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# Geo Statistical Tool for Soil Fertility Assessment in Pulses Growing Area of Melur Block, Madurai District, Tamil Nadu

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## ABSTRACT

**Background:** Soil fertility is a significant natural property which decides the health and quality of land resources. Pulse productivity diminishes nowadays under rain fed condition due to improper nutrient management practices. Hence the present study was carried out to assess the soil fertility status under major pulses growing area by using advanced geo statistical tool with ArcGIS.

**Methods:** Soil survey was taken in 14 revenue villages in Melur block, Madurai district. Soil samples were collected and analysed for its nutrient properties. The Parker's Nutrient Index and soil fertility maps were prepared by using ArcGIS.

**Result:** Pulses growing soils were mostly neutral in pH and soluble salt content was low. The organic carbon and available nitrogen content was low to medium. The available phosphorus and potassium status were medium to high. Hence proper nutrient management practices are to be needed for augment pulse production in such area.

**Key words:** ArcGIS, Parker's index, Pulses, Soil fertility.

## INTRODUCTION

Pulses occupy an inimitable position in Indian farming as protein supplement and restoration of soil fertility (Jeevitha *et al*., 2019). Pulses are grown under poor fertile soil under imbalanced nutrient application (Hosamani *et al.,* 2017). India, China, Canada, Brazil and Myanmar are the top five countries accounting for 50% of global pulses production.

India area under pulses cultivation were 27.98 m ha, production of 23.02 m t and productivity of 823 kg $ha^{-1}$. In Tamil Nadu area of 0.82 m ha, under production 0.6 m t and productivity of 735 kg $ha^{-1}$ (Indiastat, 2020). India consumes 30% of global pulses production. China and Brazil was a distant second in consumption, with a 6% share each. (Anonymous, 2010).

The static production of pulses in India coupled with an explosion of population has led to steep fall in per capita availability of pulses from 70 gram per day in 1960-61 to less than 40 gram per day during present decade (Pushpa, 2007) as against FAO/WHO's recommendation of 80 gram per day. The crisis of shortage of pulses has aggravated the problem of malnutrition. Thus, there is an imperative need to increase the production of pulses to meet the requirement. Soil fertility assessment in pulse growing area can be done with the help of geo graphical information (GIS) system with advanced geostatistical tools called Kriging for preparation of thematic maps (Burgess and Webster, 1980). Proper nutrient management practices can be effectively made with thematic maps based on deficient of nutrients.

## MATERIALS AND METHODS

### Study area

The study area of Melur block, Madurai District is having an area of 3057 ha is located between 10° 03′ 36″ N latitude, 78° 33′ 58″ E longitude and elevation with 101 m above MSL. The length of growing period (LGP) is >120 days (Ramamurthy *et al*., 2009). The climate is semi-arid with a mean annual average rainfall of 857.63 mm (Fig 1).

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### Soil sampling and analysis

A detailed soil survey of the study area was carried out based on grid map using ArcGIS software. Soil samples, 280 nos. were collected with soil auger from 0-20 cm depth in 14 revenue villages. Each revenue villages 20 soil samples collected. The sample locations (latitude and longitude) were recorded with GPS. The collected soil samples were processed and stored for further soil analysis. The stored samples were analyzed for pH, electrical conductivity, organic carbon, available nitrogen, $P_2O_5$ and $K_2O$. The soil

reaction (pH) and electrical conductivity was determined by Jackson (1973). The organic carbon was determined by Walkley and Black (1934) method. Available nitrogen was determined by modified alkaline permanganate method as described by Sharawat and Burford (1982). The available phosphorous was determined by spectrophotometer (Olsen *et al.,* 1954). Available potassium was determined by Flame Photometer with neutral ammonium acetate as an extractant by Hanway and Heidel (1952) method.

**Nutrient availability index (NAI) determination**

Nutrient Index was introduced by Parker *et al.,* (1951) and modified by Pathak (2010); Kumar *et al.,* (2013) and RaviKumar *et al.,* (2007). Nutrient Index can be calculated by using the following formula:

$$\text{Nutrient index} = \frac{\{(1 \times A) + (2 \times B) + (3 \times C)\}}{TNS}$$

Where:
A= Number of samples in low category.
B= Number of samples in medium category.
C= Number of samples in high category.
TNS= Total number of samples.

**Spatial analysis by ArcGIS**

The location of sampling sites was fed into GIS environment and digitized using ArcGIS-10 software; they are validated for digitization errors, polygonized and finally transformed in to thematic map (Burgess and Webster, 1980).

## RESULTS AND DISCUSSION

**Soil fertility status of study area**

The results on physico-chemical properties of soil samples are presented in Table 1 and 2. The data on Nutrient Index status and correlation data are presented in the Table 3 and 4.

**Soil reaction (soil pH)**

The data revealed that the pH of soils varied from slightly acidic to neutral (6.8 to 7.90) with a mean of 7.38. About 2.15% soils of pulses grown in acidic condition and 97 per cent of the area were neutral in nature (Table 1). The high pH values are possibly due to the presence of soluble salt and exchangeable sodium along with bicarbonate ions, which precipitates calcium and magnesium during evaporation (Singh *et al.,* 2016 and Denis *et al.,* 2016). The variation in soil pH of acid to neutral could be attributed to leaching of bases, rainfall, continuous decaying of organic matter and parent material (acid rich ingenious rocks and granite gneiss) *etc*. as reported by Kumar and Paliyal (2018) and Thakur *et al.,* (2021). According to Brady and Weil (2005), the alkalinity problem in soils is due to indigenous calcareous parent material with low organic matter content. Therefore, in such areas, fertilization, organic manures along with legumes as crop rotation with minimum/no-tillage practices play an important role to sustain soil fertility (Sainju *et al*., 2008).

**Electrical conductivity**

The electrical conductivity (EC) is the measure of soluble salts of soil and is affected by cropping sequence, irrigation, land use and application of fertilizers, manure and compost (Singh *et al*., 2016). High value of electrical conductivity represents higher degree of salinity. Excessive amount of dissolved salts in soil solutions causes hindrance in normal nutrient uptake process either by imbalance of ions uptake, antagonistic effect between nutrients or excessive osmotic potentials of soil solution or a combination of the three effects (Rahman *et al*., 2010). The results presented in Table 1 indicate that salinity hazard does not presently exist in the study area. The mean value of EC is 0.4 dS/m with a range varying from 0.17 to 1.97 $dSm^{-1}$. According to Roy and Landey (1962), low EC of soils is indicated that conditions are not favourable for accumulation of salts.

**Organic carbon**

Organic matter has a vital role in agricultural soils. It supplies plant nutrients, improves soil structure, water infiltration and retention, feeds soil micro flora and fauna, retention of

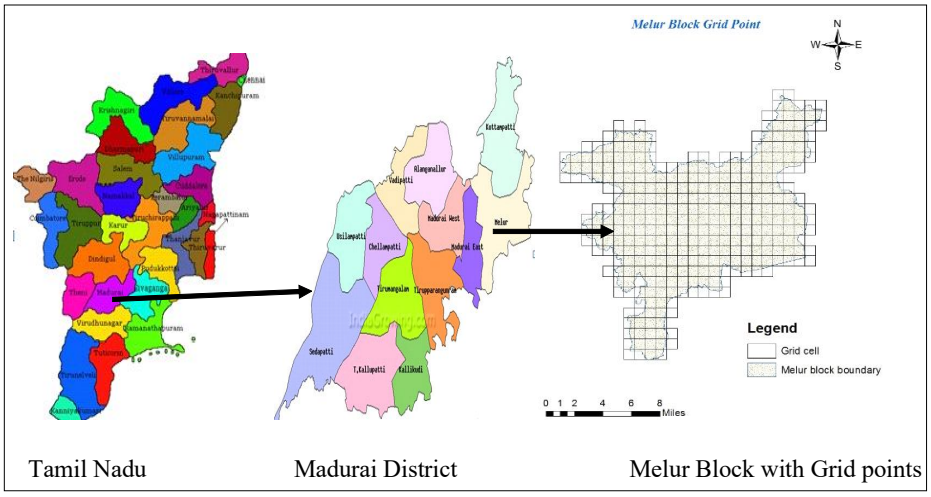


**Fig 1:** Study area with grid points of soil samplings.

nutrients andcycling of applied fertilizer (Johnston, 2007). The organic carbon content of soils in the study area varied from 3.4 to 6.3 g $kg^{-1}$ with a mean value of 4.4 g $kg^{-1}$. The mean value was significantly high (16.66%) in Surakkundu and low (91%) in kiddaripatti (Table 1). The study revealed that organic carbon content of soil falling under low (<5 g $kg^{-1}$ category). According to Kavitha and Sujatha (2015), high levels of organic matter not only provides part of the N requirement of crop plants, but also enhanced nutrient and water retention capacity of soils and create favourable physical, chemical and biological environment. Similar findings as reports of Babalola *et al.,* (2021), this can be attributed to the presence of more decomposable plant materials and phytocyling (Fig 2).

**Available nitrogen**

The available nitrogen content was low in most of the revenue villages in Melur block (Table 2), except the Surakundu village had medium in available nitrogen status, which might be due to low organic matter content. According to Ashok Kumar (2000), such variation in N content may be related to soil management, application of FYM and fertilizer

**Table 1:** Per cent distribution of electrochemical properties and organic carbon status in melur block soils.

| Revenue village | pH | | | | Electrical conductivity (dS $m^{-1}$) | | | | Organic carbon (g/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Acid (<6.0) | Neutral (6.0-8.5) | Alkaline (>8.5) | Mean | Safe (1-2) | Critical | >2 | Mean | Low (<5) | Medium (5-7.5) | High (>7.5) |
| Surakundu | 7.55 | 9.1 | 90.9 | 0.0 | 0.48 | 100.0 | 0.0 | 0.0 | 6.3 | 0.0 | 90.90 | 9.90 |
| Therkkutheru | 7.56 | 0.0 | 100.0 | 0.0 | 0.41 | 100.0 | 0.0 | 0.0 | 4.5 | 70.0 | 30.0 | 0.0 |
| Kidaripatti | 6.83 | 0.0 | 100.0 | 0.0 | 0.43 | 100.0 | 0.0 | 0.0 | 4.0 | 91.66 | 0.0 | 8.33 |
| Melur | 7.94 | 0.0 | 100.0 | 0.0 | 0.15 | 100.0 | 0.0 | 0.0 | 4.3 | 100.0 | 0.0 | 0.0 |
| Kilaiyur | 7.92 | 0.0 | 100.0 | 0.0 | 0.14 | 100.0 | 0.0 | 0.0 | 3.4 | 100.0 | 0.0 | 0.0 |
| Thiruvathavur | 7.50 | 0.0 | 100.0 | 0.0 | 0.35 | 100.0 | 0.0 | 0.0 | 5.0 | 66.66 | 16.66 | 16.68 |
| Uranganpatti | 7.09 | 12.5 | 87.5 | 0.0 | 0.17 | 100.0 | 0.0 | 0.0 | 4.6 | 75.0 | 12.5 | 12.5 |
| Manikkampatti | 7.60 | 0.0 | 100.0 | 0.0 | 1.9 | 100.0 | 0.0 | 0.0 | 3.6 | 80.0 | 20.0 | 0.0 |
| Kottakudi | 6.80 | 0.0 | 100.0 | 0.0 | 0.20 | 100.0 | 0.0 | 0.0 | 4.0 | 90.0 | 10.0 | 0.0 |
| Veppadappu | 7.14 | 0.0 | 100.0 | 0.0 | 0.30 | 100.0 | 0.0 | 0.0 | 3.5 | 90.0 | 10.0 | 0.0 |
| Poonjuthi | 7.60 | 0.0 | 100.0 | 0.0 | 0.17 | 100.0 | 0.0 | 0.0 | 4.8 | 90.0 | 10.0 | 0.0 |
| Arittapatti | 7.20 | 0.0 | 100.0 | 0.0 | 0.36 | 100.0 | 0.0 | 0.0 | 3.9 | 90.0 | 9.90 | 0.0 |
| Ambalakaranpatti | 7.30 | 0.0 | 100.0 | 0.0 | 0.34 | 100.0 | 0.0 | 0.0 | 4.4 | 88.88 | 11.11 | 0.0 |
| Vellalapatti | 7.40 | 8.5 | 89.4 | 2.1 | 0.3 | 97.9 | 0.0 | 2.1 | 5.0 | 53.31 | 40.42 | 40.25 |
| Mean | 7.38 | 2.15 | 97.0 | 0.15 | 0.40 | 99.8 | 0 | 0.2 | 4.4 | 77.7 | 18.62 | 18.62 |

**Table 2:** Per cent distribution of available nitrogen, phosphorus and potassium status in melur block soils.

| Revenue village | Nitrogen (kg $ha^{-1}$) | | | Phosphorus (kg $ha^{-1}$) | | | | Potassium (kg $ha^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Low (<280) | Medium (280-480) | Mean | Low (<11) | Medium (11-22) | High (>22) | Mean | Low (<118) | Medium (118-280) | High (>280) |
| Surakundu | 317 | 9.1 | 90.9 | 36 | 0.0 | 36.4 | 63.6 | 392 | 0.0 | 27.2 | 72.7 |
| Therkkutheru | 253 | 70.0 | 30.0 | 24 | 0.0 | 70.0 | 30.0 | 263 | 0.0 | 55.0 | 45.0 |
| Kidaripatti | 209 | 91.7 | 8.3 | 18 | 0.0 | 91.7 | 8.3 | 450 | 0.0 | 0.0 | 100.0 |
| Melur | 200 | 100.0 | 0.0 | 30 | 0.0 | 0.0 | 100.0 | 252 | 0.0 | 75.0 | 25.0 |
| Kilaiyur | 193 | 100.0 | 0.0 | 29 | 0.0 | 33.3 | 66.7 | 389 | 0.0 | 0.0 | 100.0 |
| Thiruvathavur | 269 | 66.7 | 33.3 | 35 | 0.0 | 16.7 | 83.3 | 261 | 0.0 | 60.0 | 40.0 |
| Uranganpatti | 235 | 75.0 | 25.0 | 17 | 0.0 | 100.0 | 0.0 | 361 | 0.0 | 50.0 | 50.0 |
| Manikkampatti | 208 | 80.0 | 20.0 | 19 | 0.0 | 70.0 | 30.0 | 354 | 0.0 | 20.0 | 80.0 |
| Kottakudi | 215 | 90.0 | 10.0 | 28 | 0.0 | 30.0 | 70.0 | 356 | 0.0 | 20.0 | 80.0 |
| Veppadappu | 217 | 90.0 | 10.0 | 34 | 0.0 | 50.0 | 50.0 | 307 | 0.0 | 40.0 | 60.0 |
| Poonjuthi | 261 | 100.0 | 0.0 | 52 | 0.0 | 10.0 | 90.0 | 288 | 0.0 | 40.0 | 60.0 |
| Arittapatti | 222 | 100.0 | 0.0 | 73 | 0.0 | 0.0 | 100.0 | 381 | 0.0 | 45.4 | 54.5 |
| Ambalakaranpatti | 234 | 88.9 | 11.1 | 51 | 0.0 | 0.0 | 100.0 | 324 | 0.0 | 44.4 | 55.5 |
| Vellalapatti | 257 | 57.4 | 42.6 | 32 | 0.0 | 44.7 | 53.3 | 256 | 2.1 | 61.7 | 36.2 |
| Mean | 235 | 79.9 | 20.1 | 34.14 | 0.0 | 39.5 | 60.5 | 331 | 0.15 | 38.5 | 61.4 |

to previous crop. The available nitrogen content of soils always depends on temperature, rainfall and altitude.In addition, continuous and intensive cultivation leading to high crop removal together with insufficientreplenishment might be the reason for high degree of nitrogen deficiency in these soils. The mediumnitrogen status recorded in some portion of the study area might be due to application of N fertilizer.

**Available phosphorus**

Phosphorus is essential for growth, cell division, root growth, fruit development and earlyripening of the crop (Singh *et al.*, 2016). The available phosphorous content of soils in the study area varied from 18 to 52 kg $ha^{-1}$ in soils of Melur block (Table 2). The 39.5 per cent of soil samples were medium in available phosphorus ($P_2O_5$), 60.5% were high in available phosphorus, which might be due to the high input of phosphate fertilizers over a period of time as reported by Anonymous (2010), high level of P in soil not only impairs the availability and uptake of essential nutrients by plants but also leads to soil and water pollution.

**Table 3:** Nutrient index values for the soil samples of study area.

| Characteristics | Nutrient index | Values remarks | Nurtient index rating |
|---|---|---|---|
| Organic carbon | 1.21 | Low | <1.67 Low |
| Available nitrogen | 1.07 | Low | 1.67-2.33 Medium |
| Available phosphorus | 2.78 | High | >2.33 High |
| Available potassium | 2.71 | High | |

**Table 4:** Correlation matrix of the soil samples of study area.

| Soil properties | OC | N | P | K |
|---|---|---|---|---|
| OC | 1 | | | |
| N | 0.030614* | 1 | | |
| P | 0.083357 | 0.079688* | 1 | |
| K | -0.19351 | -0.20267 | -0.07621* | 1 |

*indicate correlation is significant at 0.05 level.

**Available potassium**

Potassium exists in $K^+$ form and its function appears to be catalytic in nature (Singh *et al.,* 2016). The available potassium content of soils in the study area varied from medium (38.5 per cent) to high (61.4 per cent) in soils of Melur block (Table 2). The soils were higher in available potassium status due to the predominance of K rich micaceous and feldspars minerals in their parent material. In addition, Kaolinite typeof clay mineralogy may be the cause for their medium and low rating for available potassium (Pulakeshi *et al.,* 2012).

**Inter-relationship of soil properties**

The correlation studies (Table 4) revealed that the nutrient status in the soil was positively correlated with soil parameters *viz.* N (r = 0.030614*), P (r = 0.079688*) and negatively correlated with K (r = -0.07621*).

**Management practices**

Pulses growing soils are low in organic carbon and available nitrogen and medium to high in available phosphorus and potassium. Pulses are generally fixed atmospheric nitrogen in soil as 80-90 percentages of crop requirements. Hence the following management practices are to be carried out for achieving the productivity in pulses.

1. Application of organic manures before sowing the crops.
2. Application of chemical fertilizer @ 20:60:20 kg $ha^{-1}$.
3. Foliar application nutrients compared to basal.
4. Integrated nutrient management as 50% recommended

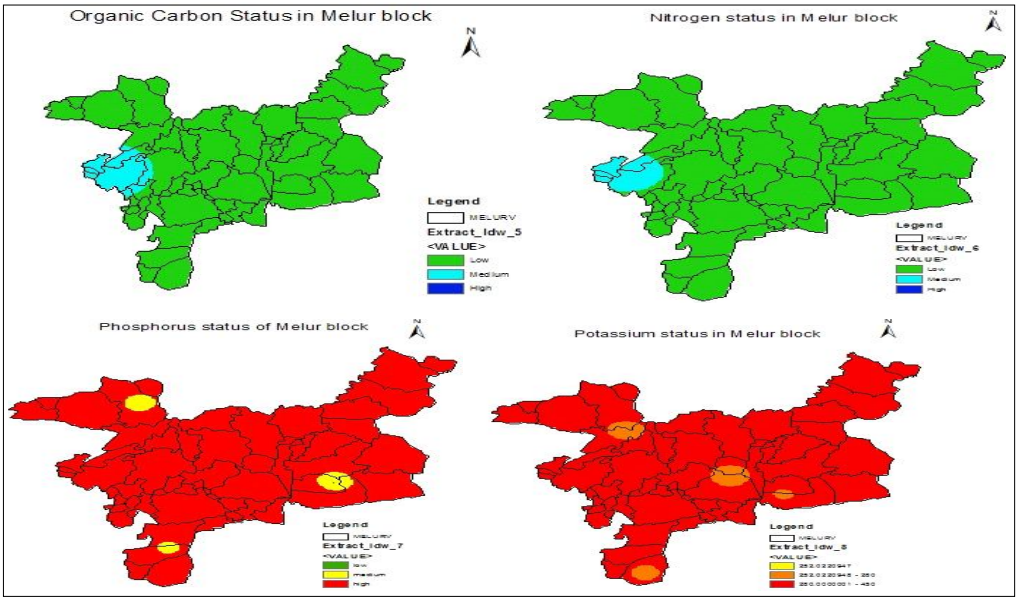


**Fig 2:** Per cent distribution of soil available organic carbon, nitrogen, phosphorus and potassium status in pulses growing areas of Melur block.

dose of fertilizer (RDF) + FYM at 5 t $ha^{-1}$ + bio-fertilizers (*Rhizobium* + PSB) application are to be adopted.

5. Band placement of phosphate and bio-fertilizers.
6. Application of pulse wonder @ 5 kg $ha^{-1}$ to reduce the flower drops and enhances the yield.

## CONCLUSION

Soil fertility assessment of pulse growing soils of Melur block was assessed with one of the GIS tools and Nutrient Availability Index (NAI). The soils were neutral in reaction, low in soluble salt content, low in available nitrogen, medium in available phosphorus and high in potassium. Hence the present study will be used for finding out the deficiency and sufficiency of nutrients in the particular area by seeing thematic maps. The pulse productivity should be improved with application of soil Test based fertilizer application, foliar application of micro nutrients and pulse wonder.

### Conflict of interest

All Authors declare that they have no conflict of interest.

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