Research Article

SOIL SITE SUITABILITY EVALUATION FOR RICE IN SOILS OF TIRUPATI DIVISION OF CHITTOOR DISTRICT, ANDHRA PRADESH

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Abstract: The weighted averages of soil-site characteristics *viz.*,climate, wetness, topography, physical soil characteristics (texture, depth), fertility characteristics (CEC, base saturation and pH), salinity and alkalinity were summarized and correlated with optimum soil-site requirements for rice cultivation and assessed based on degree of limitations. The soils of pedon 1, 2, 3, 4, 5, 6, 7 and 10were grouped under moderately suitable (S2f), pedon 7 and 9 were grouped under S2sf and S2csf, respectively. Based on spatial assessment using Geographic information system (GIS) tolls indicated that the 80.9 percent soils representing 26831 ha were under S2f and 8.5 and 10.6 percent of study area representing 2806 and 3507 ha grouped under S2sf and S2csf, respectively.

Keywords: *Geographic information system, Moderately suitability, Soil-site characteristics*

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Introduction

Rice (*Oryza sativa* L) is the major food grain crop and more than two billion people depend on rice and value-added rice-based products for their energy requirement. In India, during 1960's rice was cultivated only in an area of 340.5 lakh ha with the production of 345.7 lakh tonnes with the average productivity of 1013 kg ha^{-1}. The maintenance and enhancement of fertility without hampering the *in-situ* soil nutrient imbalance in the intensive rice-based cropping systems, is pre-requisite to maintain and enhancing current production levels.

The detailed characterization of soil resources, evaluation and subsequent mapping for their interpretation attains greater significance. The soil-site suitability provides the detailed inventory about nature and extent of land resources and their distribution for making predictions based on their potentialities and limitations in a given agro-ecosystem [1].

Rice is the major crop being cultivated in an area of 41080 ha during rabi season and 10812 ha during kharif season in Chittoor district of A.P, out of which 80.3 percent of area confined in Tirupati division only and limited patches present in the western mandals of the district with concentrated in Kuppam and Palamaneru. The cultivation of short stature, fertilizer responsive high yielding varieties with best management practices have resulted higher yields and economic returns, but recent years unfortunately the average yield remained static, rather declining trend, in spite of all management practices such as fertilizers, selection of good varieties and control of pest and diseases. For instance, rice yields ranged from 2100 kg ha^{-1} to 5971 kg ha^{-1} with average productivity of 3300 kg ha^{-1}, which was far lesser than the world's average productivity of 4360 kg ha^{-1} [2]. Further to increase rice yields on sustainable basis crop suitability evaluation is essential to know the limitations and management options available to address them.

Materials and Methods

The study area of Tirupati division consists of three agricultural divisions *viz.*, Satyavedu, Srikalahasti and Tirupati and comprised of fifteen mandals *viz.*, 1. Satyavedu, 2.Varadaiahpalem, 3. Nagalapuram and 4. Pichatur (Satyavedu sub-division), 5. Srikalahasti, 6.Tottambedu, 7. B.N Kandriga, 8. K.V.B Puram and 9.Yerpedu (Srikalahasti sub-division) and 10. Tirupati (U), 11. Tirupati (R), 12. Chandragiri, 13. Renigunta, 14. Pakala and 15. Pulicherla mandals (Tirupati sub-division) which falls under southern agro climatic zone (NARP-AP-3) and geographically located between 13.28 to 14.0 N latitude and 78.88 to 80.13 E longitude with an elevation between from 53 m and 183 m from mean sea level (MSL).
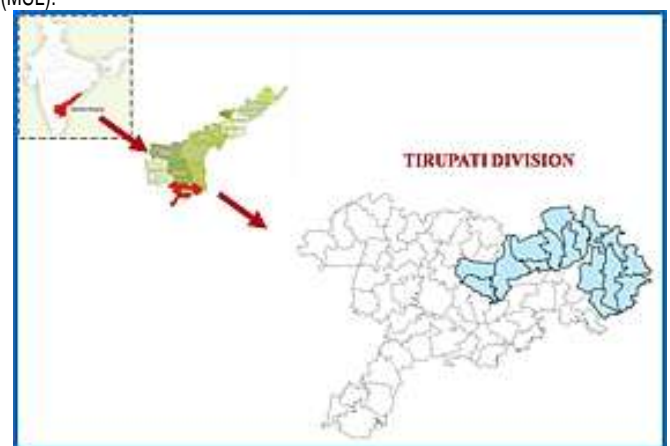

Fig-1 Location map of the study area is depicted

Table-1 *Methods of soil analysis*

S	Analytical property	Method	Reference
1	Texture analysis	International pipette method	[3]
2	Bulk density	Clod method	[4]
3	Particle density	Pycnometer method	--
4	Soil reaction (pH)	Potentiometry (1:2.5)	[5]
5	Electrical conductivity	Conductometry (1:2.5)	[5]
6	Organic carbon	Chromic acid wet digestion method	[5]
7	Cation exchange capacity (CEC)	1 N Ammonium acetate method	[6]
8	Exchangeable Ca and Mg	Complexometric titration - Versenate method	[7]
9	K & Na	Ammonium acetate method	[5]

Table-2 *Soil-site characteristics (weighted averages) for crop suitability*

Pedon No.	Wetness (W) drainage	Physical soil characteristics (s)				Soil fertility characteristics (f)					Salinity and alkalinity (n)	
		Texture	Coarse fragments volume (%)	Soil depth (m)	Slope (%)	CEC [c mol (p+) kg^{-1} soil]	Sum of basic cations [c mol (p+) kg^{-1} soil]	BS	pH 1:2.5	% OC (0-15 m)	EC (dS m^{-1})	ESP
1	Moderately well drained	sc	Nil	1.25	0-1	17.6	14.5	81.0	7.86	1.17	2.21	0.25
2	Moderately well drained	scl	Nil	1.40	0-1	18.0	13.7	76.0	7.87	0.52	1.85	0.54
3	Moderately well drained	scl	Nil	1.30	0-1	16.0	12.1	70.5	7.61	0.85	2.50	0.29
4	Imperfectly drained	scl	Nil	1.35	0-1	14.1	12.0	80.2	8.91	0.98	3.97	13.79
5	Moderately well drained	scl	Nil	1.25	0-1	19.6	17.4	77.8	7.98	0.65	1.60	0.19
6	Moderately well drained	scl	Nil	1.35	0-1	19.2	14.7	77.6	7.84	0.91	2.28	0.44
7	Well drained	sl	Nil	1.40	0-1	16.5	11.0	67.8	7.90	0.65	1.80	0.42
8	Imperfectly drained	cl	Nil	1.40	0-1	21.3	17.5	81.1	8.36	0.72	2.28	0.44
9	Imperfectly drained	scl	Nil	1.25	0-1	24.4	19.2	77.1	7.60	0.39	0.37	0.63
10	Moderately well drained	scl	Nil	1.35	0-1	26.4	21.4	80.7	8.08	0.65	1.77	0.41

Table-3 *Crop suitability requirements for rice crop*

Soil-site characteristics		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic Regime	Mean temperature in growing season	°C	30.-34	35-38 21-29	39-40 15-20	>40 <15
	Total rainfall	mm	1110-1250	900-1110	750-900	<750
Land Quality	Land characteristics					
Oxygen Availability to Roots	Soil drainage	Class	Imperfectly drained	Moderately drained	Well drained; somewhat excessively drained	Excessively drained
	Free from flooding (duration)	Months	>4	3-4	2-3	
	Depth of water	cm	<10	10-20	>20-40	>40
Nutrient Availability	Texture*	Class	c, sic, cl, sicl, sc	scl, sil, l	sl, ls	s
	pH	1:2.5	5.5-6.5	6.4-7.5 4.5-5.4	7.6-8.5	>8.5 <4.5
	CaCO$_3$ in root zone	(%)	<15	15to 25	25 to 30	>30
Rooting Conditions	Effective soil depth	cm	>75	51 to 75	25 to 50	<25
Soil Toxicity	Salinity (EC saturation extract)	dS/m	<3	3 to 6	6 to 10	>10
	Sodicity (ESP)	%	<15	15 to 40	40 to 50	>50
Erosion Hazard	Slope	%	0 to 1	1-3	3-5	>5

Ten typical profiles representing the soils of Tirupati division were selected and collected horizon wise soil samples were collected and studied for morphological, physico-chemical and electro chemical properties by adopting standard procedures [Table-1].

The soil-site characteristics *viz.*, topography (% slope), wetness (flooding and drainage), physical soil characteristics (texture / structure, % coarse fragments by volume, soil depth in cm, CaCO3), soil fertility characteristics (CEC, base saturation, sum of basic cations, pH, % organic carbon) and salinity (EC) and alkalinity (ESP) were considered for crop suitability evaluation for rice cultivation.

Results and Discussion
The soil-site characteristics calculated on weighted average basis based on depth wise properties [Table-2] were compared with soil-site suitability requirements of rice [Table-3] at different limitations levels: no (0), slight (1) moderate (2) severe (3) and assessed the rice suitability [Table-4] The Limitations are deviations from the optimal conditions of a land characteristic, land quality, which adversely affect kind of land use [8]. The soils were moderately well to imperfectly drained, sandy clay to sandy loam in texture with leveled (<1 percent slope). The CEC ranged from 14.1 to 26.4 c mol (p+) kg^{-1} with medium to high base saturation (67.8 to 81.1 percent). The pH, O.C, E.C values ranged from 7.60 to 8.91, low to medium (0.39 to 1.17 percent) and non saline to saline (0.37 to 3.97 dS m^{-1}). The ESP is very low except pedon 4 (13.79 percent).

Crop suitability evaluation
Rice was grown wide variety of climate, soil, hydrological regimes and requires temperature of 21 to 35 °C with water requirement of 1110 to1250 mm and soil pH

of 4.5-8.0. The heavy textured soils *viz.*, clay, clay loam and loamy soils were most suited for rice cultivation. The soils of pedons 1, 2, 3, 4, 5, 6, 7 and 10were grouped under moderately suitable (S2f) with moderate limitation of soil pH. The soils of pedon 7 grouped under moderately suitable (S2sf) with moderate limitations of soil reaction, texture and wetness. Whereas, the soils of pedon 9 grouped under moderately suitable (S2csf) with slight limitations (>3) of climate, texture and fertility characteristics.
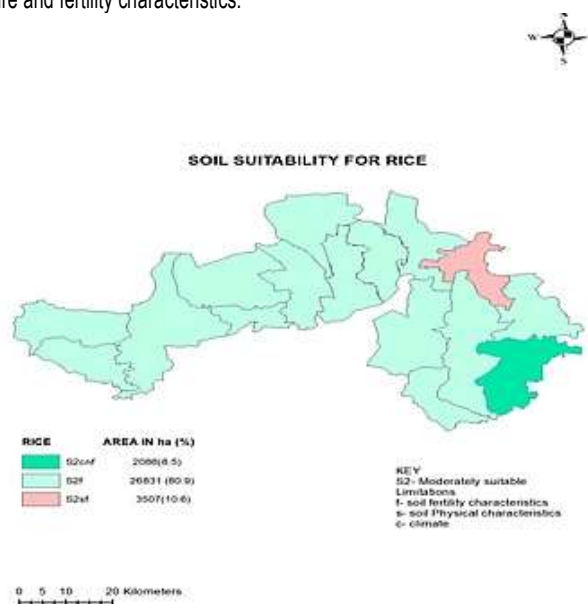

Fig-2 Soil-site suitability map for Rice crop in Tirupati division

Similarly assessed soil site suitability for rice, the soils of Rajental, Algol and Zaheerabad and found moderately suitable (S2) due to limitations of slope and high permeability and marginally suitable (S3) in Parvatapur, Bilalpuur and Krishnapur due to severe limitations of slope (3 to 5percent) [9]. The soils of Nalgonda were moderately suitable for rice cultivation. Further, the suitability might be modified to highly suitable (S1) by soil reclamation through gypsum application and adequate drainage [10].

Based on the spatial analysis of soil-site suitability for rice using GIS tools indicated that the study area was categorized as moderately suitable (S2) with three sub-classes *viz*., S2f, S2sf and S2cnf with the extent of 2806, 26831 and 3507 ha, which represents 8.5, 80.9 and 10.6 percent of rice grown soils, respectively [Fig-1]. Similarly, assessed crop suitability for rice using GIS and revealed that 75 percent cultivated area was highly suitable and remaining 25 percent was moderately suitable for rice cultivation [11].

Conclusion

The soils of pedon 1, 2, 3, 4, 5, 6, 7 and 10 were grouped under moderately suitable (S2f) for rice with the extent of 26831 ha (80.9 percent) and pedon 7 and 9 were grouped under S2sf and S2csf with the extent of 2806 and 3507 ha, representing 8.5 and 10.6 percent, respectively. The suitability rating of the soils improved by application of gypsum @ 2 to 4 tonnes ha^{-1}, raising of green manure crop especially daincha once in three years.

Application of research: The soil suitability assessment for rice very useful to delineate the areas which are not suitable and moderately suitable from highly suitable areas and discourage the rice for unsuitable areas and to recommend appropriate management practices for moderately suitable areas for sustainable yields.

Research Category: Crop suitability evaluation

Abbreviations: S1- highly suitable S2- moderately suitable and Geographic information system (GIS)

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Study area / Sample Collection: Tirupati division of Chittoor district

Cultivar / Variety / Breed name: Soil-site suitability

Conflict of Interest: None declared

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Ethical Committee Approval Number: Nil

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