-	d	L``d
11.	Antharam	L	*	-	-	-	-	-	-	-	-	d	L`d
12.	Pulakurty	C	*	-	-	*	-	*	-	-	-	dvb	Cdvb
13	Mudguntal thanda	L	*	-	-	-	-	-	-	-	-	d	L``d
14.	Ramakkapet	L	*	-	-	-	-	-	-	-	-	d	L``d

S: high rate of infiltration, low water-holding capacity.

L: medium infiltration rate, good water-holding capacity.

C**:** low infiltration rates, good water-holding capacity, high potential, runoff if sloping, difficult to till

SC, LC, LR, SR: susceptible to severe soil degradation from erosion exposing undesirable subsoil;

high priority should be given to erosion control.

d - ustic moisture regime: dry > 90 consecutive days in 20 – 60 cm depth

v - Vertic condition, very sticky and plastic with clay > 35 per cent.

k - Potassium deficiency in the surface soils (less than 0.2 cmol (p^+) $kg^{-1}$of exchangeable K).

b - Basic reaction with soil pH more than 7.3 or free $CaCO_3$ within 50 cm.

e - Low CEC (< 7 cmol (p^+) kg^{-1} of soil by sum of cations at pH 7).

i - phosphorus fixation. Hues of 7.5 YR or redder and granular structure

h- Acid but not Al-toxic or pH in between 5.0 and 6.0

n- 15% Na-saturation of CEC within 50 cm of the soil surface

s- 4 mmhos/cm of electrical conductivity of saturated extract at 25ºC within 1 m of the soil surface

Prime **(`)** symbol denotes presence of gravel 15-35% up to 50cm depth

Double Prime **(``)** symbol denotes presence of gravel >35% up to 50cm depth

Table 8: 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.
	9	Andole	Moderately suitable to highly suitable	Drainage, texture, runoff, erosion and high $CaCO_3$, high pH in subsurface horizon	
	12	Pulakurty	Moderately suitable to highly suitable	Drainage, texture, runoff, erosion and high $CaCO_3$, high pH, sub surface hard pan	
	7	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.

Red Soils					
	8	Mamdipally	Marginally suitable to Moderately suitable	Texture, slope, Low N and 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.
	11	Antharam	Marginally suitable to Moderately suitable	Texture, slope, Low N and Zn	
	13	Mudguntal thanda	Marginally suitable to Moderately suitable	Texture, slope, low OC, Low N and Zn	
	14	Ramakkapet	Marginally suitable to Moderately suitable	Texture, slope, low OC, Low N and Zn	
	10	Kaudloor	Marginally suitable to Moderately suitable	Depth, Slope, Erosion, Texture, Coarse fragments, OC, Low N & low Zn	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					
	2	Paidigummal	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.
	3	Burdipad	Marginally suitable to Moderately suitable		
	4	Kuppanagar	Marginally suitable to Moderately suitable		
	5	Basanthpur	Marginally suitable to Moderately suitable		
	6	Kothur	Marginally suitable to Moderately suitable		

Conclusion

The red and red laterite soil pedons (2, 3, 4, 5, 6, 8, 10, 11, 13 and 14 were classified into 'III stef' land capability sub-class due to the limitations of slope, texture, soil depth, erosion and soil fertility whereas the pedon 10 classified as 'III tsdef' capability sub-class due to the limitations of slope, texture, soil depth, severe erosion, coarse fragments and soil fertility limitations. The pedons 1, 7, 9 and 12 were classified into 'III swef' land capability sub-class due to the limitations of drainage, texture, erosion and soil fertility limitations. If these improvements could be done, the marginally suitable land could be converted to the moderately suitable, moderately suitable land onverted to highly suitable lands and moderately suitable lands become highly suitable for Sugar cane cultivation. Soil productivity can be improved by maintenance of enhanced soil fertility, addition of organic matter, proper drainage facilities, reduced sub surface crusting and erosion control practices.

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