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Soil - site suitability evaluation for major crops in Jammalamadugu - Proddutur tract of Pennar river basin in YSR Kadapa district, Andhra Pradesh

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Abstract

A reconnaissance soil survey was undertaken in Jammalamadugu - Proddutur tract of Pennar river basin in YSR Kadapa district, Andhra Pradesh to evaluate the suitability of soils for growing rice, cotton, bengalgram and sunflower crops. The soil belongs to Inceptisols, Entisols and Vertisols. All the pedons (P1 to P11) were marginally suitable for growing crops such as rice, cotton, sunflower and bengalgram except P1 which is moderately suitable for growing cotton. Soil texture, pH and organic carbon, CaCO₃ and drainage are the major limitations for crop growth in all the pedons. In general, the limitation levels of the land characteristics varied from crop to crop. The suitability classes for major crops can be improved if soil fertility characteristics are altered through soil amelioration measures. The actual and potential suitability classes of the soils also varied depending upon kind of limitations. If the limitation is due to properties like slope, erosion *etc.*, it can be rectified or improved by adopting suitable soil and water conservation measures and introducing lifesaving irrigations but if the limitations are of permanent type like soil depth it is impossible to convert those lands into better suitability classes than the prevailing one.

Keywords: Soil-site suitability evaluation, soil taxonomy, limitations and potential

Introduction

Land suitability evaluation is the pre-requisite for sustainable agricultural production. It involves evaluation of the criteria ranging from soil, terrain to socio-economic, market and infrastructure (Prakash, 2003) [16]. Land evaluation for ecological regions and territories aims at creating a new good production power together with stability and sustainability (Jamal, 2003) [8]. The evaluation relates to the environmental and socio-economic conditions of the area as it includes a consideration of inputs and projected outputs of production process. According to the FAO general framework for land suitability evaluation (1976), the land suitability classification consists of assessing and grouping the land types in to orders and classes according to their capacity, which portrays the suitability of the land for agriculture and other uses, wherein land is classified considering a number of soil characteristics, associated land features and environmental factors such as climate. Many researchers in India evaluated suitability of soils in diverse agro-ecologies for various field crops using categorized soil-site suitability for the sugarcane crop in Chittoor district of Andhra Pradesh (Devi and Naidu 2016) [4]; major crops across India (Naidu *et al.*, 2006) [13]; turmeric in Wardha district, Maharashtra (Mandal *et al.*, 2008) [12]; assessed the suitability of shrinks well soils for cotton, sorghum, pigeonpea, soybean and groundnut for soils of Selsura KVK research farm in Wardha district, Maharashtra (Jagdish Prasad *et al.*, 2009) [7] and evaluated the crop suitability for commonly growing crops in Yerpedu mandal of Chittoor district, Andhra Pradesh (Leelavathi *et al.*, 2013) [11]. However, information on soil site suitability of crops for Jammalamadugu - Proddutur tract of Pennar river basin in YSR Kadapa district in Andhra Pradesh is very much lacking. Hence, an attempt has been made to evaluate the soil - site suitability for major crops such as rice, cotton, sunflower and bengalgram for Jammalamadugu - Proddutur tract of Pennar river basin in YSR Kadapa district of Andhra Pradesh.

Material and Methods

The study area lies in between 14°45' and 14°53' North latitudes and 78°21' to 78°36' East longitudes at an elevation of ranging from 160-330 m (msl) The area qualified for semi – arid monsoonic climate with a distinct summer, winter and rainy seasons with a mean annual rainfall of 943 mm (2011-2020). The mean annual temperature is 25.9°C with a mean annual summer temperature of 28.0°C and mean annual winter temperature of 23.3°C. The maximum temperature for the last 10 years is 42.6°C, recorded in the month of May whereas the minimum temperature is 12°C, noticed in the month of December. The study area qualifies for ustic soil moisture regime and iso-hyperthermic soil temperature regime. The natural vegetation in the study area comprises of *Azadirachta indica*, *Parthenium hysterophorus*, *Cynodon dactylon*, *Calotropis gigantea*, *Acacia nilotica*, *Tephrosia perpurea*, *Amaranthus viridis*, *Cypurus rotundus*, *Pongamia pinnata*, etc.

Field survey

A reconnaissance soil survey was conducted in Jammalamadugu – Proddutur tract of Pennar river basin in YSR Kadapa district using toposheet of 1:50,000 scale as per the procedure outlined by AIS & LUS (1970) [1]. After traversing the area, based on the visual observations and based on the variations in soil site characteristics (Table 1), twenty sites were selected for digging profiles by following

the procedure outlined by soil survey division staff (2000) [21]. Soil correlation exercise yielded eleven typical pedons i.e., four pedons in upper slope, four pedons in mid slopes and three in foots slopes in the study area. Horizon-wise soil samples were collected for laboratory analysis. Processed soil samples (< 2 mm) were analyzed for various physico-chemical properties such as pH (1:2.5 soil water suspension), organic carbon, texture, electrical conductivity, calcium carbonate, exchangeable bases and cation exchange capacity by adopting standard analytical procedures (Bower *et al.* 1952; Chopra and Kanwar, 1991; Jackson 1973; Piper, 1966; Walkley and Black 1934) [2, 3, 6, 15]. The morphological properties of soil profiles were recorded as per Soil Survey Staff (1951) [22] and classified as per USDA soil taxonomy (Soil Survey Staff 2014) [23]. These eleven pedons were evaluated for commonly growing crops of the study area based on the guidelines of FAO (FAO, 1976) [5] as mentioned by Sys (1985) [24] and the crop requirements as suggested by Naidu *et al.* (1996) are followed.

The landscape and soil requirements for these 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 degrees of limitations suggested the suitability class for pedons to particular crops and the potential land suitability sub- classes were determined after considering the improvement measures to correct these limitations (FAO, 1976; Sys *et al.*, 1985) [5, 24].

Table 1: Landscape characteristics of Pedons

Pedons	Villages	Location	Elevation Above MSL (m)	Physio-graphy	Slope (%)	Drainage
P1 Typic Torriorthents	Kottala	N 14° 45' 55.1" E 078° 21' 51.6"	330	Upper slope	5-10	Well drained
P2 Lithic Torriorthents	Mallambhavi	N 14° 46' 53.1" E 078° 22' 41.1"	260	Upper slope	5-10	Well drained
P3 Typic Haplustepts	Kondapuram	N 14° 48' 47.1" E 078° 22' 38.8"	200	Back slope	3-5	Somewhat poorly drained
P4 Typic Haplustepts	Kanneluru	N 14° 50' 37.8" E 078° 24' 29.9"	188	Back slope	1-3	Somewhat poorly drained
P5 Typic Haplusterts	Seshareddipalli	N 14° 50' 30.1" E 078° 36' 25.1"	183	Foot slope	3-5	Somewhat poorly drained
P6 Sodic Haplusterts.	Peddapasupula	N 14° 53' 07.9" E 078° 26' 50.6"	174	Foot slope	1-3	Somewhat poorly drained
P7 Typic Haplusterts	Sumanchipalli	N 14° 53' 07.9" E 078° 26' 50.6"	230	Upper slope	0-1	Somewhat poorly drained
P8 Fluventic Haplustepts	Chinnadandluru	N 14° 46' 26.3" E 078° 28' 52.1"	200	Upper slope	0-1	Somewhat poorly drained
P9 Leptic Haplusterts	Chouduru	N 14° 46' 55.5" E 078° 32' 48.4"	180	Back slope	1-3	Somewhat poorly drained
P10 Typic Haplusterts	Kakirenipalle	N 14° 47' 16.6" E 078° 28' 51.0"	175	Back slope	1-3	Somewhat poorly drained
P11 Typic Haplusterts	Pottipadu	N 14° 49' 17.5" E 078° 32' 12.7"	160	Foot slope	1-3	Somewhat poorly drained

Result and Discussion

Weighted means of soil characteristics are given in table 2. Kind and degree of limitations of the soils for the four crops are presented in table 3. The soils with no or only four slight limitations were 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 (s) under marginally suitability class (S3); the soils with very severe limitations which can be corrected under N1 (currently not suitable); the soils with very severe limitations which cannot be corrected were grouped under unsuitable class (N2) (FAO, 1976; Sys *et*

al., 1991) [5, 25]. This method also identifies the dominant limitations that restrict the crop growth 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 suitable classes and sub- classes were decided by the most limiting soil characteristics (Table 3). Pedon1, which is grouped under Typic Torriorthents, is marginally suitable for rice, bengalgram and sunflower but moderately suitable for cotton (Table 3). The major limitations are wetness (drainage), physical soil characteristics (depth) and soil fertility characteristics (organic carbon, pH and CaCO₃). Similarly, soils of Telangana were marginally suitable for growing cotton and

chickpea crops (Satyavathi and Reddy, 2004) ^[17] and soils of Vadamalapeta mandal of Chittoor district, Andhra Pradesh were marginally suitable for growing rice crop (Satish *et al.*, 2012) ^[18].

Pedon 2, which is grouped under Leptic Torriorthents, is marginally suitable for rice, cotton, bengalgram and sunflower. These soils showed major limitations *viz.*, wetness (drainage), physical soil characteristics (texture, depth) and soil fertility characteristics (organic carbon). Soils of Nalgonda district were highly suitable for growing soybean and moderately suitable (S2) for paddy and cotton crops (Kiran *et al.* 2014) ^[10]. Similarly, the soils of Peri - urban watershed area were moderately (S2) to marginally suitable (S3) for rice cultivation (Zothansiami *et al.* 2017) ^[27].

Pedon 3 (Typic Haplustepts), Pedon 4 (Typic Haplustepts), Pedon 5 (Typic Haplusterts) and Pedon 6 (Sodic Haplusterts) are also marginally suitable for rice, cotton, bengalgram and sunflower crops. These soils showed major limitations namely wetness (drainage), physical soil characteristics (texture, depth) and soil fertility characteristics (pH, organic carbon and CaCO₃). However, in addition to above limitations pedons 3,5 and 6 had a limitation of alkalinity. Typic

Haplustepts were marginally suitable (S3) for paddy crop (Selvaraj and Naidu, 2012) ^[19] and soils of central India had a limitations of alkalinity for growing rice crop as the alkalinity limited the growth of rice crop causing low availability of soil water as affected by poor hydraulic conductivity (Kadu *et al.*, 2003) ^[9]. Pedons 7 (Typic Haplusterts), 8 (Fluventic Haplustepts), 9 (Leptic Haplusterts), 10 (Typic Haplusterts) and 11 (Typic Haplusterts) are marginally suitable for growing rice, cotton, bengalgram and sunflower, as the crops suffer from the soil constraints like wetness (drainage), physical soil characteristics (texture) and soil fertility characteristics (pH, organic carbon, CaCO₃) and alkalinity except pedon 7, texture is not a limitation. These findings were in conformity with findings of Vedadri *et al.* (2015) ^[26], who reported Typic Ustorthents and Typic Haplustepts were marginally suitable (S3) for rice and sunflower crops. Vertic Haplustepts of Banaganapalle mandal of Kurnool district, Andhra Pradesh were marginally suitable for (S3) for growing paddy crop (Shireesha *et al.*, 2013) and Ultic Haplustalfs, Typic Haplustepts were marginally suitable for (S3) for growing paddy crop in Yerpedu mandal of Chittoor district, Andhra Pradesh (Leelavathy *et al.*, 2010) ^[11].

Table 2: Soil site characteristics (weighted means) selected for suitability evaluation for major crops

Soil site characteristics	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Site characteristics											
Slope (%)	5-10	5-10	3-5	1-3	3-5	1-3	0-1	0-1	1-3	1-3	1-3
Erosion	e1	e1	e2	e2	e2	e2	e1	e1	e2	e2	e2
Drainage / wetness	WD	WD	MWD	MWD	MWD	MWD	WD	WD	MWD	MWD	MWD
Soil characteristics											
Texture	cl	sicl	scl	cl	c	c	cl	sl	c	c	c
Depth (cm)	0.60	0.45	1.10	1.84	1.60	2.14	2.30	2.00	1.15	2.10	2.10
CaCO ₃	5.91	4.30	12.80	19.49	15.71	12.97	6.84	8.03	17.28	13.09	14.90
CEC(cmol(p+) ⁻¹ kg ⁻¹ of soil	24.74	19.11	17.90	38.74	52.28	49.07	40.76	10.59	32.64	46.28	48.43
OC(%)	0.38	0.41	0.40	0.65	0.51	0.64	0.63	0.60	0.53	0.56	0.53
BS(%)	91.35	86.01	95.50	90.78	84.09	83.21	85.29	91.84	87.53	86.06	90.05
EC(dSm ⁻¹)	0.47	0.56	0.81	0.75	0.89	0.78	0.82	0.94	0.61	0.92	0.86
pH(1:2)	6.01	6.50	8.53	8.22	8.54	8.81	8.62	8.09	8.02	8.18	7.97
ESP	1.18	1.06	9.79	5.22	7.14	10.37	5.03	13.35	7.40	8.19	7.20

ED-Excessively drained, WD-Well drained, MWD-moderately well drained

Table 3 Limitation levels of the land characteristics and land suitability classes.

Cont...

Pedon	Crop	Wetness (w) Drainage	Physical soil characteristics (s)			CaCO ₃	Soil fertility characteristics (f)			Salinity/ alkalinity (n)		
			Texture	Coarse fragments	Soil Depth		Sum of basic cations (cmol (p+) kg ⁻¹ soil)	pH (1:2.5 H ₂ O)	OC (%)	ESP	Actual land suitability sub class	Potential land suitability subclass
P1	Rice	3	0	0	1	0	0	0	3	0	S3wsf	S1ws
	Cotton	0	0	0	2	1	0	1	2	0	S2sf	S1s
	Bengalgram	1	0	0	2	0	0	1	3	0	S3wsf	S1ws
	Sunflower	1	0	0	3	0	0	1	3	0	S3wsf	S1ws
P2	Rice	3	0	0	2	0	0	0	3	0	S3wsf	S1ws
	Cotton	0	0	0	3	0	0	0	1	0	S3sf	S1s
	Bengalgram	1	1	0	3	0	0	0	3	0	S3wsf	S1ws
	Sunflower	1	0	0	2	0	0	0	3	0	S3wsf	S1ws
P3	Rice	1	0	0	0	0	0	3	3	0	S3wsf	S1ws
	Cotton	2	2	0	0	1	0	3	1	0	S3wsf	S1ws
	Bengalgram	1	1	0	0	1	0	3	3	2	S3wsfn	S2ws
	Sunflower	1	1	0	1	1	0	3	3	1	S3wsfn	S2ws

Limitations: 0- No; 1-Slight; 2-Moderate; 3-Severe, 4-Verysevere

Suitability classes: f-Soil fertility limitations; s-Physical soil limitations; w-Wetness limitations; n-Salinity (and / or alkalinity) limitations.

Cont...

Pedon	Crop	Wetness (w) Drainage	Physical soil characteristics (s)			CaCO ₃	Fertility characteristics (f)			Salinity/ alkalinity (n)		
			Texture	Coarse fragments	Soil Depth		Sum of basic cations (cmol (p+) kg ⁻¹ soil)	pH (1:2.5 H ₂ O)	OC (%)	ESP	Actual land suitability sub class	Potential land suitability subclass
P4	Rice	1	1	0	0	3	0	3	3	0	S3wsf	S2ws
	Cotton	2	0	0	0	0	0	3	3	0	S3wf	S1w
	Bengalgram	1	0	0	0	1	0	3	3	0	S3wf	S1w
	Sunflower	1	0	0	1	2	0	3	3	0	S3wf	S1w
P5	Rice	1	1	0	0	3	0	3	3	1	S3wsfn	S2ws
	Cotton	2	0	0	0	1	0	3	1	0	S3wf	S1w
	Bengalgram	1	2	0	0	1	0	3	3	1	S3wsfn	S2ws
	Sunflower	1	2	0	0	2	0	3	3	0	S3wsf	S2ws
P6	Rice	1	0	0	0	2	0	3	3	1	S3wsfn	S2w
	Cotton	2	0	0	0	1	0	3	1	0	S3wf	S1w
	Bengalgram	1	2	0	0	1	0	3	3	2	S3wsfn	S2ws
	Sunflower	1	2	0	0	1	0	3	3	1	S3wsfn	S2ws
P7	Rice	3	0	0	0	2	0	3	3	0	S3wf	S1w
	Cotton	0	0	0	0	0	0	3	1	0	S3f	S1
	Bengalgram	1	0	0	0	0	0	3	3	1	S3wsfn	S2w
	Sunflower	1	0	0	0	1	0	3	3	0	S3wf	S1w

Limitations: 0- No; 1-Slight; 2-Moderate; 3-Severe, 4-Verysevere

Suitability classes: f-Soil fertility limitations; s-Physical soil limitations; w-Wetness limitations; n-Salinity (and / or alkalinity) limitations.

Cont...

Pedon	Crop	Wetness (w) Drainage	Physical soil characteristics (s)			CaCO ₃	Fertility characteristics (f)			Salinity/ alkalinity (n)		
			Texture	Coarse fragments	Soil Depth		Sum of basic cations (cmol (p+) kg ⁻¹ soil)	pH (1:2.5 H ₂ O)	OC (%)	ESP	Actual land suitability sub class	Potential land suitability subclass
P8	Rice	3	3	0	0	0	0	1	3	1	S3wsfn	S2ws
	Cotton	0	2	0	0	0	0	3	1	0	S3sf	S2s
	Bengalgram	1	2	0	0	0	0	3	3	3	S3wsfn	S2ws
	Sunflower	1	2	0	0	1	0	3	3	1	S3wsfn	S2ws
P9	Rice	1	1	0	0	1	0	1	3	0	S3wsf	S1ws
	Cotton	2	0	0	0	1	0	3	1	0	S3wsfn	S2ws
	Bengalgram	1	2	0	0	1	0	3	3	1	S3wsf	S1ws
	Sunflower	1	2	0	1	2	0	3	3	0	S3wsf	S1ws
P10	Rice	1	1	0	0	1	0	1	3	0	S3wsf	S1ws
	Cotton	2	0	0	0	1	0	3	1	0	S3wf	S1w
	Bengalgram	1	2	0	0	1	0	3	3	1	S3wsfn	S2ws
	Sunflower	1	2	0	0	1	0	3	3	1	S3wsfn	S2ws
P11	Rice	1	1	0	0	1	0	1	3	0	S3wsf	S1ws
	Cotton	2	0	0	0	1	0	2	1	0	S3wf	S1w
	Bengalgram	1	2	0	0	1	0	2	3	1	S3wsfn	S2ws
	Sunflower	1	2	0	0	1	0	2	3	0	S3wsf	S1ws

Limitations: 0- No; 1-Slight; 2-Moderate; 3-Severe, 4-Verysevere

Suitability classes: f-Soil fertility limitations; s-Physical soil limitations; w-Wetness limitations; n-Salinity (and / or alkalinity) limitations.

Management practices

Drainage (P1 to P11) is a major limiting factor for paddy cultivation because it does not allow maintaining standing water, which can be corrected by giving irrigations in frequent intervals. The organic carbon is a major limiting factor for pedons from P1 to P11, hence organic carbon status in soils can be improved by the application of farmyard manure, or green manuring with legumes. The limitation of texture (P2 to P11) can be corrected by mixing the soil with tank silt year after year. Alkalinity (P5 to P11) can be controlled by application of gypsum there by replacing sodium on exchangeable complex with calcium ions and the replaced sodium can be leached out of the root zone. The high pH (P3 to P11) can be lowered by application of amendments like sulphur or locally available spent wash.

Conclusions

In conclusion, the soil site suitability evaluation of study area revealed that all the pedons were marginally suitable (S3) for growing rice, cotton, sunflower and bengalgram crops. Pedon 2 is marginally suitable for growing rice, bengalgram and sunflower and moderately suitable for growing cotton crop. All the pedons (P1 to P11) had organic carbon and drainage

as severe limitation for growing rice, chickpea and sunflower. Texture was limitation in all the pedons except for P2 and P7. Alkalinity and pH are the major limitations for all the pedons (P2 to P11) except P1. By correcting these limitations by adopting above said management practices, sustainable yields can be achieved in these soils besides maintaining the soil health for future generations.

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