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Classification and Mapping of Rice Growing Soils in Tirupati Division of Chittoor District of Andhra Pradesh Using *Arc*GIS

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ABSTRACT

The scientific inventory involving detailed characterization of land resource base and ensuing classification are momentous in deciding the productive potential of soils for various land use. Similar soils with known soil characteristics proxy suitable crops could be propounded for scientific management of land, water and other input resources. Ten typical pedons representing rice growing soils of Tirupati division were studied for morphology, physical, physico-chemical properties and classified the soils based on keys to soil taxonomy and further mapping was done by using *Arc*GIS *ver.* 10. The soils of pedons 2 and 5 were classified under Typic Haplustepts with the extent of 4624 ha representing 14.0 per cent of study area. The pedons 3 and 6 were classified under Typic Haplustalfs with the extent of 6721 ha representing 20.3 per cent. The soils of pedons 8, 9 and 10 were classified under Typic Endoaquepts with the extent of 13172 ha representing 39.7 per cent. The soils of pedon 1, 4 and 7 were classified under Vertic Haplustepts, Typic Natraqualfs and Typic Ustorthents with the extent of 2404ha, 2716 ha and 3507 ha representing 7.3, 8.2, and 10.5 per cent of rice growing soils, respectively.

Keywords: *Characterization, Classification and Mapping and Geographic information system.*

The detailed characterization of soil resources, evaluation and subsequent mapping attains greater significance for their interpretation for land use. The soil survey, which 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 (Mandal and Sharma, 2005). However, traditional soil survey methods are tedious, time taking and cost involved is higher and hence, new technological advances such as Global positioning system (GPS) and Geographical information system (GIS) which provides reliable and accurate information for resource planning and further monitoring the soil resources in spatially and temporally (Shrestha, 2006).

Rice is the major food grain crop 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 70 and 49.6 percent of area during *rabi* and *kharif*, respectively is confined to Tirupati division only. The majority of rice area in study area was confined to two farming situations *viz.,* Canal irrigated under Araniyar, Swarnamukhi, Teluguganga ayacut area in Srikalahasti, Tottambedu, B.N Kandriga, Varadaiahpalem, Satyavedu, Pichatur mandals and Tube well/bore well irrigated area under Pulicherla, Pakala, Chandragiri, Renigunta, KVB Puram, Pichatur, Nagalapuram and Varadaiahpalem mandals with rice - groundnut, rice - rice, rice - jowar/bajra, rice - vegetables and fallow - rice cropping systems under varied land forms and management practices.

To know the potentialities and limitations of rice growing soils the detailed information on soil morphological, physico-chemical properties and classification as per the USDA method is highly essential, but such information related to rice growing soils of Tirupati division is not available. Therefore present study was carried out to classify the soils and mapping using *Arc*GIS techniques enables us in grouping them for effective management.

MATERIAL 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 agricultural division), 5. Srikalahasti, 6.Tottambedu, 7. B.N Kandriga, 8. K.V.B Puram and 9.Yerpedu (Srikalahasti agricultural division) and 10. Tirupati (U), 11. Tirupati (R), 12. Chandragiri, 13. Renigunta, 14. Pakala and 15. Pulicherla mandals (Tirupati agricultural division) which falls under southern agro climatic zone (NARP-AP-3), southern plateau and hills zone (Planning commission of India - X) and geographically, located between 13° 28 to 14.0 N latitude and 78.88 to 80.13 E longitude with an elevation between 53 m and 183 m from mean sea level (MSL).

Ten typical profiles representing rice growing soils were studied by digging pits of size 1m x 1m up to parent material by throwing the dugout soil towards north and south so that east and west faces are used

for profile study with maximum sunshine on the face of the profile at the time of sampling. Fresh surface layer was exposed without any tool marks and considering variations in colour, structure, texture, consistency *etc.*, horizon boundaries were demarcated and carefully observed for diagnostic properties and other variations.

The presence of diagnostic soil horizons, both surface and sub-surface, soil moisture regimes, soil temperature regimes and physical, physico-chemical and chemical properties of soils determined in the present study were used for classifying the rice growing soils of Tirupati division of Chittoor district (Table.1). The rice growing soils classified into different orders, sub-orders, great groups, sub-groups, and families as per USDA Soil Taxonomy (Soil Survey Staff, 2014)

Preparation of soil classification map

The latitude and longitudes at every profile location were collected using a hand-held GPS instrument (GARMIN-GPS60CSx). The GPS technology proved to be very useful for enhancing the spatial accuracy of the data integrated in the GIS. The *Arc*GIS version 10 was used for preparation of soil map. Based on the location data obtained, was point feature showing the position of samples in MS excel format and linked with the spatial data by join option in Arc Map. The location of profile were depicted on the study area (Fig.2)

RESULTS AND DISCUSSION

Ten typical pedons from rice growing soils under different rice based farming situations of Tirupati division were selected and horizon wise soil samples were collected and studied for morphological properties in the field and further the samples were processed and analyzed for physical properties *viz.,* particle size distribution, bulk density, particle density and maximum water holding capacity; physico-chemical properties *viz.,* soil pH, EC and organic carbon; electrochemical properties *viz.,* CEC, percent base saturation and ESP. Based on these characteristics and climate of the study area all the pedons were classified up to family level as per Soil Survey Staff (2014).

At order level

Soil order is the highest category under taxonomic classification system and categorized based on morphology as produced by soil-farming processes and indicated by the presence or absence of major diagnostic horizons**.**

The pedon 7 was evidenced by slight degree of profile development with no distinct diagnostic horizons due to extreme texture, hence it was classified as Entisols at order level. Similarly Gogoi *et al.* (2018) classified the rice growing soils into Entisols based on absence of any diagnostic horizon other than ochric epipedon and Vedadri and Naidu (2018) classified the soils of Nellore under Entisols due to absence of any diagnostic horizon.

The pedon 1, 2, 5, 8, 9 and 10 showed better horizonization than pedon 7 and evidenced the formation of secondary clay minerals and their accumulation in sub-surface horizons, and did not possess any sub-surface diagnostic horizons *viz.,* duripan, argillic, calcic, gypsic, fragipan *etc.* other than cambic horizon, which was formed by physical alterations. Hence, these pedons were classified under Inceptisols at order level. Similarly based on the occurrence of cambic sub-surface horizon the rice growing soils were categorized as Inceptisols by Singh and Agarwal (2005), Gogoi *et al.* (2018) and Kumar *et al.* (2019).

The soils of pedon 3, 4 and 6 evidenced the presence of thin, patchy cutans on ped faces in sub-surface horizons and clay content was 120% higher than above horizons enriched by process of clay illuviation and the per cent base saturation was > 35 per cent throughout the profile depth, hence these pedons were classified under Alfisols at order level. Similarly Dutta *et al.* (2017a) classified the rice cultivated soils of Jorhat district, Assam into Alfisols order based on base rich (> 35 per cent) argillic sub-surface horizon.

At sub-order level

The sub-order emphasizes genetic homogeneity, wetness, climatic enrichment especially soil moisture regime of the study area. In pedon 7, soil moisture did not reduced by water saturation below 25 cm from soil surface and presence of coarse textured soil with absence of rock fragments and showed decreased organic carbon in profile and hence it was grouped under Orthent at sub-order level.

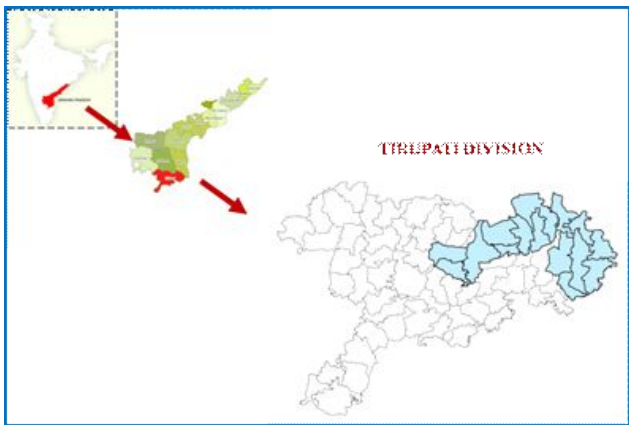

Fig. 1 Location map of the study area is depicted

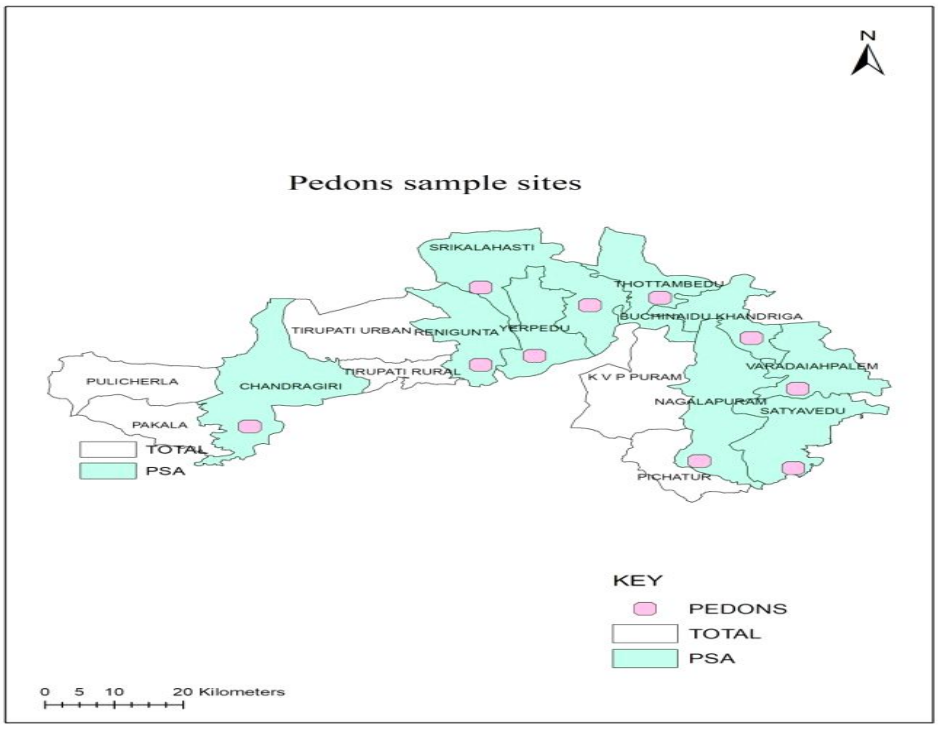

Fig.2. Pedon locations depicted in the study area

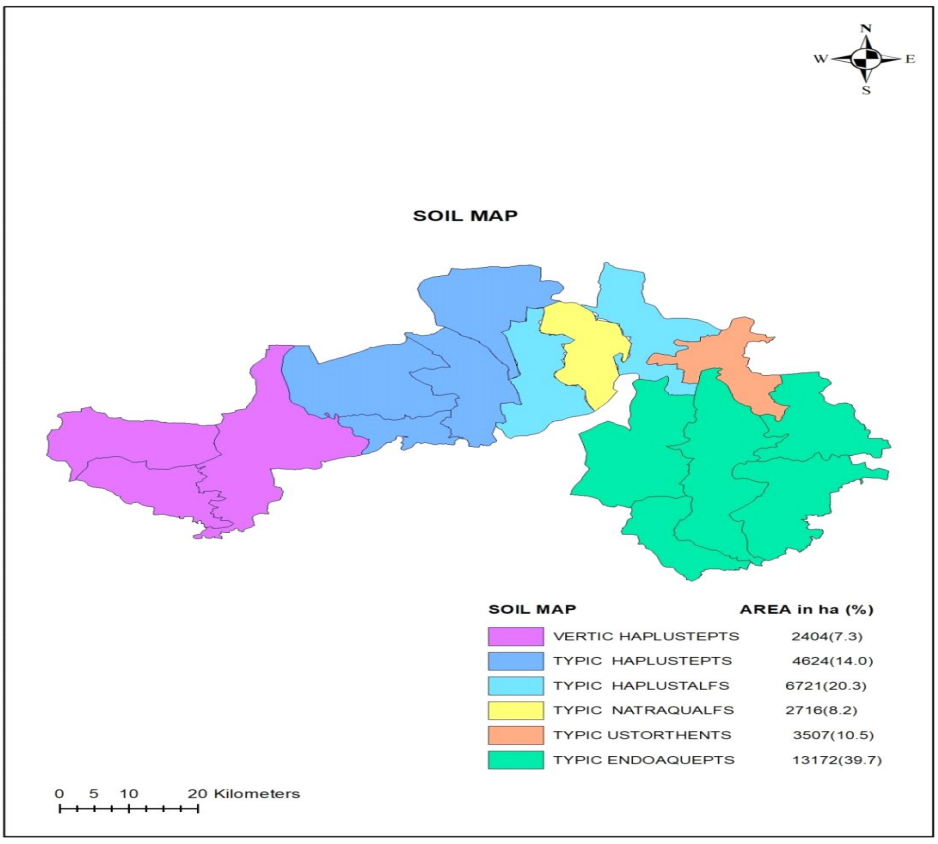

Fig 3. Soil classification map of rice growing soils of Tirupati division

Table 1. Standard methods for profile characterization

S.No	Analytical property	Method	Reference
Soil Morphological properties			
1	Soil colour	Munsell's colour Chart	Soil Survey Staff (1951)
Physical properties			
1	Texture analysis	International pipette method	Piper (1966)
2	Bulk density	Clod method	Singh (1980)
3	Particle density	Pycnometer method	--
4	Water holding capacity	Keen Raczkowaski box method	Piper (1966)
Physico-chemical properties			
5	Soil reaction (pH)	Potentiometry: using soil water suspension of 1:2.5 ratio	Jackson (1973)
6	Electrical conductivity	Conductometry using soil water suspension of 1:2.5 ratio	Jackson (1973)
7	Organic carbon	Chromic acid wet digestion method	Jackson (1973)
8	Cation exchange capacity (CEC)	1 N Ammonium acetate method	Bower *et al* . (1952)

Pedon 1, 2, 3, 5, 6 and 7 exhibited Ustic moisture regime as the SMCS was moist for more 180 cumulative days and continuously moist for more than 90 consecutive days and hence classified under Ustepts (pedon 1, 2 and 5) Ustalfs (pedon 3 and 6).

The Ap horizon soils of pedon 4, 8, 9 and 10 saturated with water with redoxymorphic features at a depth of below 25 cm from the mineral soil surface due to poor drainage and hence classified under Aqualfs (pedon 4) and Aquepts (pedon 8, 9 and 10) at sub-order level.

At great group level

The pedons did not report presence of duripan, plinthite, sulphuric and sombric horizons and the per cent base saturation exceeds 60 per cent within the depth of 0.25 to 50 cm and indicated the central concept of sub-orders and hence grouped as Haplustepts (pedon 1, 2 and 5), Haplustalfs (pedon 3 and 6) and Ustorthents (pedon 7) The pedons 8, 9 and 10 did not exhibited fragipan, sulphuric, plinthite and other features, hence classified under Endoaquepts and whereas the pedon 4 showed natric horizon (ESP > 15 per cent) without duripan at a depth between 30 cm and 150 cm, hence classified under Natraqualfs at great group level.

At sub-group level

The soils were classified under Typic Haplustepts (pedon 2 and 5), Typic Haplutalfs (pedon 3 and 6) and Typic Ustorthents (pedon 7) due to the absence of Lithic contact within 50 cm depth and andic, aquic properties within 75 cm depth, and calcic, gypsic sub-surface horizons, base saturation > 60 per cent in all the horizons with no vertic properties and further did not exhibit intergradations from the central concept of each great group.

The pedon 1 has showed vertic properties *viz.,* cracks with more than 30 per cent clay on weighted average up to 100 cm depth and hence grouped under vertic Haplustepts.

The pedon 8, 9 and 10 were classified under Typic Endoaquepts, whereas the pedon 4 was classified under Typic Natraqualfs due to absence of mollic, glossic and albic horizons.

At family level

Particle size class

The pedon 1 and 8 has more than 35 to 60 per cent clay on weighted average basis and hence grouped under Fine particle size class. The pedons 2, 3, 4, 5, 6, 9 and 10 exhibited 18 to 35 per cent clay and grouped under Fine loamy particle size class. Whereas, pedon 7 has less than 18 per cent clay and hence categorized as coarse loamy particle size class.

Mineralogy class

Based on CEC to clay ratio, physico-chemical and electro-chemical properties, the mineralogy class of all the pedons grouped under mixed mineralogy class

Temperature class

The Mean annual soil temperature (MAST) of the study area was 31.9 ^{0}C, which was arrived by adding 3.5 ^{0}C to MAAT (Mean annual air temperature) as the study area situated between 8^0 to 16 ^{0} N and classified as Megathermic (Soil survey staff, 1998).

The Mean summer soil temperature (MSST) was 31.9 ^{0}C by addition of 2.5 ^{0}C to mean summer air

temperature (MSAT) of study area and subtracting amplitudinal factor (1/6th of difference between mean summer and mean winter air temperature). Similarly mean winter soil temperature (MWST) of 26.4 ^{0}C was calculated (Van Wambeke, 1985) and difference between MSST and MWST was less than 6 ^{0}C and MAST of the study area was more than 28^{0}C. Therefore temperature class of rice area was isohyperthermic

Based on Typifying pedon characteristics and climate data, the rice growing soils of Tirupati division were classified as follows

Pedon 1-Fine, mixed, isohyperthermic, Vertic Haplustepts

Pedon 2 and 5-Fine loamy, mixed, isohyperthermic, Typic Haplustepts

Pedon 3 and 6-Fine loamy, mixed, isohyperthermic, Typic Haplustalfs

Pedon 4-Fine loamy, mixed, isohyperthermic, Typic Natraqualfs

Pedon 7-Coarse loamy, mixed, isohyperthermic, Typic Ustorthents

Pedon 8-Fine, mixed, isohyperthermic, Typic Endoaquepts

Pedon 9 and10- Fine loamy, mixed, isohyperthermic, Typic Endoaquepts

CONCLUSION

Based on morphological characteristics, physical, physico-chemical, presence or absence of diagnostic horizons, soil moisture regime and climatic attributes of the study, the soils of pedons 2 and 5 were classified as Typic Haplustepts representing 14.0 per cent of study area. The pedon 3 and 6 were classified Typic Haplustalfs representing 20.3 per cent. The pedon 8, 9 and 10 were classified under Typic endo aquepts representing 39.7 per cent and the soils of pedon 1, 4, 7 and were classified as Vertic Haplustepts, Typic Natraqualfs and Typic Ustorthents representing 7.3, 8.2 and 10.5 per cent, respectively based on USDA soil taxonomic classification.

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