Evaluation of soil site for suitability of maize and fertility mapping using GIS
10.1 in Ponnaniyar basin, Trichy, Tamil Nadu, India

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Received: 12-12-2017 Accepted: 15-03-2018 DOI: 10.18805/ag.D-4706

ABSTRACT
Five pedons (P) were evaluated for their suitability to maize as an alternate crop for the existing dominant rice crop at water
scarce condition by variation in physiography, parent materials, and soil nutrients in Ponnaniyar basin. The pedons had the
parent materials of non-calcareous gneiss with feldspar (P1), granite and feldspar intermingled (P2), weathered gneiss
(P3), weathered quartz and felspathic gneiss (P4) and gneiss with lime (P5) with soil orders of Vertisol (P3, P5), Inceptisol
(P1, P2) and Alfisol (P4). The soils were low, medium and high in available N, P and K status respectively. Based on the
soil analytical report suitability of maize was established. Kunnatur, Eliyattur and Tiruchengodu series are moderately
suitable (S1) for maize cultivation. Whereas, Manapparai and Pilamedu series are highly suitable (S2) for maize cultivation.
Also, based on the soil fertility data, the map was generated using-the software Arc GIS 10.1 with the help of GPS information
for future reference.

Key words: Crop suitability, Fertility mapping, Land evaluation, Pedological investigations.

INTRODUCTION
Ponnaniyar reservoir basin is situated in Mugavanur village of Manapparai taluk in Trichy district of Tamil Nadu.
The amount of annual rainfall was diminished from 747.7 mm in 1986 to 444.6 mm in 2016. At the time of water
scarcity condition the maize cultivation getting declined, thus the decline on maize production. Nowadays due to changing climatic
conditions the maize cultivation getting declined, thus the crop was chosen to find out their extent of suitability in
Ponnaniyar basin as an alternate crop for the existing dominant rice crop. Utilizing the crops that are suited in the area,
given the soil and environmental condition can be of great help to improve crop production, this idea cannot be
easily achieved without ample soil information. Thus, a fast and efficient way of generating necessary information on a
large scale basis must be innovated. It introduced the use of GIS 10.1 in agricultural aspect as a tool in spatial data analysis,
inTEGRATED WITH EXTRACTED SOIL DATA TO COME UP WITH THE OUTPUT MAPS INFORMATIVE TO THE FARMERS FOR THE FUTURE USE.

MATERIALS AND METHODS

The study area lies between 10°60’ N to 10°63’ N latitude and 78°28’ E to 78°33’ E longitude ranging from
213 to 230 m above mean sea level with an area of 1830 acres of agricultural land. The average rainfall received is
787 mm per year with maximum rainfall during the North- East monsoon season and also a fair amount of rainfall during
summer. The geology of the study area comprises of granite and gneiss. The soil moisture and soil temperature regimes
of the study area are ustic and isohyperthermic, respectively. Five major soil series covering 1830 acres viz., Kunnatur,
Eliyattur, Manapparai, Tiruchengodu and Pilamedu were identified for the pedological investigations. The horizon-
wise soil samples were collected processed and analysed for pH, electrical conductivity (EC), particle size distribution,
organic carbon (OC), moisture retention, macro nutrients pursuing standard analytical procedures (piper 1966;
Richards 1954; Jackson 1973, 1979; Olsen 1954; Standford and English 1949; Subbiah and Asija 1956) and classified
according to Soil Taxonomy (Soil Survey Staff 2006). The pedons were evaluated for their suitability as per the criteria
are given by NBSS and LUP.

Soil fertility mapping: The map was generated through GPS and ArcGIS 10.1 by collecting 137 surface samples (0-15
cm) of an area extent of 1830 acres. Base map was collected from the Department of Agriculture, Coimbatore. This helps
monitor the changes the nutrient status over a period as geo-referenced sampling sites can be revisited with the help

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of GPS, which is otherwise difficult in the random sampling. Geographical Information System based map help in formulating the site-specific balanced fertilizer recommendation and to understand the status of soil fertility by spatially and temporally and for making decision for alternate land utilization.

**RESULTS AND DISCUSSION**

In Kunnatur soil series, the moist soil spectral colour varied from dark reddish brown 5YR 3/3 to reddish brown 5YR 4/4. Eliyattur soil series got the colour variations from reddish brown 5YR 4/4 to yellowish red 5YR 4/6. Tiruchengodu and Pilamedu soil series had similar colour in all the horizons i.e., very dark grey 10YR 3/1. In Manapparai soil series, the colour varied from reddish brown 2.5YR 9/4 to Red 10 R 9/6. The variation in colour among the soils studied may be ascribed to difference in organic matter content and chemical composition of soils (Sawhney et al., 2005).

The depth of soils ranged from shallow (<35 cm) to very deep (>150 cm). Soil depth was shallow in steep slope whereas deep soils were found in nearly level to very gently sloping plain. The same types of observations were reported by Meena et al. (2009).

The bulk density of different horizons in five pedons varied from 1.34 to 1.59 Mg m\(^{-3}\). The highest value of 1.59 Mg m\(^{-3}\) and lowest value of 1.34 Mg m\(^{-3}\) were noticed in Bt\(_1\) and Ap horizons of Manapparai soil series. All the pedons showed increasing trend with depth except Kunnatur soil series. High bulk density values in the subsurface could be ascribed to decreased organic matter and secondary accumulation of illuviated clays in pore space. Ram et al. (2010) also ascribed the same as high bulk density in subsurface is due to decreased organic matter. The decrease in the porosity with depth in all soil series is due to increase in coarse fraction in Inceptisols and Entisols and filling up of pores by eluvial materials in Alfisol was reported by Walia and Rao, (1996).

The percentage of water available under field capacity (33 kPa) varied from 10.69 to 24.79 per cent. The available water holding capacity of soils was found to vary from 1.30 to 11.34 per cent in Pilamedu soil series and Manapparai soil series respectively. Except Eliyattur and Tiruchengodu soil series, all the pedons exhibit increasing trend with soil depth. The moisture content of soil at different tensions depends on the quantity and quality of clay and the moisture holding capacity of soil (Bruand and Tessier, 2000).

The clay content of the soils ranged from 12.35 to 55.25 per cent. Except Eliyattur and Tiruchengodu soil series, all other pedons exhibit increasing trend in clay content with depth. The decrease in clay content with depth was observed in Tiruchengodu soil series, this might be due to variability of weathering in different horizons. These results was in accordance with the findings of Giri Prakash (1997) who reported an irregular decrease of clay content with depth in soils of Gudiyatham taluk in Tamil Nadu.

The silt content of the soils varied from 8.95 to 49.50 per cent. The sand content of the soils ranged from 16 per cent to 71.55 per cent. Eliyattur soil series registered maximum amount of sand in CB (subsurface) horizon and Bss\(_1\) (subsurface) horizon of Pilamedu soil series recorded minimum amount of sand fraction. All the pedons more or less follows the decreasing trend with depth (Table 1).

The pH of 1: 2.5 soil water suspension ranged from 7.15 to 8.98 indicating neutral to moderately alkaline, in reaction. Eliyattur, Tiruchengodu and Pilamedu soil series exhibit decreasing trend with depth. The remaining pedons did not show any particular trend with depth.

The electrical conductivity of 1: 2.5 soil water suspension varied from 0.10 to 0.28 dS m\(^{-1}\). The maximum value of 0.28 dS m\(^{-1}\) was recorded in Ap surface) horizon of Pilamedu soil series, whereas the minimum electrical conductivity of 0.10 dS m\(^{-1}\) was noticed in Bss\(_1\) (subsurface) horizon of Pilamedu soil series and Bt\(_1\) (subsurface) horizon of Manapparai soil series. Tiruchengodu and Pilamedu soil series showed decreasing trend with depth and the remaining pedons did not show any particular trend with depth.

The soil organic carbon ranged from 0.13 to 0.39 per cent (Table 2). All the five soil series recorded low organic carbon status invariably. The low organic carbon might be due to erosion, leaching and rapid oxidation of organic matter under isohyperthermic regime prevailing in the area. These findings are in line with that of Singh and Agarwal (2005). Similar findings in line with Vertisols, Inceptisols and Alfisols were also reported by Vijayakumar et al. (1994).

The available nitrogen content of the Ponnaniyar basin soils ranged from 51.0 to 92.2 kg ha\(^{-1}\). In Ponnaniyar basin, 100 per cent of the surface soil sample recorded low
Table 1: Physical properties of soil.

| Pedon No. | Name of soil series | Horizon | Depth (cm) | Bulk density (Mg m⁻³) | Porosity (%) | FC (%) at 33 kPa | PWP (%) at 1500 kPa | Particle size distribution (%) |
|-----------|---------------------|---------|-----------|-----------------------|--------------|------------------|------------------------|-------------------------------|
| 1         | Kunnatur            | A₁       | 0-13      | 1.41                  | 50.0         | 10.83            | 6.00                   | 64 15 16                     |
|           |                     | A₂       | 13-40     | 1.35                  | 45.2         | 13.76            | 8.67                   | 53 13.25 26.5               |
|           |                     | B₁       | 40-55     | 1.38                  | 40.8         | 13.90            | 8.14                   | 47 16 31                    |
|           |                     | C₁       |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
| 2         | Eliyattur           | A₁       | 0-6       | 1.35                  | 52.6         | 11.58            | 8.10                   | 60 13 26.50                 |
|           |                     | AB       | 6-21      | 1.38                  | 52.9         | 14.25            | 9.15                   | 55 15.25 28.55              |
|           |                     | CB       | 21-35     | 1.48                  | 50.0         | 14.87            | 9.91                   | 71.55 8.95 12.85            |
|           |                     | C₁       |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
| 3         | Tiruchengodu        | A₁       | 0-14      | 1.35                  | 41.2         | 22.74            | 15.81                  | 18 45 35.25                 |
|           |                     | B₁       | 14-150    | 1.51                  | 33.5         | 20.81            | 19.07                  | 17.25 49.50 30.95           |
|           |                     | C₁       |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
| 4         | Manapparai          | A₁       | 0-8       | 1.34                  | 52.6         | 21.11            | 16.45                  | 70.90 9.85 12.35            |
|           |                     | B₁       | 8-38      | 1.42                  | 41.6         | 14.73            | 9.43                   | 68.90 11.25 13.65           |
|           |                     | B₁       | 38-76     | 1.45                  | 38.1         | 10.69            | 5.75                   | 58 18 23                    |
|           |                     | B₁       | 76-84     | 1.58                  | 37.6         | 13.07            | 7.60                   | 56 17.25 21.85              |
|           |                     | B₁       | 84-100    | 1.59                  | 37.0         | 24.79            | 13.45                  | 54.95 18.25 26.05           |
|           |                     | C₁       |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
| 5         | Pilamedu            | A₁       | 0-4       | 1.38                  | 44.2         | 20.94            | 19.64                  | 18.25 45.50 26.25           |
|           |                     | B₁       | 4-35      | 1.45                  | 40.1         | 23.54            | 15.94                  | 30.90 26.55 39.35           |
|           |                     | B₁       | 35-95     | 1.51                  | 37.2         | 23.89            | 15.01                  | 16 25.30 55.25              |
|           |                     | C₁       |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |
|           |                     |          |           |                       |              |                  |                        |                               |

Table 2: Chemical properties and available nutrient status of soil.

| Pedon Horizon | Depth (cm) | pH  | EC (dS m⁻¹) | OC (%)  | Available macronutrients (Kg/ha) | N |  | P |  | K |  |
|---------------|------------|-----|-------------|---------|---------------------------------|---|---|---|---|---|---|
|               |            |     |             |         |                                  |   |   |   |   |   |   |
| 1             | A₁         | 0-13| 7.28        | 0.14    | 0.20                            |   |   |   |   |   |   |
|               | A₂         | 13-40| 7.15       | 0.13    | 0.18                            |   |   |   |   |   |   |
|               | B₁         | 40-55| 7.52       | 0.15    | 0.14                            |   |   |   |   |   |   |
|               | C₁         |     |            |         | Non calcareous gneiss with feldspar |   |   |   |   |   |   |
| 2             | A₁         | 0-6 | 7.74        | 0.17    | 0.17                            |   |   |   |   |   |   |
|               | AB         | 6-21| 7.65       | 0.13    | 0.14                            |   |   |   |   |   |   |
|               | BC         | 21-35| 7.22      | 0.19    | 0.13                            |   |   |   |   |   |   |
|               | C₁         |     |            |         | Granite and feldspar intermingled |   |   |   |   |   |   |
| 3             | A₁         | 0-14| 8.81        | 0.17    | 0.36                            |   |   |   |   |   |   |
|               | B₁         | 14-150| 8.48     | 0.14    | 0.30                            |   |   |   |   |   |   |
|               | C₁         |     |            |         | Weathered gneiss                |   |   |   |   |   |   |
| 4             | A₁         | 0-8 | 7.55        | 0.14    | 0.24                            |   |   |   |   |   |   |
|               | B₁         | 8-38 | 7.27       | 0.15    | 0.19                            |   |   |   |   |   |   |
|               | B₁         | 38-76| 7.30       | 0.13    | 0.18                            |   |   |   |   |   |   |
|               | B₁         | 76-84| 7.32       | 0.15    | 0.18                            |   |   |   |   |   |   |
|               | B₁         | 84-100| 7.36     | 0.10    | 0.14                            |   |   |   |   |   |   |
|               | C₁         |     |            |         | Weathered quartz and feldspatic gneiss |   |   |   |   |   |   |
| 5             | A₁         | 0-4 | 8.98        | 0.28    | 0.39                            |   |   |   |   |   |   |
|               | B₁         | 4-35 | 8.65       | 0.19    | 0.29                            |   |   |   |   |   |   |
|               | B₁       | 35-95| 8.04       | 0.10    | 0.20                            |   |   |   |   |   |   |
|               | C₁       |     |            |         | Gneiss with lime                 |   |   |   |   |   |   |

in available nitrogen. The available N status of 18.30 acre (5 soil series) was mapped in Fig.2.

The available phosphorus content of Ponnaniyar reservoir soils ranged from 9.7 kg ha⁻¹ to 33 kg ha⁻¹. Paramasivan (1992) was also reported that phosphorus status was medium in Kangayampalayam and Koduveri series in lower Bhavani project command area. The available P status of 18.30 acre (5 soil series) was mapped in Fig.3.

The available potassium content of Ponnaniyar reservoir basin soils ranged from 195 to 799 kg ha⁻¹ (Table 2). The relatively higher content of available K was due to prevalence of K rich minerals like feldspar, muscovite mica,
Table 3: Soil site characteristics

| Climatic regime | Mean temp. in growing season °C | Pedon 1 | Pedon 2 | Pedon 3 | Pedon 4 | Pedon 5 |
|-----------------|----------------------------------|---------|---------|---------|---------|---------|
| Land Quality    | Total Rainfall mm                | S1      | S1      | S1      | S1      | S1      |
| Moisture availability | Length of growing period days class | S1      | S1      | S1      | S1      | S1      |
| Oxygen availability to roots | soil drainage class | S1      | S1      | S3      | S2      | S3      |
| Nutrient availability | Texture class | S1      | S1      | S2      | S1      | S2      |
| pH              | 1:2.5                            | S1      | S2      | S3      | S1      | S3      |
| OC              | %                                | S3      | S3      | S3      | S3      | S3      |
| Rooting conditions | Effective soil depth cm | S2      | S3      | S1      | S1      | S1      |
| Soil toxicity   | Salinity (EC) dSm⁻¹              | S1      | S1      | S1      | S1      | S1      |
| Erosion hazard  | Slope %                          | S2      | S2      | S1      | S1      | S1      |

Table 4: Crop requirements.

| soil site characteristics | unit | Highly suitable S1 | Moderately suitable S2 | Marginally suitable S3 | Not suitable N1 N2 |
|---------------------------|------|---------------------|------------------------|------------------------|-------------------|
| Climatic regime | Mean temp. in growing season °C | 21-32 | 33-38 | 39-40 | |
| Land Quality | Total Rainfall mm | 900-1000 | 750-900 | 500-750 | <500 |
| Moisture availability | Length of growing period days | well drained | 100-80 | 60-80 | |
| Oxygen availability to roots | soil drainage class | High | Medium | Low | |
| Nutrient availability | Texture class | sl, scl, sil | 5.5-7.5 | 7.6-8.5 | 8.6-9.0 | |
| pH | 1:2.5 | 5.5-7.5 | 7.6-8.5 | 8.6-9.0 | |
| OC | % | High | Medium | Low | |
| Rooting conditions | Effective soil depth cm | >75 | 50-75 | 25-50 | <25 |
| Stoniness | % | Non gravelly | 15-35 | 35-50 | >50 |
| Soil toxicity | Salinity (EC) dSm⁻¹ | Non Saline | 1.0-2.0 | 2.0-4.0 | |
| Erosion Hazard | Slope | <3 | 3-5 | 5-8 | |
Soil site suitability evaluation for crops forms an essential part of every land use planning programme. Several soil and site characteristics are used as parameters for assessing the suitability of land for crops in every land evaluation exercise. The land is given a suitability rating depending on how well its properties meet the requirement of the crop. If all the properties match well with the crop requirements, the land is considered highly suitable otherwise less suitable (moderate and marginal) and even not suitable, depending upon the deviation of the land properties from the optimal growth requirement of the crops. The Pedon 4 and 5 was classified under highly suitable class (S1), whereas Pedon 1, 2 and 3 were grouped as moderately suitable class (S2) for maize cultivation. Minor limitation on unaltered parameter like soil depth and an correctable factor like soil drainage, soil OC and pH was observed.

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