



RESEARCH ARTICLE

SOIL-SITE SUITABILITY EVALUATION OF RED GRAM IN PONNANIYAR BASIN SOILS OF
TIRUCHIRAPALLI, TAMIL NADU, INDIA

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ABSTRACT

Five pedons were evaluated for their suitability to red gram on the basis of variation in physiography, parent materials, and soil nutrients in Ponnaniyar basin soils of Tiruchirapalli, Tamil Nadu. The pedons were developed by non calcareous gneiss with feldspar (P1), granite and feldspar intermingled in pedon 2, weathered gneiss (P3), weathered quartz and felspathic gneiss (P4) and gneiss with lime parent materials (P5) and classified as Vertisol (P3, P5), Inceptisol (P1, P2) and Alfisol (P4). In general, sand, silt and clay contents ranged from 16.00 to 71.55, 8.95 to 49.50 and 12.35 to 55.25% in different horizons, respectively. The soils were calcareous and moderately alkaline to strongly alkaline in reaction. The organic carbon ranged from 0.13 to 0.39 g kg⁻¹ and cation exchange capacity from 16.23 to 19.91 cmol(p⁺)kg⁻¹ soil. The soils were low, medium and high in available N, P and K respectively. All five pedons are moderately suitable (S₁) for red gram cultivation, except Eliyattur series, it showed temporarily not suitable (N₁) category.

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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, farmers from the village were tried for alternate crops in order to mitigate the water stress, many times they failed due to improper selection of crops. The better crop selection based on soil physical, chemical and physico-chemical properties enhance the crop productivity and help the farmers to get profitable income at the time of limited water availability due to climate change. Red gram is commonly known as Tur or Arhar (Pigeon pea) in India and is the second important pulse in the country after gram (chana). The ability of red gram to produce high economic yields under soil moisture deficit makes it an important crop in rainfed and dryland agriculture. Red gram also had an excellent nutritional value in view of their good protein content and better amino acid profile.

MATERIALS AND METHODS

The study area lies between 10.59688 to 10.61374° N latitude and 78.268288 to 78.303818° 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., Kunnattur, Eliyattur, Manapparai, Tiruchengode and Pilamedu were identified for the pedological investigations. The horizon-wise soil samples were collected processed and analysed for pH, electrical conductivity (EC), particle sizedistribution, organic carbon (OC), moisture retention, exchangeable cations, macronutrients pursuing standard analytical procedures (piper 1966; Richards 1954; Jackson 1973, 1979; Olsen 1965; Stanford 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 given by NBSS & LUP.

RESULTS AND DISCUSSION

In Kunnattur 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

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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 B_{t4} and A_p 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. This was in line with the findings of Ram *et al.* (2010). 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. These are in accordance with the findings of Saravanan *et al.* (2000). The clay content of the soils were ranged from 12.35 to 55.25 percent. 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 were 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 slit content of the soils varied from 8.95 to 49.50 percent. The sand content of the soils were ranged from 16 percent to 71.55 percent. Eliyattur soil series registered maximum amount of sand in CB (subsurface) horizon and B_{ss1}(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 A_p(surface) horizon of Pilamedu soil series, whereas the minimum electrical conductivity of 0.10 dS m⁻¹ was noticed in B_{ss1}(subsurface) horizon of Pilamedu soil series and B_{t4} (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 per cent base saturation on the exchange complex varied from 96.98 (B_{t1}) to 99.47 (B_{t2}) percent in Manapparai soil series. Eliyattur and Tiruchengodu soil series exhibited a decreasing trend with depth and the remaining pedons showed an irregular trend with depth. The available nitrogen content of the Ponnaniyar basin soils were ranged from 51.0 to 92.2 kg ha⁻¹. In Ponnaniyar basin, 100 per cent of the surface soil sample recorded low in available nitrogen. The available phosphorus content of

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 (%) | | |
|----------------|---------------------|------------------|------------|---------------------------------|--------------|------------------|--|--|-------|-------|
| | | | | | | | | Sand | Silt | Clay |
| 1 | Kunnatur | A _p | 0-13 | 1.41 | 50.0 | 10.83 | 6.00 | 64 | 15 | 16 |
| | | 2A ₁ | 13-40 | 1.35 | 45.2 | 13.76 | 8.67 | 53 | 13.25 | 26.5 |
| | | B _s | 40-55 | 1.38 | 40.8 | 13.90 | 8.14 | 47 | 16 | 31 |
| | | C _r | | | | | | Non calcareous gneiss with feldspar loamy mixed isohyperthermicTypicHaplustepts | | |
| 2 | Eliyattur | A _p | 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 |
| | | C _r | | | | | | Granite and feldspar intermingled loamy mixed isohyperthermicTypicHaplustepts | | |
| 3 | Tiruchengodu | A _p | 0-14 | 1.35 | 41.2 | 22.74 | 15.81 | 18 | 45 | 35.25 |
| | | B _c | 14-150 | 1.51 | 33.5 | 20.81 | 19.07 | 17.25 | 49.50 | 30.95 |
| | | C _r | | | | | | Weathered gneiss Fine mixed isohyperthermicTypicCalcisterts | | |
| 4 | Manapparai | A _p | 0-8 | 1.34 | 52.6 | 21.11 | 16.45 | 70.90 | 9.85 | 12.35 |
| | | B _{t1} | 8-38 | 1.42 | 41.6 | 14.73 | 9.43 | 68.90 | 11.25 | 13.65 |
| | | B _{t2} | 38-76 | 1.45 | 38.1 | 10.69 | 5.75 | 58 | 18 | 23 |
| | | B _{t3} | 76-84 | 1.58 | 37.6 | 13.07 | 7.60 | 56 | 17.25 | 21.85 |
| | | B _{t4} | 84-100 | 1.59 | 37.0 | 24.79 | 13.45 | 54.95 | 18.25 | 26.05 |
| C _r | | | | | | | Weathered quartz and feldspatic gneiss Fine mixed isohyperthermicTypicHaplustalfs | | | |
| 5 | Pilamedu | A _p | 0-4 | 1.38 | 44.2 | 20.94 | 19.64 | 18.25 | 45.50 | 26.25 |
| | | B ₁ | 4-35 | 1.45 | 40.1 | 23.54 | 15.94 | 30.90 | 26.55 | 39.35 |
| | | B _{ss1} | 35-95 | 1.51 | 37.2 | 23.89 | 15.01 | 16 | 25.30 | 55.25 |
| | | C _k | | | | | | Gneiss with lime Fine mixed isohyperthermicTypicCalcisterts | | |

Table 2. Chemical properties and available nutrient status of soil

| Pedon No | Horizon | Depth (cm) | pH | EC (dS m ⁻¹) | OC (%) | Available macronutrients (Kg ha ⁻¹) | | | | | |
|----------|------------------|------------|------|--------------------------|--------|---|------|-----------|------|---------|------|
| | | | | | | N | | P | | K | |
| | | | | | | Range | Mean | Range | Mean | Range | Mean |
| 1 | A _P | 0-13 | 7.28 | 0.14 | 0.20 | | | | | | |
| | 2A ₁ | 13-40 | 7.15 | 0.13 | 0.18 | 51.0-92.2 | 70.7 | 9.7-33.0 | 14.4 | 195-799 | 555 |
| | B _S | 40-55 | 7.52 | 0.15 | 0.14 | | | | | | |
| 2 | C _r | | | | | Non calcareous gneiss with feldspar | | | | | |
| | A _P | 0-6 | 7.74 | 0.17 | 0.17 | | | | | | |
| | AB | 6-21 | 7.65 | 0.13 | 0.14 | 54.0-91.7 | 71.1 | 10.1-32.0 | 14.2 | 197-805 | 557 |
| 3 | BC | 21-35 | 7.22 | 0.19 | 0.13 | | | | | | |
| | C _r | | | | | Granite and feldspar intermingled | | | | | |
| | A _P | 0-14 | 8.81 | 0.17 | 0.36 | | | | | | |
| 4 | B _C | 14-150 | 8.48 | 0.14 | 0.30 | 51.2-93.0 | 70.8 | 10.0-31.0 | 14.0 | 194-809 | 556 |
| | C _r | | | | | Weathered gneiss | | | | | |
| | A _P | 0-8 | 7.55 | 0.14 | 0.24 | | | | | | |
| 5 | B _{t1} | 8-38 | 7.27 | 0.15 | 0.19 | 50.7-92.3 | 70.6 | 9.9-32.0 | 14.0 | 200-800 | 559 |
| | B _{t2} | 38-76 | 7.30 | 0.13 | 0.18 | | | | | | |
| | B _{t3} | 76-84 | 7.32 | 0.15 | 0.18 | | | | | | |
| 5 | B _{t4} | 84-100 | 7.36 | 0.10 | 0.14 | | | | | | |
| | C _r | | | | | Weathered quartz and feldspatic gneiss | | | | | |
| | A _P | 0-4 | 8.98 | 0.28 | 0.39 | | | | | | |
| 5 | B ₁ | 4-35 | 8.65 | 0.19 | 0.29 | 55.2-90.8 | 70.5 | 9.4-30.5 | 13.9 | 197-798 | 553 |
| | B _{SS1} | 35-95 | 8.04 | 0.10 | 0.20 | | | | | | |
| | C _K | | | | | Gneiss with lime | | | | | |

Table 3. Exchangeable properties of soil

| Pedon No. | Name of series | Horizon | Ca | Mg | Na | K | CEC | ESP (%) | BSP (%) |
|-----------|----------------|------------------|------------------------------|------|------|------|-------|---------|---------|
| | | | (cmol(p+)/kg ⁻¹) | | | | | | |
| 1 | Kunnatur | A _P | 10.0 | 4.00 | 1.7 | 0.70 | 16.60 | 10.2 | 98.80 |
| | | 2A ₁ | 11.0 | 4.22 | 1.8 | 0.50 | 17.80 | 10.1 | 98.43 |
| | | B _S | 11.0 | 3.20 | 2.1 | 0.64 | 17.10 | 12.3 | 99.06 |
| 2 | Eliyatur | A _P | 9.7 | 6.00 | 2.2 | 0.40 | 18.50 | 11.9 | 98.92 |
| | | AB | 8.9 | 5.00 | 2.1 | 0.20 | 16.40 | 12.8 | 98.78 |
| | | BC | 10.2 | 3.80 | 1.5 | 0.60 | 16.50 | 9.1 | 97.58 |
| 3 | Tiruchengodu | A _P | 9.5 | 5.20 | 3.93 | 0.51 | 19.32 | 20.3 | 99.07 |
| | | B _C | 10.89 | 4.65 | 3.1 | 0.50 | 19.33 | 16.0 | 99.02 |
| | | A _P | 9.4 | 4.30 | 1.7 | 0.60 | 16.23 | 10.5 | 98.58 |
| 4 | Manapparai | B _{t1} | 10.5 | 3.90 | 2 | 0.42 | 16.91 | 11.8 | 99.47 |
| | | B _{t2} | 10.2 | 6.30 | 1.9 | 0.54 | 19.53 | 9.7 | 96.98 |
| | | B _{t3} | 10.5 | 6.10 | 1.8 | 0.50 | 19.10 | 9.4 | 98.95 |
| 5 | Pilamedu | B _{t4} | 9.9 | 4.30 | 1.8 | 0.50 | 16.80 | 10.7 | 98.21 |
| | | A _P | 11.0 | 4.00 | 4.1 | 0.30 | 19.80 | 20.7 | 97.98 |
| | | B ₁ | 9.8 | 5.28 | 3.81 | 0.82 | 19.91 | 19.1 | 99.00 |
| | | B _{SS1} | 11.9 | 4.80 | 2.4 | 0.50 | 19.80 | 12.1 | 98.99 |

Table 4. Soil site suitability requirements for Red gram

| Soil site characteristics | | Rating | | | | |
|------------------------------|---|---------------------------|-----------------------------------|---------------------------------------|---------------------------------------|---|
| | | Unit | Highly suitable S ₁ | Moderately suitable S ₂ | Marginally suitable S ₃ | Not Suitable N ₁ N ₂ |
| Climatic regime | Mean temp. in °c | | 25-28 | 22-24 | 20-21 | <20 |
| | growing season | | | | | |
| Land Quality | Rainfall | mm | 800-1000 | 600-800 | 400-600 | <400 |
| | Land characteristics | | | | | |
| Moisture availability | Length of growing period for short duration | Days | >120 | 100-120 | 80-100 | <80 |
| | Length of growing period for long duration | Days | >180 | 150-180 | 120-150 | <120 |
| Oxygen availability to roots | soil drainage | class | well drained | Mod. well to imperfectly | Poorly; Excessively drained | v. Poorly |
| Nutrient availability | Texture | class | cl, scl, sil, sl | c, sicl, sic | ls | |
| | pH | 1:2.5 | 6.0-7.5 | 7.6-8.0 | 8.1-9.0 | >9.0 |
| Rooting conditions | CEC | cmol (p ⁺)/kg | >20 | 15-20 | 10-15 | |
| | OC | % | High | Medium | Low | |
| Soil toxicity | Effective soil depth | cm | >100 | 85-100 | 40-85 | <40 |
| | Coarse fragments | Vol % | <20 | 20-35 | >35 | |
| Erosion Hazard | Salinity (EC) | dSm ⁻¹ | <1.0 | 1.0-2.0 | 2.0 | |
| | Exchangeable sodium percentage | % | <10 | 10-15 | >15 | |
| | Slope | % | <3 | 3-5 | 5-10 | |

Ponnaniyar reservoir soils were 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 potassium content of Ponnaniyar reservoir basin soils were 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, biotite mica and secondary minerals such as illite, vermiculite, weathered mica and smectite in these soils (Singh *et al.*, 2006). 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. Red gram registered its suitability class of S₂ (moderately suitable) in all the five soil series, except Eliyattur series, which had its unaltered limitation such as soil depth. The correctable minor limitations such as pH, organic carbon, alkalinity and drainage were observed in Ponnaniyar basin soils.

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