Land suitability evaluation for crops in Eturunagaram division of Warangal District, Telangana State

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Abstract
Six typical Pedon from central and eastern part of Warangal district, Eturunagaram division in Telangana State were evaluated for their suitability to major crops viz., rice, cotton, maize, redgram and chilli. In the study area, 6 pedons samples were collected and characterized. Crop suitability classification was carried out adopting FAO guidelines. The suitability classes ranged from highly suitable to permanently not suitable to these crops. Pedon 1 was not suitable for rice, moderately suitable for maize and chilli and highly suitable for redgram. Pedon 2 was highly suitable for maize chilli and redgram slightly suitable for rice cultivation and moderately suitable for cotton cropping. Pedon 3 moderately suitable for cultivation of the irrigated-dry crops maize, cotton, chilli and redgram and highly suitable for rice cultivation due to drainage related constraints. Very severe soil limitations in pedon 4 made it unsuitable for cultivation of arable crops except redgram, for which it was slightly suitable. Maize, chilli and redgram cultivation was highly suitable for pedon 5 soils. Pedon 6 was moderately suitable for cultivation of the irrigated dry crops and highly suitable for cultivation of rice crop. Soil constraint analysis was done and remedial measures were also suggested.

Keywords: Soil, soil taxonomy, limitation levels, potential and land suitability

1. 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 [1]. 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 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[2]. Proper use of this vital natural resource influences the existence of life systems and socio-economic development of any country. The performance of any crop was largely dependent on soil parameters (depth, texture, drainage etc.) as conditioned by climate and topography. The study of soil-site characterization for predicting the crop performance of an area forms land evaluation. According to Wambke (1998), land evaluation was the rating of soil for optimum returns per unit area. The yield influencing factors for crops have to be evaluated and the results obtained may be applied for higher production of these crops through proper utilization of similar soils that occur elsewhere in same agro-climatic sub-region under scientific management practices (Khadse and Gaikwad, 1995).

Land suitability evaluation is the process of estimating the potential of land for land use planning[3]. However, each crop requires specific soil and climatic conditions for its optimum growth. Information on soil site suitability for crops in Eturunagaram division of Warangal district, Telangana state is lacking. Hence, an attempt has been made to evaluate the soil suitability for five major crops viz., rice, cotton, maize, chilli and redgram on Alfisols, Entisols, Inceptisols and Vertisols in central and eastern parts of Warangal district of Telangana state.
2. Materials and Methods

2.1 Description of the study area

The area selected for the present study, Eturunagaram division in Warangal district, lies in central Telangana Zone in Telangana State has a total geographical area of 820 km² which lies between 18° 20’ 08.10’’N latitude 79° 36’ 10.72’’East longitudes. The climate is semi-arid with district summer, winter and rainy seasons. The mean annual rain fall is 803.2 mm of which 90.11% received during South-West monsoon, 4.80% during summer season.

The mean annual temperature is 28°C and the mean maximum and minimum temperature of the district are 32.44°C and 23.31 °C respectively. The maximum and minimum mean monthly temperature ranges from 17°C to 40.8°C. The lowest temperature is recorded during December month (17.0°C) and the maximum during May (40.8°C). The soil moisture regime is ustic, and soil temperature regime is isohyperthermic. The natural vegetation comprises of trees such as Ficus benghalensis, Tamarindus indica, Azadiracta indica, Ziziphus jujubae.

2.2 Methodology

After traversing the Eturunagaram division of Waranagal district, six typical pedons were selected on two land forms (plains and uplands) in central and eastern parts of the division. The morphological characteristics of these typical pedons were described in the field by following the procedure outlined by Soil Survey Staff [4]. Horizon wise soil samples were collected from these typical pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures and were classified according to Soil Taxonomy. These pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations [3]. 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 [4]. The potential land suitability (table 4) subclasses were determined after considering the improvement measures to correct these limitations [4].

Soil suitability for major crop growing was evaluated based on FAO (1976) [13] frame work for land evaluation. It involved formulation of climatic and soil requirements of crop and ratings of these parameters viz., highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N) for agriculture. Soil-site suitability for some of the major crops was evaluated based on the criteria suggested by Sehgal (1986) [12] and Sys et al. (1991) [3]. The soil-site characteristics of the study area were matched with soil-site suitability criteria for a few important crops viz., rice, maize, cotton, chilly and redgram (Appendix II) given by Sys et al. (1993). The kind and degree of limitation and suitability class was determined and evaluated. The studied soils vary in their suitability for different crops according to the criteria for the determination of the land suitability classes.

| Land Classes          | Criteria                        |
|-----------------------|---------------------------------|
| S1: Very suitable     | Land units with no, or only 4 slight limitations. |
| S2: Moderately suitable| Land units with more than 4 slight limitations, and / or no more than 3 moderate limitations. |
| S3: Marginally suitable| Land units with more than 3 moderate limitations, and / or one or more severe limitation(s). |
| N1: Actually unsuitable and potentially suitable | Land units with very severe limitations which can be corrected. |
| N2: Unsuitable         | Land units with very severe limitations which cannot be corrected. |

3. Results and Discussion

The study area has favourable climatic conditions for growing annual crops. Temperature and availability of water through rains and other irrigation sources make this area suitable for growing many crops. But, the soil resources have some limitations which can be managed to achieve higher production. Hence, the major soil constraints of the study area were identified and remedial measures were suggested to sustain the soil fertility and yields of crops.

Details of pedons and relevant soil characteristics are given in table 2 and site characteristics and weighted means of soil characteristics are given in table 3. These soils are developed from granite-gneiss, alluvial deposits and sandstone. The optimum requirements of a crop are always region specific, climatic and soil characteristics parameters play a significant role to maximize crop yields. The depth wise soil characteristics used to arrive at site. Soil characteristics for assessing crop suitability the soil site suitability criteria for rice, maize, cotton chilly and redgram that are grown in eturunagaram division, Warangal district, Telangana state, the kind and degree of limitations were evaluated and suitability of soils of study area for growing these crops in givenbelow. The performance of any crop was largely dependent on soil parameters (depth, texture, drainage etc.) as conditioned by climate and topography. The study of soil-site characterization for predicting the crop performance of an area forms land evaluation.

Pedons 1, 2 and 5 were taxonomically classified under Alfisols. However slight variations in soil colour differentiated these profiles into Haplustalfs and Rhodustalfs. Depth of the pedon, amount of clay, presence or absence of coarse fragments, and relative location of the pedon on the landscape were the major factors that determined the crop suitability. Pedons 2 and 5 highly suitable for cultivation of maize, chilly and redgram due to the good drainage and no other soil related constraints. However, the suitability for cotton and rice is Moderate (S2) due to the medium texture of the soil.

Pedon 3 was classified under Typic Haplustert. This pedon was moderately suitable for cultivation of all the four crops under evaluation (except rice). Despite absence of any other crop productivity related constraint, these soils were classified as S2 due to alkaline soil reaction, which may cause several nutrient deficiencies and also limit the availability of P and N. Patil et al. (2010) reported that Typic Haplusterts in Lendi watershed of Chandrapur district in Maharashtra were moderately suitable (S2) for growing cotton, pigeonpea and soybean.

Pedon 4 was taxonomically classified as Lithic Ustorthenth. This pedon is permanently not suitable (N2) for rice and cotton cultivation owing to the serious limitations existing in these pedons in terms of excessive drainage, coarse texture of the soil, shallow depth, low CEC which rendered this pedon permanently unsuitable for rice cultivation. These limitations...
cannot be overcome by management practices. For maize and
chilly crops, the crop suitability classification was N1 due to
severe limitation excessive drainage (poor WHC), high erodability, high quantity of the coarse fragments in the root
zone, very low CEC due to lower clay content etc. These
limitation can be managed by adding management
mechanisms such as addition of tank silt/ regular addition of
high quantity of organic manures. For redgramp, this pedon
was classified as S2 (moderately suitable) in view of the
hardy nature of the Geetha Sireesh and Naidu (2013)
reported that Lithic Ustorthents were marginally suitable for
growing rice, sorghum, chickpea and sunflower crops in
Banaganapalle mandal of Kurnool district in Andhra Pradesh
Pedons 6 was categorized as Vertic Haplustep according to

| Location                 | Horizons | Depth (cm) | Physical characteristics (s) of < 2 mm soil | CaCO₃ (%) | Physico-Chemical characteristics | Salinity and alkalinity (n) |
|--------------------------|----------|------------|------------------------------------------|-----------|----------------------------------|-----------------------------|
|                          |          |            | Texture                                  |           | CEC [cmol (p+) kg⁻¹ soil] | BS (%) | pH (1:2.5 H₂O) | OC (%) | EC (dS m⁻¹) | ESP |
| Ramanagudem              | Ap 0-15  | 84.5       | 5                                        | 10.5      | -                               | 6.2   | 59.68         | 6.3    | 0.28         | 0.15 |
|                          | Bt1 15-32| 70.9       | 6.5                                      | 22.6      | -                               | 11.5  | 73.91         | 6.7    | 0.35         | 1.17 |
|                          | Bt2 32-50| 57.3       | 8.2                                      | 34.5      | -                               | 16.5  | 81.82         | 6.9    | 0.31         | 3.03 |
|                          | Bt3 50-72| 48.5       | 11                                       | 40.5      | -                               | 21.2  | 80.19         | 7.3    | 0.28         | 1.6  |
| Cr 72+                   |          |            |                                          |           |                                 | 4.8   | 77.08         | 7.5    | 0.48         | 0.16 |
| Etunagaram               | Ap 0-16  | 84.5       | 7.5                                      | 8         | -                               | 10.4  | 80.77         | 7      | 0.34         | 2.88 |
|                          | Bt1 16-28| 70.5       | 8.5                                      | 21        | -                               | 11.6  | 81.9          | 6.9    | 0.29         | 5.17 |
|                          | Bt2 28-61| 60.5       | 9.5                                      | 30        | -                               | 16.5  | 80.19         | 7.3    | 0.28         | 2.83 |
| C 61+                    |          |            |                                          |           |                                 | 4.8   | 77.08         | 7.5    | 0.48         | 0.16 |
| Mangapet                 | Ap 0-8   | 83.2       | 6.5                                      | 10.3      | -                               | 2.9   | 66.21         | 6.7    | 0.38         | 1.36 |
|                          | A2 8-18  | 79.3       | 8.3                                      | 12.4      | -                               | 3.65  | 67.12         | 6.5    | 0.32         | 1.27 |
|                          | A3 18-29 | 73.2       | 12.3                                     | 14.5      | -                               | 4.32  | 71.53         | 6.6    | 0.25         | 1.43 |
| Cr 29+                   |          |            |                                          |           |                                 | 4.8   | 77.08         | 7.5    | 0.48         | 0.16 |
| Narlapur                 | AP 18-30 | 73.2       | 9.4                                      | 17.4      | -                               | 10.21 | 66.01         | 6.91   | 0.65         | 1.96 |
|                          | Bt1 18-40| 64.3       | 8.9                                      | 26.8      | -                               | 13.45 | 65.65         | 6.85   | 0.48         | 0.21 |
|                          | Bt2 40-62| 61.5       | 10.2                                     | 28.3      | -                               | 15.98 | 68.02         | 6.79   | 0.42         | 0.09 |
|                          | Bt3 62-82| 57.2       | 13.7                                     | 29.1      | -                               | 17.16 | 71.27         | 6.83   | 0.39         | 0.12 |
| Cr 82+                   |          |            |                                          |           |                                 | 4.8   | 77.08         | 7.5    | 0.48         | 0.16 |
| Govindaraopet            | Ap 0-16  | 33.8       | 23                                       | 43.2      | 9.85                            | 28.5  | 97.54         | 8.85   | 0.72         | 0.15 |
|                          | Bw1 16-45| 18.3       | 28.3                                     | 53.4      | 10.21                           | 34.8  | 98.85         | 8.75   | 0.44         | 0.14 |
|                          | Bw2 45-72| 15.2       | 26.3                                     | 58.5      | 12.52                           | 36.5  | 99.18         | 8.68   | 0.32         | 0.42 |
|                          | Bw3 72-105| 15.8      | 24.3                                     | 59.9      | 11.62                           | 40.2  | 99.25         | 8.71   | 0.66         | 1.12 |

Table 2: Depth wise Soil characteristics used for assessing crop suitability evaluation

| Pedon No | Soil           | Drainage (w) | Physical characteristics (s) | Soil fertility characteristics (f) | Salinity and alkalinity (n) |
|----------|----------------|--------------|------------------------------|-----------------------------------|-----------------------------|
|          |                |              | Texture                     | Coarse fractions Volume (%) | Cation Exchange Capacity [cmol (P+ kg⁻¹ soil) | Sum of basic cations [cmol (P+ kg⁻¹ soil) | Base Saturation (%) | pH (1:2.5) | Organic Carbon (%) | ECE (dS m⁻¹) | ESP (%) |
| 1        | Typic Rhodustalfs| Well drained | scl                          | 21.73                               | 0.72                           | 14.6                           | 11.35                           | 74.84 | 6.75 | 0.35 | 0.14 | 2.03 |
| 2        | Typic Haplustalfs| Well drained | scl                          | 21.39                               | 0.61                           | 17.7                           | 7.76                           | 80.39 | 7.07 | 0.36 | 0.2  | 6.21 |
| 3        | Typic Haplustalfs | Imperfectly drained | c                          | 32.38                               | 0.13                          | 43.5                           | 43.59                           | 100   | 8.02 | 0.36 | 0.65 | 0.65 |
| 4        | Lithic Ustorthents | Excessively drained | sl                          | 20.52                               | 0.29                           | 3.6                            | 2.55                           | 68.54 | 6.59 | 0.31 | 0.43 | 3.65 |
| 5        | Typic Rhodustalfs | Well drained | l                          | 22.68                               | 0.82                           | 14.32                          | 9.7                            | 67.73 | 7.12 | 0.48 | 0.29 | 2.35 |
| 6        | Vertic Haplustept | Imperfectly drained | c                          | 32.14                               | 0.105                          | 35.89                          | 35.59                          | 98.86 | 8.7  | 0.58 | 0.52 | 1.6  |

Table 2: Site and soil characteristics of studied profiles for crop suitability classification (Weighted average)
4. Constraint analysis and Management practices
The study area has favorable climatic conditions for growing annual crops. Temperature and availability of water through rains and other irrigation sources make this area suitable for growing many crops. But, the soil resources have some limitations which can be managed to achieve higher production. Hence, the major soil constraints of the study area were identified and remedial measures were suggested to sustain the soil fertility and yields of crops.

A. Physical constraints
The major physical constraints found in the study area were:
- Poor drainage – Pedons 3, 6
- Low infiltration rate – Pedons 3, 6
- Excessive drainage: Pedons 2, 4
- Low water holding capacity: Pedons 2, 4
- Runoff – Pedons 3, 6
- Erosion – Pedons: 1, 2, 4, 5
- Shrinkage cracks - Pedons: 3, 6, 8, 11, 13, 15, 20, 25
- Shallow soil depth – Pedons 2, 4

4.1 Management Practices suggested
- Heavy texture in soils caused low infiltration, poor drainage, leading to runoff and erosion. It 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.
- Light textured soils which also had low water holding capacity, can be improved by addition of tank silt (pond mud) along with careful soil and water management practices like mulching or addition of bulky organic manures / green leaf manuring.
- 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.

B. Physico-chemical constraints
- Low organic carbon content – In the surface horizons of most of the pedons except 5, 6,
- High pH – Pedons 3, 6
- High CaCO₃ content – Pedons: 6 (in sub soil)
- Low CEC: pedons 1, 2, 4, 5

4.2 Management practices suggested
- The 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. These measures along with judicious water and soil management reduce the adverse affects of high CaCO₃ content in soils.
- The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash.
- Addition of gypsum and green manuring with dhaincha can reduce the alkalinity problem.

C. Nutritional constraints
- Low available nitrogen: Most of the pedons exhibited nitrogen deficiency
- Zinc deficiency – 1, 2

4.3 Management practices suggested
- Soil test based fertilizer recommendation should be followed to avoid nutrient imbalance and to supply the right nutrients at right time.
- Judicious use of organic manures and biofertilizers in combination with inorganic fertilizers not only improves the supply of major nutrients but also increases the availability of micronutrients for better crop production in these soils.

Soil application of ZnSO₄ @ 25 kg ha⁻¹ once in two seasons and / or foiliar application of ZnSO₄ @ 0.2 per cent for 2-3 times in a week helps in alleviating zinc deficiency.

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Table 3: Limitation levels of the land characteristics and land suitability classes for major crops.

| Pedon No. | Soil Type | Crop | Wetness (w) | Physical soil characteristics | CaCO₃ (%) | Soil fertility characteristics | Alkalinity (n) | Actual land suitability sub-class | Potential land suitability sub-class |
|-----------|-----------|------|-------------|-------------------------------|-----------|------------------------------|----------------|-----------------------------------|-----------------------------------|
| 1         | Typic Rhodustalfs | Rice | 3 | 3 | 3 | 2 | 0 | 3 | 0 | 0 | 0 | N1wsf | N1wsf |
|           |           | Maize | 0 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | S2sf | S2s |
|           |           | Cotton | 2 | 1 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | S3wsf | S2s |
|           |           | Chillies | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | S2sf | S2s |
|           |           | Redgram | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | S1sf | S1 |
| 2         | Typic Haplustalfs | Rice | 3 | 2 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | S3ws | S2s |
|           |           | Maize | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | S1w | S1 |
|           |           | Cotton | 2 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | S2sw | S2s |
|           |           | Chillies | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | S1ws | S1s |
|           |           | Redgram | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | S1 | S1 |
| 3         | Typic Haplusterts | Rice | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | S1f | S1 |
|           |           | Maize | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | S2wf | S1 |
|           |           | Cotton | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | S2sf | S2f |
|           |           | Chillies | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | S2f | S1 |
|           |           | Redgram | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | S2f | S1 |
| 4         | Lithic Ustorthents | Rice | 4 | 4 | 3 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | N2 | N2 |
|           |           | Maize | 3 | 2 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | N1ws | S3s |
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