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E Narsaiah
Associate Professor, Department of Soil Science & Agricultural Chemistry, Agricultural College, Warangal, Telangana, India

G Bhupal Raj
Director of Extension, MS Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India

T Ramprakash
Principal Scientist, AICRP on Weed Management, PJTSAU, Hyderabad, Telangana, India

D Vishnuvardhan Reddy
Ex-Dean of Student of Affairs, PJTSAU, Hyderabad, Telangana, India

M Chandhini Patnaik
Principal Scientist, AICRP on Micronutrients, ARI, Rajendranagar, Hyderabad, Telangana, India

Corresponding Author:
E Narsaiah
Associate Professor, Department of Soil Science & Agricultural Chemistry, Agricultural College, Warangal, Telangana, India

Land suitability evaluation for crops in Eturunagaram division of Warangal District, Telangana State

E Narsaiah, G Bhupal Raj, T Ramprakash, D Vishnuvardhan Reddy and M Chandhini Patnaik

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Abstract
Six typical Pedon from central and eastern part of Warangal district, Eturunagaram division in Telangana State were evaluated for their suitability to major crops *viz,* rice, cotton, maize, redgram and chilli. In the study area, 6 pedons samples were collected and characterized. Crop suitability classification was carried our adopting FAO guidelines. The suitability classes ranged from highly suitable to permanently not suitable to these crops. Pedon 1 was not suitable for rice, moderately suitable for maize and chilliess and highly suitable for redgram. Pedon 2 was highly suitable for maize chillieds and redgram slightly suitable for rice cultivation and moderately suitable for cotton cropping. Pedon 3 moderately suitable for cultivationof the irrigated-dry crops maize, cotton, chilli and redgram and highly suitable for rice cultivation due to drainage related constraints. Very severe soil limitations in pedon 4 made it unsuitable to cultivation of arable crops except redgram, for wchih it was slightly suitable. Maize, chilli and redgram cultivation was highly suitable for pedon 5 soils. Pedon 6 was moderaly sutiable for cultivation of the irrigated dry crops and highly cuitable for cultivation of rice crop. Soil constraint analysis was done and remedial measures were also suggested.

Keywords: Soil, soil taxonomy, limitation levels, potential and land suitability

1. Introduction
Soil is the most important natural resource, which is a treasure of any country. But, it is finite, non-renewable and is constantly degrading. India has to support nearly 18 per cent of the world's population from its meager share of 2.5 per cent of world's land area [1]. The population of India has increased from 456 million in 1961 to 700 million in 1980 to 1053 million in 2000 and is projected to reach 1665 million by 2050. The per capita cultivable land in India is also reported to decline from 0.34 ha in 1961 to 0.14 ha in 2010 and is projected to further decline to 0.09 ha by 2050[2]. Proper use of this vital natural resource influences the existence of life systems and socio-economic development of any country. The performance of any crop was largely dependent on soil parameters (depth, texture, drainage *etc.*) as conditioned by climate and topography. The study of soil-site characterization for predicting the crop performance of an area forms land evaluation. According to Wambeke (1998), land evaluation was the rating of soil for optimum returns per unit area. The yield influencing factors for crops have to be evaluated and the results obtained may be applied for higher production of these crops through proper utilization of similar soils that occur elsewhere in same agro-climatic sub-region under scientific management practices (Khadse and Gaikwad, 1995).

Land suitability evaluation is the process of estimating the potential of land for land use planning[3]. However, each crop requires specific soil and climatic conditions for its optimum growth. Information on soil site suitability for crops in Eturunagaram division of Warangal district, Telangana state is lacking. Hence, an attempt has been made to evaluate the soil suitability for five major crops *viz*., rice, cotton, maize, chilli and redgram on Alfisols, Entisols, Inceptisols and Vertisols in central and eastern parts of Warangal district of Telangana state

2. Materials and Methods

2.1 Description of the study area

The area selected for the present study, Eturunagaram division in Warangal district, lies in central Telangana Zone in Telangana State has a total geographical area of 820 km^2 which lies between 18° 20' 08.10"N latitude 79° 36' 10.72"East longitudes. The climate is semi-arid with district summer, winter and rainy seasons. The mean annual rain fall is 803.2 mm of which 90.11% received during South-West monsoon, 4.80% during summer season.

The mean annual temperature is 28ºC and the mean maximum and minimum temperature of the district are 32.44^{0}C and 23.31 ºC respectively. The maximum and minimum mean monthly temperature ranges from 17^{0}c to 40.8^{0}c. The lowest temperature is recorded during December month (17.0^{0}C) and the maximum during May (40.8^{0}C). The soil moisture regime is ustic, and soil temperature regime is isohyperthermic. The natural vegetation comprises of trees such as *Ficus benghalensis*, *Tamarindus indica*, *Azadiracta indica*, *Ziziphus jujubae*.

2.2 Methodology

After traversing the Eturunagaram division of Waranagal district, six typical pedons were selected on two land forms (plains and uplands) in central and eastern parts of the division. The morphological characteristics of these typical pedons were described in the field by following the procedure outlined by Soil Survey Staff [4]. Horizon wise soil samples were collected from these typical pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures and were classified according to Soil Taxonomy. These pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations [3]. The landscape and soil requirements for the selected crops were matched with generated data at different limitation levels: no (0), slight (1), moderate (2), severe (3) and very severe (4). The number and degree of limitations suggested the suitability class of pedons for a particular crop [4]. The potential land suitability (table 4) subclasses were determined after considering the improvement measures to correct these limitations [4].

Soil suitability for major crop growing was evaluated based on FAO (1976) [13] frame work for land evaluation. It involved formulation of climatic and soil requirements of crop and ratings of these parameters *viz*., highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N) for agriculture. Soil-site suitability for some of the major crops was evaluated based on the criteria suggested by Sehgal (1986) [12] and Sys *et al.* (1991) [3].

The soil-site characteristics of the study area were matched with soil-site suitability criteria for a few important crops *viz*., rice, maize, cotton, chilly and redgram (Appendix II) given by Sys *et al*. (1993). The kind and degree of limitation and suitability class was determined and evaluated. The studied soils vary in their suitability for different crops according to the criteria for the determination of the land suitability classes.

Table 1: Criteria for the determination of the land suitability classes

Land Classes	Criteria
S1: Very suitable	Land units with no, or only 4 slight limitations.
S2: Moderately suitable	Land units with more than 4 slight limitations, and / or not more than 3 moderate limitations.
S3: Marginally suitable	Land units with more than 3 moderate limitations, and / or one or more severe limitation(s).
N1: Actually unsuitable and potentially suitable	Land units with very severe limitations which can be corrected.
N2: Unsuitable	Land units with very severe limitations which cannot be corrected.

3. Results and Discussion

The study area has favourable climatic conditions for growing annual crops. Temperature and availability of water through rains and other irrigation sources make this area suitable for growing many crops. But, the soil resources have some limitations which can be managed to achieve higher production. Hence, the major soil constraints of the study area were identified and remedial measures were suggested to sustain the soil fertility and yields of crops.

Details of pedons and relevant soil characteristics are given in table 2 and site characteristics and weighted means of soil characteristics are given in table 3. These soils are developed from granite-gneiss, alluvial deposits and sandstone. The optimum requirements of a crop are always region specific, climatic and soil characteristics parameters play a significant+ role to maximize crop yields. The depth wise soil characteristics used to arrine at site. Soil characteristics for assessing crop suitability the soil site suitability criteria for rice, maize, cotton chilli and redgram that are grown in eturunagaram division, Warangal district, Telangana state, the kind and degree of limitations were evaluated and suitability of soils of study area for growing these crops in given below. The performance of any crop was largely dependent on soil parameters (depth, texture, drainage etc.) as conditioned by climate and topography. The study of soil-site characterization for predicting the crop performance of an area forms land evaluation.

Pedons 1, 2 and 5were taxonomically classified under Alfisols. However slight variations in soil colour differentiated these profiles into Haplustalfs and Rhodustalfs. Depth of the pedon, amount of clay, presence or absence of coarse fragments, and relative location of the pedon on the landscape were the major factors that determined the crop suitability. Pedons 2 and 5 highly suitable for cultivation of maize, chilly and redgram due to the good drainage and no other soil related constraints. However, the suitability for cotton and rice is Moderate (S2) due to the medium texture of the soil.

Pedon 3 was classified under Typic Haplustert. This pedon was moderately suitable for cultivation of the all the four crops under evaluation (except rice). Despite absence of any other crop productivity related constraint, these soils were classified as S2 due to alkaline soil reaction, which may cause several nutrient deficiencies and also limit the availability of P and N. Patil *et al.* (2010) reported that Typic Haplusterts in Lendi watershed of Chandrapur district in Maharashtra were moderately suitable (S2) for growing cotton, pigeonpea and soybean.

Pedon 4 was taxonomically classified as Lithic Ustorthent. This pedon is permanently not suitable (N2) for rice and cotton cultivation owing to the serious limitations existing in these pedons in terms of excessive drainage, coarse texture of the soil, shallow depth, low CEC which rendered this pedon permanently unsuitable for rice cultivation. These limitations

cannot be overcome by management practices. For maize and chilly crops, the crop suitability classification was N1 due to severe limitation excessive drainage (poor WHC), high erodability, high quantity of the coarse fragments in the root zone, very low CEC due to lower clay content etc. These limitation can be managed by adding management mechanisms such as addition of tank silt/ regular addition of high quantity of organic manures. For redgram, this pedon was classified as S2 (moderately suitable) in view of the hardy nature of the Geetha Sireesha and Naidu (2013) reported that Lithic Ustorthents were marginally suitable for growing rice, sorghum, chickpea and sunflower crops in Banaganapalle mandal of Kurnool district in Andhra Pradesh

Pedons 6 was categorized as Vertic Haplustept according to soil taxonomy. Finer texture of the soil, absence of coarse fragments, high CEC and high base saturation and no other soil related problems make these soils suitable for rice. The fine texture of these soils may cause some drainage problems for maize, especially during the seedling stages. Hence these soils were categorized as moderately suitable for maize (S2). However, very high clay content which may cause drainage related problems of the ID crops evaluated in this study. Hence this pedon was classified as moderately suitable (S2) for maize, cotton, chilly and redgram and as highly suitable for rice (S1). Similar suitability was suggested by Leelavathi *et al.* (2010), who reported that Typic Haplustepts were marginally suitable (S3) for growing rice crop in Yerpedu mandal of Chittoor district in Andhra Pradesh.

Table 2: Depth wise Soil characteristics used for assessing crop suitability evaluation

Pedon No	Location	Horizons	Depth (cm)	Physical characteristics (s)% of < 2 mm soil			$CaCO_3$ (%)	Physico-Chemical characteristics				Salinity and alkalinity (n)	
				Texture				CEC [cmol (p+) kg^{-1} soil]	BS (%)	pH (1:2.5 H_2O)	OC (%)	EC (dSm^{-1})	ESP
				Sand	Silt	Clay							
1	Ramannagudem	Ap	0-15	84.5	5	10.5	-	6.2	59.68	6.3	0.28	0.15	0
		Bt1	15-32	70.9	6.5	22.6	-	11.5	73.91	6.7	0.35	0.13	1.74
		Bt2	32-50	57.3	8.2	34.5	-	16.5	81.82	6.9	0.31	0.12	3.03
		Bt3	50-72	48.5	11	40.5	-	21.2	80.19	7.3	0.28	0.16	2.83
		Cr	72+	**Weathered Parent Material**									
2	Eturnagaram	Ap	0-16	84.5	7.5	8	-	4.8	77.08	7.5	0.48	0.16	0
		Bt1	16-28	70.5	8.5	21	-	10.4	80.77	7	0.4	0.34	2.88
		Bt2	28-61	60.5	9.5	30	-	11.6	81.9	6.9	0.29	0.13	5.17
		C	61+	**Weathered Parent Material**									
3	Mangapet	Ap	0-18	21.5	26.5	52	2.8	37.6	100	8.4	0.49	0.48	1.06
		BA	18-36	26.5	18.5	55	3.2	39.1	100	8.8	0.36	0.53	2.3
		Bss1	36-69	28.5	14.5	57	7.9	41.8	100	8.5	0.34	0.61	5.5
		Bss2	69-97	24.3	13.5	62.2	6.5	45.6	100	9.3	0.3	0.58	6.8
		Bss3	97-130+	21.5	19.3	59.2	6.8	49.4	100	6.7	0.38	0.16	8.3
4	Narllapur	Ap	0-8	83.2	6.5	10.3	-	2.9	66.21	6.7	0.38	0.16	3.45
		A2	8-18	79.3	8.3	12.4	-	3.65	67.12	6.5	0.32	0.14	2.74
		A3	18-29	73.2	12.3	14.5	-	4.32	71.53	6.6	0.25	0.12	4.63
		Cr	29+	**Weathered Parent Material**									
5	Medaram	AP	0-18	73.2	9.4	17.4	-	10.21	66.01	6.91	0.65	0.16	1.96
		Bt1	18-40	64.3	8.9	26.8	-	13.45	65.65	6.85	0.48	0.21	1.49
		Bt2	40-62	61.5	10.2	28.3	-	15.98	68.02	6.79	0.42	0.09	2.5
		Bt3	62-82	57.2	13.7	29.1	-	17.16	71.27	6.83	0.39	0.12	3.5
		Cr	82+	**Weathered Parent Material**									
6	Govindaraopet	Ap	0-16	33.8	23	43.2	9.85	28.5	97.54	8.85	0.72	0.15	1.05
		Bw1	16-45	18.3	28.3	53.4	10.21	34.8	98.85	8.75	0.44	0.14	1.44
		Bw2	45-72	15.2	26.3	58.5	12.52	36.5	99.18	8.68	0.32	0.42	1.64
		Bw3	72-105	15.8	24.3	59.9	11.62	40.2	99.25	8.71	0.66	1.12	1.99

Table 2: Site and soil characteristics of studied profiles for crop suitability classification (Weighted average)

Pedon No	Soil	Drainage (w)	Physical characteristics (s)			$CaCO_3$ (%)	Soil fertility characteristics (f)					Salinity and alkalinity (n)	
			Texture	Coarse fragments Volume (%)	Soil depth (cm)		Cation Exchange Capacity [cmol (P+) kg^{-1} soil]	Sum of basic cations [cmol (P+) kg^{-1} soil]	Base Saturation (%)	pH (1:2.5)	Organic Carbon (%)	ECE (dSm^{-1})	ESP (%)
1	Typic Rhodustalfs	Well drained	scl	21.73	0-72	-	14.6	11.35	74.84	6.75	0.35	0.14	2.03
2	Typic Haplustalfs	Well drained	scl	21.39	0-61	-	17.7	7.76	80.39	7.07	0.36	0.2	6.21
3	Typic Haplusterts	Imperfectly drained	c	32.38	0-130	5.96	43.5	43.59	100	8.02	0.36	0.65	0.65
4	Lithic Ustorthents	Excessively drained	sl	20.52	0-29	-	3.6	2.55	68.54	6.59	0.31	0.43	3.65
5	Typic Rhodustalfs	Well drained	l	22.68	0-82	-	14.32	9.7	67.73	7.12	0.48	0.29	2.35
6	Vertic Haplustept	Imperfectly drained	c	32.14	0-105	11.19	35.89	35.59	98.86	8.7	0.58	0.52	1.6

4. Constraint analysis and Management practices

The study area has favorable climatic conditions for growing annual crops. Temperature and availability of water through rains and other irrigation sources make this area suitable for growing many crops. But, the soil resources have some limitations which can be managed to achieve higher production. Hence, the major soil constraints of the study area were identified and remedial measures were suggested to sustain the soil fertility and yields of crops.

A. Physical constraints

The major physical constraints found in the study area were

- Poor drainage – Pedons 3, 6
- Low infiltration rate – Pedons 3, 6
- Excessive drainage: Pedons 2, 4
- Low water holding capacity: Pedons 2, 4
- Runoff – Pedons 3, 6
- Erosion – Pedons: 1, 2, 4, 5
- Shrinkage cracks - Pedons: 3, 6, 8, 11, 13, 15, 20, 25
- Shallow soil depth – Pedons 2, 4

4.1 Management Practices suggested

- Heavy texture in soils caused low infiltrartion, poor drainage, leading to runoff and erosion. It can be improved by cultivation with precautions against permanent damage like bunding / adoption of broad bed and furrow method of irrigation. Following agronomic measures like crop rotation / mixed cropping / growing leguminous crops in rotation or application of organic manures or organic mulches add organic matter to the soil which not only improve the drainage condition but also reduce runoff and erosion.
- Light textured soils which also had low water holding capacity, can be improved by addition of tank silt (pond mud) along with careful soil and water management practices like mulching or addition of bulky organic manures / green leaf manuring.
- Shallow depth of soils can be improved by deepening of soil by ridging, deep ploughing / breaking up of soil crust or contour bunding and contour farming or adoption of very careful soil and water management practices.

B. Physico-chemical constraints

- Low organic carbon content – In the surface horizons of most of the pedons except 5, 6,
- High pH – Pedons 3, 6
- High $CaCO_3$ content – Pedons: 6 (in sub soil)
- Low CEC: pedons 1, 2, 4, 5

4.2 Management practices suggested

- The organic carbon content in these soils can be improved by incorporation of crop residues or application of farm yard manure / compost / press mud or green manuring with legumes or inclusion of legumes in crop rotation. These measures along with judicious water and soil management reduce the adverse affects of high $CaCO_3$ content in soils.
- The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash.
- Addition of gypsum and green manuring with dhaincha can reduce the alkalinity problem.

C. Nutritional constraints

- Low available nitrogen: Most of the pedons exhibited nitrogen deficiency
- Zinc deficiency – 1, 2

4.3 Management practices suggested

- Soil test based fertilizer recommendation should be followed to avoid nutrient imbalance and to supply the right nutrients at right time.
- Judicious use of organic manures and biofertilizers in combination with inorganic fertilizers not only improves the supply of major nutrients but also increases the availability of micronutrients for better crop production in these soils.

Soil application of $ZnSO_4$ @ 25 kg ha^{-1} once in two seasons and / or foiliar application of $ZnSO_4$ @ 0.2 per cent for 2-3 times in a week helps in alleviating zinc deficiency

Table 3: Limitation levels of the land characteristics and land suitability classes for major crops.

Pedon No.	Soil	Crop	Wetness (w) drainage	Physical soil characteristics (s)			$CaCO_3$ (%)	Soil fertility characteristics (f)				Alkalinity (n)	Actual land suitability sub-class	Potential land suitability sub-class
				Texture	Coarse fragments (Vol. %)	Soil depth (cm)		CEC	Sum of basic cation	pH 1:2.5	OC (%)	Esp		
1	Typic Rhodustalfs	Rice	3	3	3	2	0	3	0	0	0	0	N1wsf	N1wsf
		Maize	0	0	1	2	0	2	0	0	0	0	S2sf	S2s
		Cotton	2	1	2	2	0	2	0	0	0	0	S3wsf	S2s
		Chillies	1	1	2	2	0	0	0	0	0	0	S2sf	S2s
		Redgram	0	0	1	1	0	0	0	0	0	0	S1sf	S1
2	Typic Haplustalfs	Rice	3	2	3	2	0	1	0	0	0	0	S3ws	S2s
		Maize	1	0	1	1	0	0	0	0	0	0	S1w	S1
		Cotton	2	1	2	2	0	1	0	0	0	0	S2ws	S2s
		Chillies	1	1	1	0	0	1	0	0	0	0	S1ws	S1s
		Redgram	0	0	0	0	0	0	0	0	0	0	S1	S1
3	Typic Haplusterts	Rice	0	0	0	0	0	0	0	2	0	0	S1f	S1
		Maize	1	1	0	0	0	0	0	2	0	0	S2wf	S1
		Cotton	0	0	0	0	2	0	0	2	0	0	S2sf	S2f
		Chillies	0	0	0	0	1	0	0	2	0	0	S2f	S1
		Redgram	1	0	0	0	2	0	0	2	0	0	S2f	S1
4	Lithic Ustorthents	Rice	4	4	3	4	0	3	0	0	0	0	N2	N2
		Maize	3	2	2	3	0	2	0	0	0	0	N1ws	S3s

		Cotton	4	3	3	4	0	3	0	0	0	0	N2ws	N2
		Chillies	3	2	3	3	0	2	0	0	0	0	N1wsf	S3s
		Redgram	2	1	2	2	0	2	0	0	0	0	S2wsf	S2s
5	Typic Rhodustalfs	Rice	2	2	0	0	0	2	0	0	0	0	S2wsf	S2s
		Maize	0	0	0	0	0	1	0	0	0	0	S1	S1
		Cotton	1	1	0	1	0	2	0	0	0	0	S2wsf	S2s
		Chillies	0	1	0	0	0	1	0	0	0	0	S1sf	S1s
		Redgram	0	0	0	0	0	0	0	0	0	0	S1	S1
6	Vertic Haplustept	Rice	0	0	0	0	1	0	0	2	0	0	S1f	S1
		Maize	1	1	0	0	1	0	0	3	0	0	S2sf	S2f
		Cotton	0	0	0	0	2	0	0	1	0	0	S2s	S1s
		Chillies	1	0	0	0	2	0	0	2	0	0	S2sf	S2s
		Redgram	0	0	0	0	1	0	0	3	0	0	S2f	S1f

Limitations: 0- No; 1- Slight; 2- Moderate; 3- Severe; 4- Very severe
Suitability classes: f- soil fertility limitations; s- Physical soil limitations; w- wetness limitations; n- Salinity (and /or alkalinity) limitations

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