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# Characterization, and evaluation for crop suitability in lateritic soils

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**Six typical representative pedons viz., Rejental ($P_1$), Parvatapur ($P_2$), Algol ($P_3$), Bilalpur ($P_4$), Zaheerabad ($P_5$) and Krishnapur ($P_6$) of Zaheerabad Mandal in Medak district of Andhra Pradesh were studied for their morphological, physical and physico-chemical properties and their suitability to rice, sugarcane and potato cultivation. The soils are red to dark brown in colour, moderately acidic to neutral (pH-5.9 to 7.0), non-saline, shallow to deep in depth. Texture ranged from loamy sand to sandy clay loam in surface soils whereas sandy to clay in subsurface with high sesquioxide percentage. Organic carbon, cation exchange capacity (CEC) and base saturation ranged from 0.04 to 0.57%, 12.0 to 38.0 c mol ($p^+$)/kg and 30.2 to 78.6%, respectively. The dominance of exchangeable ions was in the order viz. $Ca^{2+}$> $Mg^{2+}$>$Na^+$>$K^+$. Soils were low in available nitrogen (N) and phosphorus (P), low to high in available potassium (K). The soils developed with argillic ($B_t$) horizon, they were classified as Typic Haplustalfs ($P_4$, $P_5$), Lithic Rhodustalfs ($P_2$), Rhodic Kandiustalf ($P_3$), Typic Rhodustalfs ($P_1$, $P_6$). Suitability for three crops $P_1$, $P_3$, $P_5$ were moderately suitable ($S_2$), $P_2$, $P_4$, $P_6$ were marginally suitable ($S_3$). For sugarcane; $P_1$, $P_3$, $P_4$, $P_5$ were moderately suitable ($S_2$), $P_2$, $P_6$ were marginally suitable ($S_3$). For potato, $P_3$, $P_5$, $P_6$ were marginally suitable ($S_3$), Rejental, Parvatapur and Bilalpur- N $P_1$, $P_2$, $P_4$ were not suitable (N).**

**Key words:** Characterization, classification, lateritic soil, land suitability, rice, sugarcane, potato.

## INTRODUCTION

Characterization, classification and evaluation of soils for different land uses are the first milestone to develop database for formulating land use models. Soil is one of the most important natural resources and proper understanding of its properties is necessary for judicious, beneficial and optimal use on suitable basis (Jagdish et al., 2009). Such basic information about the soils is provided by soil survey (Jagdish and Mandal, 1996; Jagdish, 2000; Ray et al., 2000). Studies relating to soil and site characteristics and crop requirements form the basis for soil suitability evaluation and formulation of meaningful land use plan (Hagen, 1990; Meena et al., 2009). Laterite soils are typically formed under tropical climate experiencing alternate wet and dry seasons

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(Srivastava et al., 2000). Red and lateritic soils are generally acidic and have low cation exchange capacity (CEC), low to moderate base saturation (Buol and Cook, 1998). These soils are dominated by kaolinite clay and rich in sesquioxides. Surface crusting, poor inherent fertility, P fixation, aluminium toxicity, soil erosion among others are the major constraints in these soils (Sehgal et al., 1998). Each plant species requires definite soil and site conditions for its optimum growth (Sehgal, 2008). Soil-site suitability evaluation is devoted to the implications of different parameters on soil productivity and its result on the overall suitability class. However, at no stage, could give the number and degree of limitations and their relation with the overall suitability class (Sehgal, 2008). Yield of the crops depend on various factors. The reasons for yield variations are assigned to the variation in landforms (hilly terrain and plains), land use, management practices and the soil itself (Tamgadge et al., 2002). To achieve sustainable yields of crops besides maintaining soil health needs knowledge on morphological, physical and chemical characteristics of soils which is an essential requirement (Leelavathi et al., 2009).

Rice is not only the staple food for nearly half of the world's population as the major daily source of calories and protein, but is also a key source of employment and income for rural people (FAO, 2003). Rice ranks second in agricultural production in most Asian countries (Orhan, 2013). Little work has been done on the lateritic soils of Medak district. Out of the total cropped area (42% of total area) in the Medak district, about 47% is under cereals including rice; 28% under pulses; 18% is under commercial crops like sugarcane and cotton; 2% under oilseed; 5% under horticultural and other vegetable crops including potato (Reddy et al., 2005). Since the area is cultivated for sugarcane and rice, the evaluation of soils for the respect would be meaningful to suggest the appropriate management of soil to reap the rich harvest (Dudal, 1958; Riquier et al., 1970). Suitability of the soils for potato is also targeted as the crop is well suited to acidic (pH 5.0-6.5) soils (NBSS and LUP, 2006). Therefore, an investigation, especially in the Zaheerabad area was conducted with the view to characterize and classify the soils of the area and indexing their suitability for important crops and recommending the suitable fertility and physical soil managements.

## MATERIALS AND METHODS

### Soil and climatic resource

The laterite and lateritic soils occur in the districts of Srikakulam, Visakhapatnam, East Godavari, Nellore and Medak of Andhra Pradesh. Laterite soils cover an area of 82,869 hectares in the Medak district occupying 61,793 ha (56.6%) in Zaheerabad area alone followed by Sadasivapet (Reddy et al., 2005). The district forms a part of Southern Deccan Plateau. Physiographically, the district is located between 17°27' and 18°18' N latitudes and 79°10' and 77°28' E longitudes and 306 to 662 m above MSL. The average rainfall is 890 mm of which 76, 14 and 8% are received during the south-west monsoon, north-east monsoon and summer, respectively. The mean annual temperature ranges from 19.6 to 31.9°C, minimum being recorded during December (13°C) and maximum in May (38.8°C). The district is characterized by semi-arid climate. The Archaean or Peninsular gneisses occur all over the district in 6,86,853 ha or 70.7% of the area (Reddy et al., 2005) is regarded to be parent material. Length of growing period (LGP) in this region is around 90-150 days. The area is endowed with the irrigation facilities from the shallow and deep tube wells.

### Vegetation

The entire district is covered by tropical dry deciduous forest. The principal forest tree species are Terminalia tomentosa, Langerstroemia parviflora (Small Flowered Crape Myrtle), Chloroxylon sweitenia (Satinwood), Bassia latifolia (Butter tree), Azadirachta indica (Neem), Diospyros melanoxylon (Abnus), Hardwickia binata (Anjan), Anogeissus latifolia (Axlewood), Borswellia serrata (Olibanum) and Gymnosporia montana (Baikal). Some dry species plants like Ixora parviflora, Memecylon edule and Tectona grandis (Teak) are also seen mixed with other species. The geological formations encountered in the district are Archaean Group, Mesozoic-Lower Tertiary, Pleistocene, and recent (Reddy et al., 2005). The rocks associated with red and laterite soils are Deccan traps and Archaean.

### Soil survey and laboratory analysis

Six representative pedons viz., Rejental ($P_1$), Parvatapur ($P_2$), Algol ($P_3$), Bilalpur ($P_4$), Zaheerabad ($P_5$) and Krishnapur ($P_6$), were selected on lateritic soils which are normally cultivated farmers' fields. The profiles were dug up to parent rock and studied for their morphological characteristics (Soil Survey Division Staff, 1993). Soil samples were collected from each horizon of the six profiles. The samples were air dried and ground to pass through 2 mm sieve. Relevant physical and chemical properties were determined following standard analytical procedures (Black, 1965; Jackson, 1967; Gee and Bauder, 1986; Klute and Driksen, 1986; Walkeley and Black, 1934; Subbaiah and Asija, 1956; Watanabe and Olsen, 1965). The silica: sesquioxide ratio of <2 to 3 (not presented here) interpreted highly weathered tropical soils (Sehgal, 2008) and the area is generally referred as lateritic landforms (Reddy et al., 2005). The soils were characterized and classified as per Keys to Soil Taxonomy (Soil Survey Staff, 2003).

### Soil suitability evaluation for crops

The investigations on the suitability for crops viz. rice, sugarcane and potato were evaluated based on the maximum limitation method following set of FAO (1976) general guidelines of land evaluation for crop suitability established by NBSS and LUP (2006). Detailed procedures are given in guidelines of land evaluation for rain-fed and irrigated agriculture. The suitability tables (not presented here) which are based on the overall capability index (Sehgal, 2008) were used for assessing the suitability of soil for each particular crop considering the limitations. The categorizations were followed as highly suitable ($S_1$), moderately suitable ($S_2$), marginally suitable ($S_3$) and not suitable (N). Based on the field and laboratory soil studies sustainable fertility and soil management has been suggested for increasing the potentials of land.

**Table 1.** Morphological characteristics of lateritic soils of Medak district.

| Horizon | Depth (cm) | Colour | Texture* | Structure** | Consistency# | | | Boundary## | Cutans^ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Dry | Moist | Wet | | Ty-Th-Q |
| **Pedon 1- Rejental: Fine, mixed, iso-hyperthermic, Typic Rhodustalf** | | | | | | | | | |
| Ap | 0-15 | 2.5YR4/6 | c | sbk | sh | vfr | s/p | | - |
| $Bt_1$ | 15-25 | 2.5YR4/6 | c | sbk | sh | vfr | s/p | cs | T tn p |
| $Bt_2$ | 25-45 | 2.5YR4/6 | c | sbk | vfr | fr | s/p | as | T tk p |
| $Bt_2$ | 45-90 | 2.5YR4/6 | c | sbk | vfr | fr | s/p | ds | T tn p |
| **Pedon 2- Parvatapur: Loamy, mixed, iso-hyperthermic, Lithic Rhodustalf** | | | | | | | | | |
| Ap | 0-15 | 2.5YR4/6 | c | sbk | h | fr | s/p | - | |
| $Bt_1$ | 15-33 | 2.5YR3/6 | c | sbk | h | fr | s/p | cs | T tn p |
| $Bt_2$ | 33-44 | 2.5YR3/6 | c | sbk | h | fr | s/p | ds | T tk p |
| C | 44+ | Hard lithic contact which roots cannot penetrate | | | | | | | |
| **Pedon 3- Algol: Clay skeletal, mixed, iso-hyperthermic, Rhodic Kandiustalf** | | | | | | | | | |
| Ap | 0-15 | 2.5YR3/6 | scl | sbk | sh | vfr | s/p | - | |
| $Bt_1$ | 15-45 | 2.5YR3/6 | c | sbk | l | vfr | s/p | gs | T tn p |
| $Bt_2$ | 45-75 | 2.5YR3/6 | c | sbk | l | fr | s/po | ds | T tk p |
| **Pedon 4- Bilalpur: Clay Skelatal, mixed, iso-hyperthermic, Typic Haplustalf** | | | | | | | | | |
| Ap | 0-18 | 5 YR3/4 | c | g | h | fr | s/p | - | |
| $Bt_1$ | 18-50 | 10YR5/3 | c | abk | h | vfr | s/p | cs | T tk p |
| $Bt_2$ | 50-95 | 10YR3/6 | c | sbk | h | vfr | s/p | cs | T tk p |
| **Pedon 5- Zaheerabad: Fine, loamy, iso-hyperthermic, Typic Haplustalf** | | | | | | | | | |
| Ap | 0-16 | 7.5YR4/4 | scl | g | h | vfr | s/p | - | |
| $Bt_1$ | 16-70 | 2.5YR3/6 | sc | g | h | vfr | s/p | gs | T tk p |
| $Bt_2$ | 70-95 | 5 YR3/4 | sc | sbk | h | vfr | s/po | cs | T tn p |
| C | 95+ | | | | | | | | |
| **Pedon 6- Krishnapur: Skeletal, Loamy, Mixed, Iso-Hyperthermic, Typic Rhodustalf** | | | | | | | | | |
| Ap | 0-14 | 2.5YR3/6 | scl | g | h | fr | s/p | - | - |
| AB | 14-50 | 2.5YR4/6 | scl | sbk | h | fr | s/p | cs | |
| B t | 50-65 | 2.5YR4/8 | sc | sbk | h | fr | s/po | gs | T tn p |

*c, Clay; sc, sandy clay; scl, sandy clay loam; **g, granular; 1, weak; 2, moderate; sbk, subangular blocky; #, h-hard; l, loose; sh, slightly hard; fr, friable; vfr, very friable; po, none plastic; ## cs, clear smooth; ds, diffuse smooth; as, abrupt smooth; gs, gradual smooth. ^Type (Ty)-t- Argillan, Thickness (Th)- tn-thin, tk-thick, Quantity (Q)- p-patchy.

## RESULTS AND DISCUSSION

### Soil characteristics

#### *Soil morphology*

The solum depths varied (44-95 cm) from shallow with lithic contact ($P_2$) within the 50 cm depth which limited the root penetration for deep rooted crops, moderately shallow ($P_3$ and $P_6$) and moderately deep ($P_1$, $P_4$, $P_5$). The slopes varied from slight (1-3%) ($P_1$, $P_2$, $P_4$, $P_5$) to moderate (3-5%) ($P_3$, $P_6$). The soil colour varied from dark brown (10YR 5/3) to dark red (2.5YR 2/6). Red soil colour may be due to presence of sesquioxides as the colour is the function of chemical and mineralogical composition as well as textural make up of soil and conditioned by topographic position and moisture regime (Walia and Rao, 1997). The structure of the soils varied to granular, sub-angular blocky, angular blocky and single grained (Table 1). The blocky structures that is, angular and sub-angular blocky especially in subsoil was due to the presence of higher clay fractions (Sharma et al., 2004). The presence of more polyvalent electrolytes and continuous addition of organic matter through cultivation might be the reason for ganular structure in the pedons. The single grained structures of the bottom soils ($P_6$) may be due to the inert nature of the parent material. The consistence of the soils was soft to very hard (dry), loose to very firm (moist) and non-sticky to very sticky and non-plastic to very plastic (wet). Evidence of loose, friable and non-sticky and non-plastic or slightly sticky and slightly plastic consistence is attributed to low amount of expanding clay minerals (Thangasamy et al., 2004; Sarkar et al., 2001). Pedons showed thin or thick patchy cutans and also had argillic ($B_t$) and exhibited cambic ($B_w$) sub-surface diagnostic horizons. No effervescence with dilute HCl was observed in all pedons indicating absence of $CaCO_3$. The horizon boundaries were clear to diffuse in distinctness and smooth to wavy in topography. The roots in different horizons of the pedons were fine to coarse in size and few to common quantity.

## Physical characteristics

The soils have moderate to excessively drainage condition. Gravel content ranged from 14.1 to 70% and 46 % of surface soils was moderately gravelly. According to NBSS and LUP (1997), about 42% are highly gravelly, stony and rocky while 57% are non-gravelly in soils of Andhra Pradesh. The distribution of sand, silt and clay varied widely that is,17-73, 6-24 and 21-76%, respectively and this interpreted sandy clay loam to clay in texture (Table 2). The textural variation might be due to varied parent materials, topography. The maximum accumulation of clay was found in lower layers compared to surface layers in all the profiles. Profile $P_1$, $P_2$, $P_4$ and $P_5$ were clayey throughout the profile excepting $P_3$. The $P_5$ profile was sandy clay in the bottom layers and sandy clay loam in $P_6$. This may be due to *in situ* weathering and translocation of clays to deeper layers along with percolating water. These results are in conformity with earlier observations made by Reddy et al. (2005) and Klich et al. (1990). The bulk density increased with increasing depth. The presence of more organic matter influenced aggregation reducing bulk density and overhead weight at lower depths was attributed to surface layers which was attributed to overhead weight of surface layers (Gurumurthy, 1995). Much variation in hydraulic conductivity was observed, from moderately slow (1.2 cm/h) to rapid (20.6 cm/h) in different profiles (Table 2). The decrease in hydraulic conductivity may be due to increase in clay content. The water holding capacity recorded were 10.3-31.1% at 1/3 bar and 3.3-14.7% at 15 bar, indicating low water holding capacity. The sub-soils have better water holding capacity which may be due to increasing clay content. The findings are in conformity with Bhaskar and Subbiah (1995). The infiltration rate varied from moderately slow (0.71 in/hr.) to very rapid (56.70 in/hr.) and the rate decreased with time.

## Physico-chemical characteristics

The pH of the soils ranged from moderately acidic to neutral pH (5.4-7.0). In general the soil reaction increased with depth. The increase in pH at bottom layers may be attributed to accumulation of exchangeable bases. All the pedons showed very low to low electrical conductivity with values ranging from 0.012 to 0.275 dS/m, interpreting non-saline nature of the soil (<2 dS/m). The low electrical conductivity may be due to free drainage conditions which favoured the leaching of released bases with percolating water (Table 2). The CEC of the soils ranged from 12.0 to 29.8 c mol ($p^+$)/kg soil. Low to moderate CEC in these soils was due to the mixed type of kaolinitic, illitic and other clay types. The cation exchange capacity increased with an increase in depth of all the profiles which is attributed to increase in clay content at lower depths. The higher CEC in these soils compared to other red soils may be due to the presence of more amorphous materials and zeolites. The percentage base saturation (BS) ranged from 30.2 to 78.6 in the profile. The dominance of exchangeable cations followed the order; $Ca^{2+} > Mg^{2+} > Na^+ > K^+$. Same order was reported by Leelavathi et al. (2009). These soils recorded higher values of exchangeable cations in the second layers and decreased further. This may be due to removal of bases along with finer particles from surface layers and depositing same in sub-surface. The organic carbon content was low and decreased with depth because of the tropical climate which facilitates rapid mineralization at the surface. The surface samples recorded medium organic carbon content due to continuous addition of organic manures which along with roots buried during cultivation practices. All the profile samples recorded low nitrogen content. This may be due to rapid mineralization (Sehgal, 2008) leading to leaching losses. The available P in the pedons varied from low to medium. The surface soils recording higher P may be attributed to the confinement of crop cultivation to the rhizosphere and supplementing the depleted phosphorus through external fertilizer sources and fixation of more phosphorus in sub-surface layers. The available potassium content was low in all the pedons except the surface layer of Bilalpur profile and followed decreasing trend with depth. This could be attributed to more intense weathering, release of labile potassium from organic residues, application of potassium fertilizers and upward translocation of potassium from lower depth along with the capillary rise of ground water.

## Pedogenesis

A high clay content (45 to 69%) in Rejental complex; comparable in Parvatapur, Bilalpur, Algol and in layers of Krishnapur (21 to 42%) restricted further pedogenesis. However, comparatively higher clay content below the top layer *vis-a-vis* higher water holding capacity in the sub-soils of most pedons led to the development of $B_t$ horizon (Argillic horizon) favoring structural improvement (fine to medium, granular to

**Table 2.** Physical and chemical properties of lateritic soil profiles of Medak district.

| Depth (cm) | Mechanical fragments (%) | | | | Texture | B.D. (g/cm) | H.C. (cm/h) | M.R. (%) | | pH | EC (dS/m) | CEC* | O.C (%) | Avl. NPK (kg/ha) | | | Exchble. Cations* (%) | | | | BS (%) | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gravel | Sand | Silt | Clay | | | | 1/3 bar | 15 bar | | | | | N | P | K | Ca | Mg | Na | K | | |
| **Pedon 1- Rejental series: Fine, Mixed, Iso-Hyperthermic, Typic Rhodustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-15 | 16.3 | 33 | 14 | 53 | c | 1.34 | 5.7 | 12.4 | 5.7 | 6.0 | 0.067 | 18.3 | 0.57 | 151 | 20.4 | 82.9 | 5.8 | 3.8 | 0.45 | 0.18 | 55.9 | 2.5 |
| 15-25 | 15.0 | 32 | 8 | 60 | c | 1.41 | 2.1 | 28.1 | 13.5 | 6.2 | 0.077 | 22.4 | 0.49 | 113 | 15.9 | 94.1 | 7.2 | 5.2 | 0.69 | 0.16 | 59.2 | 3.1 |
| 25-45 | 17.2 | 23 | 8 | 69 | c | 1.58 | 1.2 | 17.3 | 10.9 | 6.6 | 0.063 | 25.5 | 0.27 | 100 | 9.4 | 84.3 | 6.8 | 4.2 | 0.65 | 0.15 | 46.3 | 2.5 |
| 45-90 | 20.2 | 31 | 24 | 45 | c | 1.61 | 4.1 | 22.0 | 9.2 | 6.8 | 0.079 | 16.3 | 0.21 | 38 | 2.2 | 84.5 | 3.0 | 2.4 | 0.44 | 0.12 | 36.5 | 2.7 |
| **Pedon 2- Parvatapur series: Loamy, Mixed, Iso-Hyperthermic, Lithic Rhodustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-15 | 19.1 | 28 | 22 | 50 | c | 1.33 | 5.6 | 25.3 | 12.0 | 6.2 | 0.06 | 23.1 | 0.45 | 188 | 16.8 | 85.1 | 8.1 | 5.9 | 0.56 | 0.32 | 64.4 | 2.4 |
| 15-33 | 14.2 | 24 | 16 | 60 | c | 1.41 | 4.1 | 31.1 | 9.2 | 6.4 | 0.065 | 25.2 | 0.30 | 163 | 22.8 | 82.9 | 8.8 | 3.9 | 0.8 | 0.21 | 54.4 | 3.2 |
| 33-44 | 15.3 | 26 | 12 | 62 | c | 1.44 | 2.2 | 19.2 | 12.4 | 6.3 | 0.102 | 24.3 | 0.27 | 125 | 44.6 | 80.6 | 7.4 | 4.6 | 0.72 | 0.21 | 53.2 | 3.0 |
| 44+ | | | | Lithic contact | | | | | | | | | | | | | | | | | | |
| **Pedon 3- Algol series: Clay skeletal, Mixed, Iso-Hyperthermic, Rhodic Kandiustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-15 | 35.0 | 48 | 15 | 37 | c | 1.44 | 8.3 | 22.2 | 13.3 | 5.9 | 0.061 | 15.0 | 0.49 | 151 | 24.6 | 86.0 | 6.4 | 4.3 | 0.45 | 0.3 | 76.2 | 3.0 |
| 15-45 | 35.0 | 27 | 8 | 65 | c | 1.62 | 2.4 | 26.2 | 12.5 | 6.3 | 0.118 | 14.7 | 0.27 | 100 | 68.8 | 91.8 | 8.6 | 5.6 | 0.77 | 0.25 | 43.8 | 5.2 |
| 45-75 | 45.0 | 17 | 7 | 76 | c | 1.64 | 2.09 | 28.5 | 14.7 | 7.0 | 0.094 | 17.0 | 0.15 | 25 | 21.5 | 81.8 | 7.8 | 3.2 | 0.87 | 0.2 | 31.7 | 5.1 |
| **Pedon 4- Bilalpur series: Clay Skelatal, Mixed, Iso-Hyperthermic, Typic Haplustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-18 | 30.7 | 37 | 15 | 48 | scl | 1.12 | 15.07 | 23.0 | 8.0 | 6.2 | 0.275 | 17.1 | 0.33 | 226 | 48.8 | 182.6 | 8.4 | 5.3 | 0.97 | 0.22 | 87.5 | 5.7 |
| 18-50 | 40.0 | 21 | 12 | 67 | c | 1.23 | 11.14 | 22.1 | 9.2 | 5.9 | 0.153 | 26.8 | 0.36 | 163 | 16.4 | 131.0 | 8.8 | 4.7 | 0.78 | 0.21 | 54.0 | 2.9 |
| 50-95 | 42.0 | 17 | 18 | 65 | c | 1.42 | 5.32 | 24.0 | 7.1 | 6.4 | 0.112 | 24.8 | 0.22 | 100 | 31.4 | 104.2 | 6.5 | 4.3 | 1.17 | 0.3 | 49.0 | 4.7 |
| **Pedon 5- Zaheerabad series: Fine, Loamy, Iso-Hyperthermic, Typic Haplustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-16 | 25.2 | 51 | 12 | 37 | scl | 1.22 | 2.4 | 11.2 | 4.4 | 6.4 | 0.03 | 27.2 | 0.40 | 211 | 56.9 | 134.4 | 8.0 | 3.5 | 0.96 | 0.34 | 47.0 | 3.5 |
| 16-70 | 31.0 | 46 | 7 | 47 | c | 1.32 | 1.4 | 10.3 | 3.3 | 6.1 | 0.103 | 28.7 | 0.30 | 108 | 15.6 | 82.9 | 8.4 | 4.9 | 0.89 | 0.24 | 50.2 | 3.1 |
| 70-95 | 47.0 | 52 | 8 | 40 | c | 1.34 | 6.2 | 16.1 | 6.7 | 7.0 | 0.098 | 29.8 | 0.04 | 70 | 10.1 | 107.5 | 5.7 | 4.3 | 0.17 | 0.16 | 34.8 | 0.6 |
| **Pedon 6- Krishnapur series: keletal, Loamy, Mixed, Iso-Hyperthermic, Typic Rhodustalf** | | | | | | | | | | | | | | | | | | | | | | |
| 0-14 | 40.9 | 61 | 8 | 31 | scl | 1.29 | 17.7 | 23.0 | 10.5 | 5.4 | 0.134 | 12.0 | 0.33 | 171 | 20.8 | 90.7 | 6.0 | 2.5 | 0.72 | 0.22 | 78.6 | 1.8 |
| 14-50 | 61.7 | 73 | 6 | 21 | scl | 1.54 | 20.6 | 15.0 | 5.2 | 5.9 | 0.036 | 15.3 | 0.21 | 150 | 21.7 | 84.5 | 6.4 | 3 | 0.94 | 0.2 | 68.9 | 1.3 |
| 50-65 | 70.0 | 47 | 11 | 42 | c | 1.25 | 2.1 | 17.0 | 9.0 | 6.1 | 0.012 | 20.1 | 0.15 | 51 | 24.0 | 82.0 | 5.8 | 4.3 | 0.58 | 0.13 | 53.7 | 0.6 |

B.D, Bulk density; H.C., Hydraulic conductivity; M.R., Moisture retention; * [cmol (p+)/kg], BS, base saturation; Avl., available, Exch, exchangeable, **

weak sub-angular blocky structure) signature of aggregation. A higher base saturation (>35%) and aggregated soil structure was noted in the respective horizons. Absence of carbonates was noticed in all the pedons indicating medium to intense leaching and weathering. Carbonate removal is the pre-requisite for illuviation of clay (Pal et al., 2003). Since Krishnapur pedon was situated at elevated location with higher sand content, low silt content (8 to 11%) with comparatively higher percentage of sand exhibited high degree of permeability and medium porosity. Regular distributions of organic carbon (Table 2) indicated that pedogenesis were fair enough to mark of stratification which is in conformity with the findings of Leelavathi et al. (2009) and Shalima and Anil (2010). The pedality was moderately strong in soils, which has subjected illuviation, receiving clay sediments during rains. A sharp decline of silt and clay content after first 50 cm of the soil profile further endorsed the findings. The alternate wet and dry period coupled with high temperatures are particularly conducive for removal of silicious material and simultaneous accumulation of iron and aluminium oxides (Ma and Rao, 1997; Shalima and Anil, 2010). The interplay of climate, topography and vegetation acting on parent material over a period of time results in the development of different soils (Leelavathi et al. 2009). The soils being lateritic, accumulation of large quantities of sesquioxides was not unnatural.

## Classification of soils

Mark of stratification, base saturation, distribution of silt and clays and structural development were marked as the diagnostic characteristics for classifying the soils of Medak District (Table 2). Based on morphology and soil properties, all pedons have been classified according to Soil Taxonomy (Soil Survey Staff, 2003) into the order Alfisols with argillic diagnostic horizon ($B_t$) having base saturation more than 35%. The thickness of the eluvial layers is more than $1/10^{th}$ of the total overlying horizons. The increase of clay content in illuvial layers were more than 8 and 1.2% compared to eluvial layers having clay percentage >40% ($P_1$, $P_2$, $P_4$) and < 40% ($P_3$, $P_5$, $P_6$), respectively. The difference between the mean maximum and minimum annual soil temperature is less than 5°C which qualifying for iso-hyperthermic temperature regime. The partially leaching (summer monsoon) *ustic* soil moisture regime was the criteria to place the soils under *ustalf* sub-order.

At the great group level, major emphasis is given to diagnostic horizons, base status, soil temperature and moisture regimes (Sehgal, 2008). As the colour of soils was red with hue of 2.5 YR, value of 3 (moist) and dry values differs only one unit, the pedons viz., P1, P2 and P6 were placed under Rhodustalf. A subsurface horizon of low activity clays without clay skins, CEC of <16 cmol $(p^+)$/kg soil with neutral range soil pH, clay content increased at the upper boundary within a vertical distance of <15 cm, a clear textural boundary with indistinct stratification signifies kandic horizon and this was the basis for classifying $P_3$ as Kandiustalf. Four pedons could not be qualified to any specified category at their sub-group levels which made them to classify as Typic Rhodustalf (P1, P6) and Typic Haplustalfs (P4, P5). The prefix Typic defines the central and intergraded concept to great group (Sehgal, 2008). The Pedon 2 (P2) was classified as Lithic Rhodustalf due to contact with a hard pan within the depth of 100 cm through which roots could not be penetrated. Pedon 3 (P3) was classified as Rhodic Kandiustalf at sub-group level having soil colour red with hue of 2.5YR, value of 3 (moist) coupled with *kandic* diagnostic horizon. All soils were the members of iso-hyperthermic, fine to loamy skeletal with mixed clay type at family level.

## Crop suitability, limitations and recommendations

Based on investigations made with reference to the soil properties, several limitations were picked up which deters successful production of major field crops of interest. Depending on the number of parameters and their degree of limitation, and using the criteria laid down, the overall suitability of different soil-units for a crop, is evaluated and presented in Table 3 with possible recommendations.

## Suitability for rice

Rice is grown in a wide variety of climate-soil-hydrological regimes. It requires high temperature and adequate water supply (Sys, 1985). The average temperature required throughout the life period of the crop ranged from 21 to 35°C. The area under study has few to moderate limitations due to low rainfall and higher temperature, higher degree of slope, higher percentage of coarse fragments, shallow depth and highly permeable soil conditions which are not congenial for rice crop. The temperature range is out of the desirable temperature range and they cannot be modified by management practices. The pedons $P_1$, $P_3$ and $P_5$ soils have limitations of slope and high soil permeability, so they were ranked as moderately suitable ($S_2$). More degree of slope (3-5) in $P_4$ and $P_6$ soils and high permeability (well drained) soils of $P_3$ and $P_6$ pushed them to marginally suitable ($S_3$). For rice cultivation in Medak district, about 1.4, 41.66 and 50.82% of total area is respectively categorized as highly, moderately suitable and permanently unsuitable (Reddy et al., 2005). Marginal suitability for growing rice in Ultic Haplustalfs and Typic Haplustepts was reported by Leelvathi (2007). Other concerned soil parameters like, free from flooding, depth of the water table (>1 m), having no $CaCO_3$, optimum pH, EC, ESP among others are conducive for the crop.

## Suitability for sugarcane

In general, sugarcane is grown in areas with a precipitation of 1254-2000 mm/year and an optimum temperature of 30-35°C. According to the meteorological data available, the mean monthly temperature of the district during the growing period is within the range but the area is limited by scanty rainfall. The relative humidity of the area at growth stage is within the range for sugarcane cultivation to consider under highly suitable condition (70-85%). The crop requires well drained, deep, sandy clay loam soils with depth more than 1 m, pH range 6-8, EC <2 dS/m, and on ESP of <10 are ideal for sugarcane crop. The parameters like $CaCO_3$, pH, EC, ESP among others are satisfying the crop needs. A soil depth of more than 100 cm is considered to be highly

**Table 3.** Pedon characteristics for soil suitability evaluation of Medak district.

| Soil and climatic attribute | | Pedon 1 | Pedon 2 | Pedon 3 | Pedon 4 | Pedon 5 | Pedon 6 |
|---|---|---|---|---|---|---|---|
| Climate | Altitude (m) | 306-662 | 306-662 | 306-662 | 306-662 | 306-662 | 306-662 |
| | (ft) | 1019-2204 | 1019-2204 | 1019-2204 | 1019-2204 | 1019-2204 | 1019-2204 |
| | Temperature (°C) | 13- 38.8 | 13- 38.8 | 13- 38.8 | 13- 38.8 | 13- 38.8 | 13- 38.8 |
| | Rainfall (mm) | 980 | 980 | 980 | 980 | 980 | 980 |
| | R.H. (%) | 62-77 | 62-77 | 62-77 | 62-77 | 62-77 | 62-77 |
| Land | Slope (%) | 1-3 | 1-3 | 1-3 | 3-5 | 1-3 | 3-5 |
| | Drainage | md | wd | md | md | md | wd |
| | Flooding | $f_O$ | $f_O$ | $f_O$ | $f_O$ | $f_O$ | $f_O$ |
| | Water table | >1 m | >1 m | >1 m | >1 m | >1 m | >1 m |
| Soil | Texture- s | c | c | scl | c | scl | scl |
| | ss | c | c | c | c | sc | scl |
| | Depth (cm) | 90 | 44 | 75 | 95 | 95 | 65 |
| | Coarse fragments (%) | 16.3 | 19.1 | 35.0 | 30.7 | 25.2 | 40.9 |
| | $CaCO_3$ (%) | nil | nil | nil | nil | nil | nil |
| Fertility | CEC* | 18.3 | 23.1 | 15 | 17.1 | 27.2 | 12 |
| | pH | 6.0 | 6.2 | 5.9 | 6.2 | 6.4 | 5.4 |
| | EC (dS/m) | 0.067 | 0.060 | 0.061 | 0.275 | 0.030 | 0.134 |
| | ESP | 2.5 | 2.4 | 3.0 | 8.0 | 3.5 | 2.5 |
| | O.C.(%)[0-15cm] | 0.57 | 0.45 | 0.50 | 0.33 | 0.41 | 0.33 |

C, Clay; sc, sandy clay; scl, sandy clay loam; md., moderately drained; wd, well drained; Fo, no flooding; s, surface; ss, sub- surface; *, [c mol (p+)/kg].

**Table 4.** Comparative evaluation for crop suitability with fertility and physical management practices for soils of Medak district.

| Pedon | Suitability | Major limitations | Fertility management | Physical management |
|---|---|---|---|---|
| $P_1$ | Rice ($S_2$)<br>Sugarcane ($S_2$)<br>Potato (N) | Drainage, slope, low O.C. (0.57 %), high amount of clay and coarse fragments | FYM addition, judicious use of NPK fertilizers, | Contour cultivation, addition of tank silt, drip irrigation |
| $P_2$ | Rice ($S_3$)<br>Sugarcane ($S_3$)<br>Potato ($S_3$) | Shallow depth (45 cm), drainage, low O.C. (0.45 %), acidity, hard pan, high coarse fragments | Organic matter/FYM addition, liming, judicious use of NPK fertilizers, shallow rooted crops | Check erosion by check bunds and live fence, drip irrigation, tank silt application |
| $P_3$ | Rice ($S_2$)<br>Sugarcane ($S_2$)<br>Potato (N) | Low pH (5.9) drainage, Low O.C. (0.50 %), high coarse fragments, low CEC | Addition of FYM and manures, judicious fertilization | Construction of side channels, application of tank silt drip irrigation |
| $P_4$ | Rice ($S_3$)<br>Sugarcane ($S_2$)<br>Potato (N) | High slope, high coarse fragments, low CEC, very low O.C. (0.33 %) | Addition of organic matter, judicious fertilizer use | Contour bunding, tank silt application, drip irrigation |
| $P_5$ | Rice ($S_2$)<br>Sugarcane ($S_2$)<br>Potato ($S_3$) | Coarse fragments, high bulk density, high clay content, low O.C. (0.41 %) | Organic matter/FYM addition, judicious use of NPK fertilizers | Drip irrigation, tank silt addition |
| $P_6$ | Rice ($S_3$)<br>Sugarcane ($S_3$)<br>Potato ($S_3$) | Low pH (5.4), Shallow depth (45 cm) slope, high fragments (40.8 %), coarse texture, high infiltration rate, low WHC and very low O.C. (0.33 %) | Liming, poultry manure and FYM addition, green manuring, balanced fertilization | Tank silt addition, soil compaction, drip irrigation, contour cultivation, short duration crops |

$S_2$, Moderately suitable; $S_3$ marginally suitable; N, not suitable; WHC, water holding capacity; O.C., organic carbon.

suitable, whereas, less than 50 cm depth is considered not suitable. Soils with clay loam, and silt loam are considered as highly suitable whereas, clay and sandy textures, poorly drained or excessively drained soils are considered not suitable for cultivation. Among the different pedons studied, pedons $P_1$, $P_3$, $P_4$ and $P_5$ are considered to be moderately suitable ($S_2$), as these soils are having desirable characters with few limitations to the growth of crop which is slightly contrasting as reported by Reddy et al. (2005) who reported the Medak as highly suitable. Shallow depth of $P_2$ and higher coarse fragments of $P_6$ make them marginally suitable ($S_3$) for growing sugarcane.

### Suitability for potato

Potato is a cool season crop. Satisfactory growth of tuber occurs at soil temperature between 17 to 19°C. Tuber development virtually stops at temperature above 30°C. The area is limited for higher temperature which will effect at any part of the growing period, reducing the tuber formation. Well drained, well aerated, friable, fairly deep sandy loam and medium loam soils, rich in organic carbon, acidic soils (pH 5.0-6.5) are most suitable for potato. Among profiles studied, $P_3$, $P_5$ and $P_6$ were considered to be marginally suitable ($S_3$) as they have limitations of coarse fragments (16.30 to 40.87%) in surface and subsurface soils. Texture is the soil physical property which is not possible to change. The pedons of $P_1$, $P_2$ and $P_4$ had high clay content in both surface and subsurface horizons which are not preferred for successful potato cultivation. Taking these factors into consideration these soils are considered not suitable (N) for growing potato.

## Conclusions

This random test study may provide some valuable information regarding lateritic soil management under hot dry-sub-humid lateritic belt of Deccan plateau. The area has limited water resource for irrigation usually depending mostly on tube-wells. Drought tolerant crops for example, sorghum, pearl millets, drought resistant varieties of other crops and biodiesel plant for example, jatropha cultivation can prove promising. Deep-rooted species that are able to bring up the basic cations from subsoil and deposit them on the surface as litter may be one remedy for reducing surface acidity and increasing various micro and macronutrient availabilities. If these soils are managed properly adopting improved technologies like mulching, drip irrigation, fertigation, adopting site specific nutrient management among others may be converted to potentially productive land.

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**Abbreviations: CEC,** Cation exchange capacity; **LGP,** length of growing period; $\mathbf{S_1}$**,** highly suitable; $\mathbf{S_2}$**,** moderately suitable; $\mathbf{S_3}$**,** marginally suitable; N, not suitable; **BS,** base saturation; $\mathbf{P_1}$**,** Rejental; $\mathbf{P_2}$**,** Parvatapur; $\mathbf{P_3}$**,** Algol; $\mathbf{P_4}$**,** $\mathbf{P_5}$**,** Bilalpur; Zaheerabad; $\mathbf{P_6}$**,** Krishnapur.

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