Suitability evaluation for crops in Prakasam district of Andhra Pradesh

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ABSTRACT

Seven typical pedons from central and eastern parts of Prakasam district, Andhra Pradesh were evaluated for their suitability to major crops viz., rice, cotton, chickpea, tobacco and sorghum. The suitability classes ranged from highly suitable (S1) to permanently not suitable (N2) to these crops. Pedons 2, 3, 5 and 7 were marginally suitable and pedons 1, 4 and 6 were permanently not suitable for rice. Pedons 1 and 3 were moderately suitable and pedons 2, 4, 5, 6 and 7 were marginally suitable for cotton. All the pedons (except 4) were marginally suitable for chickpea while pedon 4 was temporarily not suitable. Pedons 5 and 7 were marginally suitable for growing tobacco and the remaining five pedons were temporarily not suitable. Pedon 3 was highly suitable, pedons 1, 5, 6 and 7 were moderately suitable, pedon 2 was marginally suitable and pedon 4 was temporarily not suitable for growing soghum crop. Shallow soil depth, wetness, organic carbon, pH and $CaCO_3$ content were limitations in all the pedons. Texture was limiting in all the pedons except P3 and P4. In addition, alkalinity was also a limiting factor in P4. The limitation levels of land characteristics varied from crop to crop. Suitable conservation and remedial measures were suggested to improve the soil productivity on sustainable basis without deteriorating soil quality. Potential land suitability classes were also given based on the possible improvement of these soils.

Keywords: Soil-site suitability, Prakasam district, soil taxonomy, limitation levels, potential land suitability

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 (Katyal, 2012). 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 1387 million by 2020 and 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 (Lal, 2013). Proper use of this vital natural resource influences the existence of life systems and socio-economic development of any country. Land suitability evaluation is the process of estimating the potential of land for land use planning (Sys *et al.* 1991). However, each plant species requires specific soil and climatic conditions for its optimum growth. Information on soil site suitability for crops in Prakasam district in particular and in Andhra Pradesh in general is very much lacking. Hence, an attempt has been made to evaluate the soil suitability for five major crops *viz.,* rice, cotton, chickpea, tobacco and sorghum on Entisols, Inceptisols and Vertisols in central and eastern parts of Prakasam district, Andhra Pradesh.

MATERIALS AND METHODS
Description of the study area

Prakasam district lies in between 14° 57′ and 16° 17′ North latitude and 78° 43′ and 80° 25′ East longitude. The climate is semi-arid monsoonic with distinct summer, winter and rainy seasons. The mean annual rainfall is 747.07 mm of which 92.46 per cent was received during April to November. The mean annual temperature is 29.50°C with a mean summer temperature of 32.33°C and a mean winter temperature of 26.09°C. The maximum temperature is in May that rises to 40.60°C and the minimum temperature is 20.36°C in the month of January. The soil moisture regime is ustic and soil temperature regime is iso-hyperthermic. The natural vegetation comprises of species like *Acacia nilotica, Borassus flabellifer, Prosopis juliflora, Calotropis gigantia, Tamarindus indica, Azadirachta indica, Cassia auriculata, Syzygium cumini, Pongomia pinnata, Eucalyptus* spp.,

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Parthenium hysterophorus, Lantana camera, Opuntia ficus-indica, Tephrosia purpuria, Cyperus rotundus and *Cynodon dactylon, etc.*

Methodology

After traversing the Prakasam district, seven typical pedons were selected on two land forms (plains and uplands) in central and eastern parts of Prakasam district. The morphological characteristics of these typical pedons were described in the field by following the procedure outlined by Soil Survey Staff (2000). Horizon-wise soil samples were collected from these typifying pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures and were classified according to Soil Taxonomy (Soil Survey Staff, 1999). These pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations (Sys *et al.* 1991). 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 (Sys *et al.* 1991). The potential land suitability (table 3) sub-classes were determined after considering the improvement measures to correct these limitations (Sys *et al.* 1991).

RESULTS AND DISCUSSION

Details of pedons and relevant soil characteristics are given in table 1 and site characteristics and weighted means of soil characteristics are given in table 2. These soils are developed from granite-gneiss, alluvial deposits and sandstone.

Table 1: Details of selected pedons and their relevant soil characteristics

Pedon No.	Location	Depth	Sand (%)	Silt (%)	Clay (%)	CaCO$_3$ (%)	CEC (cmol(p$^+$) kg^{-1} soil)	BS (%)	Sum of basic cations (cmol(p$^+$) kg^{-1} soil)	pH (1:2.5) H$_2$O	OC (g kg^{-1})	ECe (dSm^{-1})	ESP
						Fine, smectitic, isohyperthermic Typic Haplustept							
P1	Lakkavaram	0-10	56.44	11.26	32.30	4.57	32.86	79.61	25.73	7.85	0.28	0.26	1.31
		10-24	52.86	9.78	37.36	7.76	35.62	81.41	28.08	7.68	0.24	0.26	2.58
		24-45	47.12	12.76	40.12	11.06	43.26	88.70	37.61	7.61	0.18	0.01	1.76
		45-70	43.95	13.73	42.32	12.85	47.68	87.06	40.87	7.94	0.13	0.34	1.34
						Sandy, siliceous, isohyperthermic Typic Ustipsamment							
P2	Thalamalla	0-11	80.74	6.46	12.80	12.83	15.87	89.86	14.54	8.05	0.62	0.10	4.03
		11-31	80.08	11.94	7.98	12.65	14.60	83.29	13.43	8.08	0.45	0.08	4.66
		31-48	80.37	11.43	8.20	12.46	14.05	83.63	23.06	8.19	0.32	0.08	4.56
		48-61	80.13	11.86	8.01	13.44	13.68	80.77	12.52	8.30	0.29	0.10	4.53
		61-95	88.94	8.02	3.04	10.73	4.68	75.93	3.62	8.36	0.22	0.09	1.50
		95-120	92.01	5.96	2.03	12.52	3.48	73.44	2.76	8.45	0.15	0.06	1.72
						Fine, smectitic, isohyperthermic Typic Haplustert							
P3	Surareddipalem	0-19	23.88	23.79	52.33	8.66	45.18	90.54	42.97	7.90	0.43	0.11	1.86
		19-37	19.24	26.84	53.92	10.57	42.94	91.52	40.38	7.83	0.41	0.17	2.14
		37-59	17.49	25.27	57.24	11.36	44.48	90.77	41.42	7.93	0.30	0.11	1.93
		59-80	23.14	22.08	54.78	11.68	45.65	88.13	42.02	8.05	0.33	0.12	2.65
		80-115	25.17	22.13	52.70	12.64	48.74	87.27	43.98	8.16	0.18	0.14	2.93
						Fine, mixed, isohyperthermic Typic Haplustept							
P4	Kothavaripalem	0-13	40.32	11.56	48.12	10.53	14.48	80.11	10.47	8.00	0.68	0.28	7.80
		13-30	39.95	10.77	49.28	10.96	15.26	77.59	10.96	7.79	0.39	0.30	5.77
		30-47	38.16	10.13	51.71	12.24	18.46	88.90	12.84	7.88	0.28	0.16	24.16
						Fine-loamy, smectitic, isohyperthermic Typic Haplustept							
P5	Uppalapadu	0-12	45.24	11.65	43.11	6.54	40.16	88.12	34.66	7.86	0.36	0.25	1.82
		12-29	48.77	14.79	36.44	8.36	38.96	85.54	34.56	7.65	0.28	0.19	1.59
		29-50	50.74	19.06	30.20	8.67	31.87	87.39	27.02	7.23	0.25	0.28	2.60
						Fine-loamy, smectitic, isohyperthermic Typic Ustorthent							
P6	Kandulur	0-20	71.96	8.68	19.36	10.23	40.02	88.51	34.68	7.26	0.27	0.18	1.85
		20-35	64.39	9.15	26.46	10.58	31.84	88.51	27.36	7.15	0.21	0.12	2.58
						Fine, smectitic, isohyperthermic Lithic Haplustept							
P7	Marlapadu	0-10	54.34	17.69	27.97	6.05	30.64	78.98	23.83	6.86	0.25	0.19	1.21
		10-34	57.65	6.18	36.17	6.26	35.42	82.98	28.43	6.02	0.12	0.07	2.71

The kind and degree of limitations of the soils for the major five crops are presented in table 3. The soils with no or only four slight limitations are grouped under highly suitable class (S1); the soils with more than four slight limitations, and/or with more than three moderate limitations under moderately suitability class (S2); the soil with more than three moderate limitations, and/or one or more severe limitations under marginally suitable (S3) class; the soils with very severe limitations which can be corrected under N1 (currently not suitable); the soils with very severe limitations which can not be corrected grouped under unsuitable class N2 (Sys *et al.* 1991). This method also identifies the dominant limitations that restrict the crop growth shown in the sub-class symbol such as climatic (c), topographic (t), wetness (w), physical soil characteristics (s), soil fertility (f) and soil salinity/alkalinity (n). The suitability classes and sub-classes were decided by the most limiting soil characteristics (Table 3).

Pedon 1, which is grouped under Typic Haplustepts is moderately suitable for cotton and sorghum, marginally suitable for chickpea, temporarily not suitable for tobacco and permanently not suitable for rice. The major limitations are wetness (drainage), physical soil characteristics (texture and depth), $CaCO_3$ content and soil fertility characteristics (organic carbon and pH). Wetness (drainage) is a major limiting factor for rice cultivation because it does not allow in maintaining standing water and requires irrigation at frequent intervals. For all five crops organic carbon is a major limitation factor. Hence, the organic carbon status in soils can be improved by the application of farmyard manures, green manuring and inclusion of legumes in rotation.

Table 2: Site characteristics and weighted means of soil characteristics of the profiles

Pedon	Landform	Wetness (w) Drainage	Soil depth (cm)	$CaCO_3$ (%)	Apparent CEC (cmol (p^+) kg^{-1} clay)	BS (%)	pH (1:2.5)	OC (g kg^{-1})	ECe (dSm^{-1})	ESP
P1	Upland	Well drained	70	10.11	103.60	85.35	7.75	0.25	0.21	2.58
P2	Plain	Imperfectly drained	120	12.08	165.55	79.61	8.07	0.52	0.09	4.66
P3	Plain	Moderately well drained	115	11.30	81.68	89.30	7.88	0.43	0.13	2.93
P4	Upland	Well drained	47	11.30	32.44	82.37	7.90	0.54	0.24	24.16
P5	Plain	Moderately well drained	50	8.05	103.03	86.93	7.75	0.32	0.24	2.60
P6	Plain	Moderately well drained	35	10.38	169.69	88.51	7.24	0.26	0.15	2.58
P7	Plain	Moderately well drained	34	6.20	101.34	81.80	6.36	0.17	0.11	2.71

Topography (slope) (t) : <5%
Flooding: F0; Climate (c): Semi-arid monsoonic

Pedon 2 is grouped under Typic Ustipsamments which is marginally suitable for rice, cotton, chickpea and sorghum and temporarily not suitable for tobacco. These soils showed limitations *viz.,* wetness (drainage), physical soil characteristics (texture and depth), $CaCO_3$ content and soil fertility characteristics (pH and organic carbon). Pedon 3, which is grouped under Typic Haplusterts is highly suitable for sorghum, moderately suitable for cotton, marginally suitable for rice and chickpea and temporarily not suitable for tobacco. The limitations include wetness (drainage), physical soil characteristics (soil depth for tobacco), $CaCO_3$ content and soil fertility characteristics (pH and organic carbon). Pedon 4, which is grouped under Typic Haplustepts is marginally suitable for cotton, temporarily not suitable for chickpea, tobacco and sorghum and permanently not suitable for rice. However, the major limitations include wetness (drainage) for rice and physical soil characteristics (soil depth), $CaCO_3$ content, soil fertility characteristics such as pH and organic carbon and alkalinity for all the crops. Pedon 5, which is grouped under Typic Haplustepts is moderately suitable for sorghum and marginally suitable for all other crops *viz.,* rice, cotton, chickpea and tobacco.

The limitations include wetness (drainage), physical soil characteristics (texture and soil depth), $CaCO_3$ content and soil fertility characteristics (organic carbon and pH). Similar findings were reported by Satyavathi and Suryanarayan Reddy (2004) in Telangana region of Andhra Pradesh.

Table 3: Limitation levels of the soil characteristics in the study area and land suitability classes for the five major crops

P	Crop	Wetness (w) Drainage	Texture	Coarse	Soil depth (cm)	CaCO₃ (%)	Apparent CEC (cmol (p⁺) kg⁻¹ clay)	pH (1:2.5)	OC (g kg⁻¹)	ESP	Actual land suitability subclass	Potential land suitability subclass
P1	Rice	4	3	0	2	2	0	1	3	0	N2wsf	N2ws
	Cotton	0	1	0	2	1	0	2	2	0	S2sf	S2s
	Chickpea	0	1	0	2	1	0	2	3	0	S3sf	S2s
	Tobacco	0	1	0	2	4	0	3	3	0	N1sf	S2s
	Sorghum	0	0	0	1	0	0	1	2	0	S2sf	S1
P2	Rice	2	3	0	0	2	0	1	3	0	S3wsf	S3ws
	Cotton	3	3	0	0	1	0	3	1	0	S3wsf	S3ws
	Chickpea	2	0	0	0	1	0	3	3	0	S3wf	S2w
	Tobacco	2	2	0	1	4	0	4	3	0	N1wsf	S2ws
	Sorghum	2	3	0	0	0	0	1	1	0	S3wsf	S3ws
P3	Rice	3	0	0	0	2	0	1	3	0	S3wf	S3w
	Cotton	2	0	0	0	1	0	2	1	0	S2wf	S2w
	Chickpea	1	0	0	0	1	0	2	3	0	S3wf	S1
	Tobacco	1	0	0	1	4	0	4	3	0	N1wsf	S1
	Sorghum	1	0	0	0	0	0	1	1	0	S1wf	S1
P4	Rice	4	0	0	3	2	0	1	3	2	N2wsfn	N2ws
	Cotton	0	0	0	3	1	0	2	1	2	S3sf	S2s
	Chickpea	0	0	0	3	1	0	2	3	4	N1sfn	S3s
	Tobacco	0	0	0	3	4	0	4	0	4	N1sfn	S3s
	Sorghum	0	0	0	2	0	0	1	1	4	N1sfn	S2s
P5	Rice	3	3	0	2	2	0	1	3	0	S3wsf	S3ws
	Cotton	2	1	0	2	0	0	2	2	0	S3wsf	S2ws
	Chickpea	1	1	0	2	0	0	2	3	0	S3wsf	S2s
	Tobacco	1	1	0	2	3	0	3	3	0	S3wsf	S2s
	Sorghum	1	0	0	1	0	0	1	2	0	S2wsf	S1
P6	Rice	4	2	0	3	2	0	1	3	0	N2wsf	N2ws
	Cotton	0	2	0	3	1	0	1	2	0	S3sf	S3s
	Chickpea	0	1	0	3	1	0	1	3	0	S3sf	S3s
	Tobacco	0	1	0	3	4	0	3	3	0	N1sf	S3s
	Sorghum	0	1	0	2	0	0	1	2	0	S2sf	S2s
P7	Rice	3	2	0	3	2	0	0	3	0	S3wsf	S3ws
	Cotton	2	1	0	3	0	0	1	3	0	S3wsf	S3ws
	Chickpea	1	1	0	3	0	0	1	3	0	S3wsf	S3s
	Tobacco	1	1	0	3	3	0	2	3	0	S3wsf	S3s
	Sorghum	1	1	0	2	0	0	0	2	0	S2wsf	S2s

Limitations: 0 – no slight; 1 – slight; 2 – moderate; 3 – severe; 4 – very severe
Suitability sub-classes: *f-soil fertility limitations; s-physical soil limitations; w-wetness limitations; n-salinity (and/or alkalinity) limitations*

Pedon 6 grouped under Typic Ustorthents is moderately suitable sorghum, marginally suitable for cotton and chickpea, temporarily not suitable for tobacco and permanently not suitable for rice. Wetness (drainage) is major limitation for growing rice in this soil. The other limitations for growing these crops are physical characteristics (soil depth and texture), $CaCO_3$ content and soil fertility characteristics (organic carbon and pH). In case of pedon 7, which is classified under Lithic Haplustepts is moderately suitable for sorghum while marginally suitable for other crops *viz.,* rice, cotton, chickpea and tobacco. The

limitations are wetness (drainage), physical soil characteristics (soil depth and texture) and soil fertility characteristics (organic carbon and pH).

The pedons 2, 3, 5 and 7 are marginally suitable and the pedons 1, 4 and 6 are permanently not suitable for rice. Leelavathi *et al* (2010) and Selvaraj and Naidu (2013) also reported that the soils of Yerpedu and Renigunta mandals in Chittoor district, respectively were marginally suitable for growing rice. The pedons 1 and 3 are moderately suitable while the pedons 2, 4, 5, 6 and 7 are marginally suitable for growing cotton crop. Patil *et al* (2010) and Garhwal *et al* (2013) also reported that soils in Lendi watershed of Chandrapur district in Maharashtra and Sirohi district in Rajasthan, respectively were moderately suitable (S2) for growing cotton. The pedons 1, 2, 3, 5, 6 and 7 are marginally suitable and the pedon 4 is temporarily not suitable for chickpea crop. Garhwal *et al.,* (2013) also reported that soils of Sirohi district of Rajasthan were marginally suitable (S3) for chickpea. Pedons 5 and 7 are marginally suitable and pedons 1, 2, 3, 4 and 6 are temporarily not suitable for growing tobacco. The pedon 3 is highly suitable, pedons 1, 5, 6 and 7 are moderately suitable, pedon 2 is marginally suitable whereas the pedon 4 is temporarily not suitable for growing sorghum. Geetha Sireesha and Naidu (2013) reported that the soils of Banaganapalle mandal in Kurnool district of Andhra Pradesh were marginally suitable for growing sorghum.

Wetness (drainage), soil depth, organic carbon content and pH are limitation in all the pedons. Poor drainage can be improved by soil conservation measures, growing leguminous crops in rotation and application of organic manures. 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. 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. The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash. Texture is a limitation in pedons 1, 2, 5, 6 and 7. Heavy textured soils 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. $CaCO_3$ content is also a limiting factor in all the pedons except pedons 5 and 7. High calcium carbonate content leads to greater fixation of P and Zn to limit crop production. Application of organic manures such as FYM or compost or vermicompost or green manuring with legumes reduces the P and Zn fixation by formation of organo-Zn and organo-P complexes. Further, the acids produced during decomposition of organic manures causes solubilisation of $CaCO_3$ and decrease its content in the soil. Alkalinity is a limiting factor in pedon 4. Alkalinity (high ESP) in the soils can be reduced by addition of gypsum or green manuring with dhaincha which not only reduce the alkalinity problem but also increase nutrient availability.

The crop suitability of soils in the central and eastern parts of Prakasam district ranged from highly suitable (S1) to permanently not suitable (N2) for the major crops *viz.,* rice, cotton, chickpea, tobacco and sorghum. The limitations observed in these soils were physical characteristics like soil depth, wetness and texture, high $CaCO_3$ content and fertility characteristics like high pH, low organic carbon content and alkalinity. Remedial measures were suggested to achieve potential productivity of these soils without deteriorating the soil quality and to sustain crop yields.

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