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*RESEARCH PAPER*

# Soil fertility assessment and mapping of red and black soil farm of Regional Agricultural Research Station, Kovilpatti, Thoothukudi district, Tamil Nadu state

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**Abstract :** The soil fertility status and mapping their spatial distribution play a crucial role for sustainable planning of particular area. Thus, a study was conducted to assess the soil fertility status of the Agricultural Research Station, Kovilpatti, Thoothukudi district. The farm is situated 8° 48' and 9° 20' North latitude and 78° 25' east longitude at 90 MSL. The total 18 samples were collected randomly at a depth of 0-20 cm by using soil sampling auger. A GPS device was used for determination of geographical position of soil sampling points. The collected samples were analyzed following standard analytical methods in the laboratory of Soil Science Laboratory, Agricultural Research Station, Kovilpatti. The Arc-GIS 10.1 software was used for the soil fertility distribution mapping. The In red soil farm, the observed data revealed that the soil pH ranged from 7.41 to 7.88. The distribution soil pH varied from mild alkaline to moderate. Soil EC ranged between 0.23 to 1.12 $dSm^{-1}$. The nature of the soil EC was non-saline. The soil available nitrogen ranged from 158 to 199 kg/ha. This area having low level of soil available nitrogen distribution. The soil available phosphorus ranged between 12.5 to 18.5 kg/ha. The distribution of soil available phosphorus is medium in variability. The available soil potassium ranged from 255 to 478 kg/ha. The soil available potassium having high distribution in red soil. In black soil farm, the soil pH ranged from 7.78 to 8.46. The distribution of the soil pH extended from mild alkaline to moderate alkaline. The soil EC ranged from 0.25 to 1.23 $dSm^{-1}$. The distribution of the soil EC was non - saline in nature. The soil available nitrogen ranged from 103 to 163 kg/ha. The soil available phosphorus ranged from 7.7 to 12.7 kg/ha. The distribution of the available soil phosphorus was low to medium in status. In spite of soil available potassium ranges between 360 to 560 kg/ha. The distribution of the soil available potassium is high in black soil farm. The determined soil test data can be used for sustainable soil management as well as developing future research strategy in the farm.

**Key Words :** Soil fertility, Mapping, Digitalization, Geographical positioning system, Arc-Gis

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## INTRODUCTION

Soil is an important natural dynamic body to give life to all living things in the World (Jones, 2012). Fertile and productive soil proliferate life whereas, unfertile and

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unproductive soil brings hunger and famines. Soil fertility management have great challenge now days because of various intrinsic and extrinsic factors. The soil fertility evaluation is the most basic decision making tool in order to efficient plan of a particular land use system (Havlin et al., 2010). There are several techniques for evaluation of soil fertility status. Among them soil testing is a most popular everywhere, as well as more appropriate one. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for economic production of crops. Soil analysis includes physical properties (texture, structure, colour, bulk density etc.) and chemical properties (soil pH, organic matter, macro and micronutrients etc.), which symbolize prerequisite for sustainable soil management (Panda, 2010). Among them some physical parameters can be determined in the field, while most of the chemical parameters should have to analyze in the laboratory. Soil properties vary spatially from a small to larger area might be due to effect of intrinsic (parent materials and climate) and extrinsic factors such as soil management practices, indigenous fertility status, crop rotation and nature of standing crop. Describing the spatial variability of soil fertility across a field has been difficult until new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) were introduced. Collection of soil samples by using GPS is very important for preparing thematic soil fertility maps (Mishra et al., 2013). Similarly, Geographical Information System is a potential tool used for easy access, retrieval and manipulation of voluminous data of natural resources often difficult to handle manually. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin (Mandal and Sharma, 2009).

Based on the geo statistical analysis, several studies have been conducted to characterize the spatial variability of different soil properties (Liu *et al*., 2013). Among the different geo-statistical methods, ordinary kriging is widely used to map spatial variation of soil fertility because it provides a higher level of prediction accuracy (Song *et al*., 2013). However, Information on soil fertility status and mapping their spatial distribution for Agricultural Research Station, Kovilpatti are not done yet. Therefore, it is important to investigate the soil fertility status and mapping their spatial distribution, thus may provide valuable information relating agricultural research strategy development. Considering this, the present study was initiated with the objective to assess the soil fertility status in the Agricultural Research Station, Kovilpatti, Thoothukudi district, Tamil Nadu state.

## Material and Methods

Under dryland condition during the summer season 2020 - 21, Geo-referenced surface soil samples were collected from field wise and analyzed for the soil physico-chemical properties. Fourty seven soil samples were collected randomly from red and black soil farms at the depth of 0-15 cm by using soil sample auger. The Global Positioning System (GPS) data (Eastern Longitude and Northern Latitude) were collected from each sampling sites distributed over the entire black and red soil farms of Agricultural Research Station, Kovilpatti.

The surface soil samples were collected from both farms and analyzed for various soil properties viz., pH, EC, soil available nitrogen, phosphorus, potassium and organic carbon. The farm soil samples were classified in to low, medium and high category based on the critical limits. Delineate the base map of both farms were marked on 1: 50,000 scale prepared and Digitized using Arc-GIS. The soil samples points marked using GPS were fed into the GIS environment. The database was exported to Arc-GIS software and the thematic maps on different physico-chemical properties and available nutrients were generated.

The soil data has been collected from 1981 to 2020 and developed the soil fertility level in digital format for the red and black soil farms. The geographical location of red soil latitude N9$^0$11’21.912" Longitude E77$^0$52’51.3408" and black soil Latitude N9$^0$12’21.906", Longitude E77$^0$52’51.4236 at 90 feet above MSL.

### Site and soil characteristics:

The Kovilpatti is situated between 8 ° 48’ and 9 ° 20’ North latitude and 78 ° 25’ east longitude at 90 MSL. It is a semi arid region with an annual rainfall of 737 mm. The normal maximum and minimum temperature is 35$^o$ C and 22$^o$ C, respectively.

The black soil (*Typic chromusterts*) covers an area of 70 per cent of farm area and the remaining 30 per cent area under redsoil (*Typic Haplustalf*). The depth of the black soil varies from 110 to 150 cm with the infiltration rate of 0.9cm hr$^{-1}$. Soil develop typical cracks with at least one cm wide and reaching a depth of 50cm or more in the period of moisture stress. Considering the mechanical fraction, the soil is clayley with clay

**Table A: Parameters and methods adopted for the laboratory analysis at Agricultural Research Station, Kovilpatti**

| Sr. No. | Parameters | Unit | Methods |
|---|---|---|---|
| | Soil pH | Nil | soil and water suspension (1:2), (Jackson, 1973). |
| 2. | Soil electrical conductivity | $dSm^{-1}$ | |
| 3. | Soil available nitrogen | | Alkaline Permanganate method (Subbiah and Asija,1956). |
| 4. | Soil available phosphorus | $kg\ ha^{-1}$ | Olsen's method (Olsen *et al.,* 1954). |
| 5. | Soil available potassium | | Neutral normal ammonium acetate, (Stanford and English,1949). |
| 6. | Soil organic carbon | $g\ kg^{-1}$ | Walkley and Black (Walkley and Black,1934). |


**Fig. A : Location map of Agricultural Research Station, Kovilpatti**

content of 46.4 to 61.2 per cent, 10.0 to 17.5 per cent silt and 12.6 to 24.5 per cent coarse sand.The soil bulk density varies from 1.21 to 1.36 kg $m^{-3}$ with field capacity of 35 per cent and permanent wilting point (PWP) of 14 per cent (Sunflower as an indicator plant). The soil has sub-angular blocky structure with pH generally neutral to a tendency towards alkalinity at lower depths (7.8 to 8.2) and EC 7.8-8.2 $dSm^{-1}$. Regarding soil fertility status, in black soil farm the soil available nutrients *viz.,* low in soil available nitrogen (112-134 kg $ha^{-1}$), low to medium in soil available phosphorus (9.9 to 15.6 kg $ha^{-1}$), high in soil available potassium (350-550 kg $ha^{-1}$), low in soil available zinc (0.4 ppm) and low in soil available magnesium. While in red soil farm, the soil depth is 80-100cm and soil texture is sandy loam with field capacity of 18.5% and PWP is 7.8%. The physic-chemical properties *viz.,* pH (7.80-8.11 $dSm^{-1}$), EC (0.23-0.35 $dSm^{-1}$), soil available nitrogen (108-125 kg $ha^{-1}$), phosphorus (10.9-16.5 kg $ha^{-1}$), potassium (360-450 kg $ha^{-1}$) and organic carbon (1.8-3.0 g $kg^{-1}$). The collected soil samples were processed through 2 mm size sieve and analysed for the various soil available nutrients. For soil organic carbon content soil passed through 0.2 mm sieve size.

## Results and Discussion

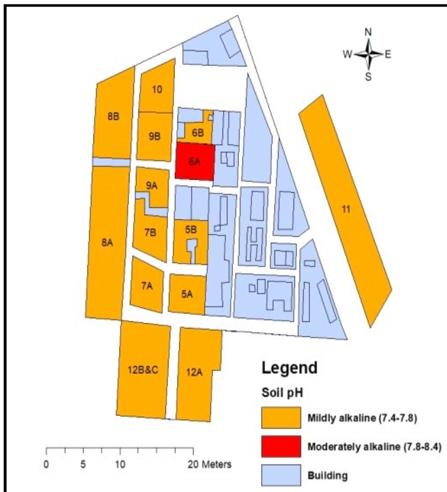
The soil fertility distribution of the studied site was assessed through soil pH, Electrical conductivity, soil available nitrogen, phosphorus, potassium and soil organic carbon. The analytical results from the laboratory analysis are presented and discussed are as follows.

Soil pH is one of the most important characteristics of soil fertility, because it has a direct impact on nutrient availability and plant growth (Brady and Weil, 2002). In red soil farm, soil pH ranged from 7.41 to 7.88. The distribution soil pH varied from mild alkaline to moderate. Soil EC ranged between 0.23 to 1.12 $dSm^{-1}$. The nature of the soil EC was Non-saline. Only two fields' recorded higher soil electrical conductivity. where irrigation was given with poor quality water during the summer season, it might be due to the excess of salts accumulation from ground water.

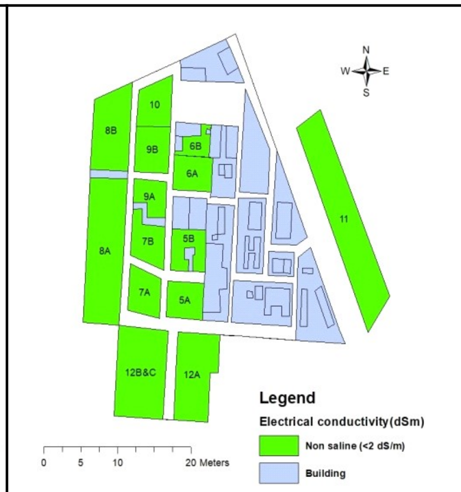
The soil available nitrogen ranged from 158 to 199 kg/ha with the low level of soil available nitrogen distribution. Phosphorus is the second most limiting nutrient after nitrogen, and has negative impacts on crop yield if found to be deficient (Sharma *et al.,* 2017). The soil available phosphorus ranged between 12.5 to 18.5 kg/ha and the distribution of soil available phosphorus is in medium in status. Potassium (K) is one of the three major nutrients needed by plants, the others being nitrogen and phosphorus (Havlin *et al.,*2010). The available soil potassium ranged from 255 to 478 kg/ha. The soil available potassium having high distribution in red soil. The different minerals such as muscovite, biotite, feldspars, orthoclase, microcline, mica etc. are major K bearing minerals found in the earth. The occurrence of their different minerals, optimum organic matter status and comparative low content of sand separates among others might be the cause of satisfactory conditions of available potassium in the farm. Organic matter is a vital parameter for making soil alive, because it improves different physical, biological and chemical properties

**Table 1 : Soil fertility status and digitalization of red soil farm on soil physico-chemical properties**

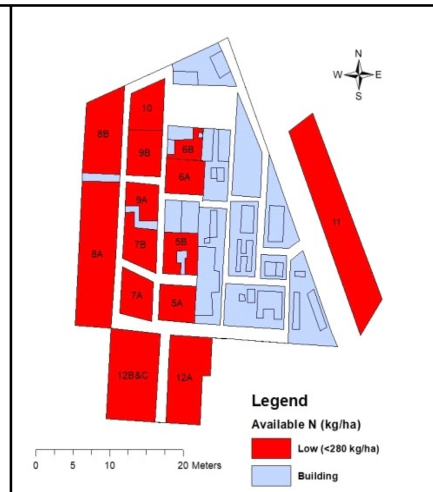
| S. No. | Field No. | Latitude | Longitude | pH | EC ($dSm^{-1}$) | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) | Available OC (g/kg) |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 5A | N09?11.463 | E077°52.831 | 7.49 | 1.12 | 143 | 14.7 | 415 | 3.74 |
| 2. | 5B | N09?11.468 | E077°52.841 | 7.75 | 1.08 | 146 | 17.6 | 438 | 3.73 |
| 3. | 6A | N09?11.456 | E077°52.884 | 7.88 | 0.72 | 134 | 18.0 | 478 | 3.22 |
| 4. | 6B | N09?11.450 | E077°52.897 | 7.76 | 0.46 | 136 | 18.5 | 447 | 3.10 |
| 5. | 7A | N09?11.502 | E077°52.827 | 7.73 | 0.81 | 142 | 16.0 | 417 | 3.13 |
| 6. | 7B | N09?11.485 | E077°52.846 | 7.50 | 0.63 | 133 | 17.9 | 458 | 3.74 |
| 7. | 8A | N09?11.536 | E077°52.853 | 7.46 | 0.47 | 158 | 15.2 | 428 | 3.15 |
| 8. | 8B | N09?11.530 | E077°52.911 | 7.41 | 0.33 | 149 | 13.9 | 416 | 3.19 |
| 9. | 9A | N09?11.495 | E077°52.874 | 7.55 | 0.50 | 143 | 13.9 | 400 | 3.13 |
| 10. | 9B | N09?11.493 | E077°52.897 | 7.68 | 0.41 | 134 | 17.2 | 388 | 3.16 |
| 11. | 10 | N09?11.491 | E077°52.919 | 7.65 | 0.23 | 156 | 15.6 | 407 | 3.22 |
| 12. | 11 | N09?11.359 | E077°52.890 | 7.60 | 0.15 | 119 | 16.2 | 255 | 3.16 |
| 13. | 12A | N09?11.449 | E077°52.746 | 7.48 | 0.57 | 135 | 12.5 | 407 | 3.17 |
| 14. | 12B&C | N 09° 11.485 | E077° 52.811 | 7.55 | 0.67 | 136 | 13.7 | 418 | 3.72 |



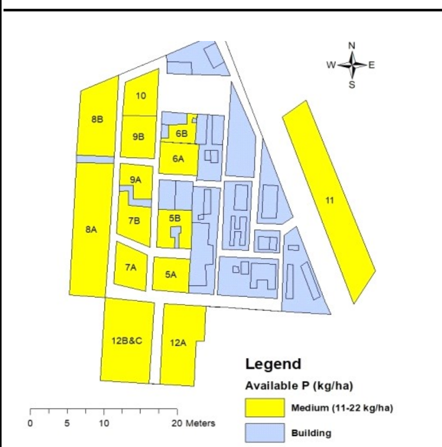

Soil pH map of red soil farm



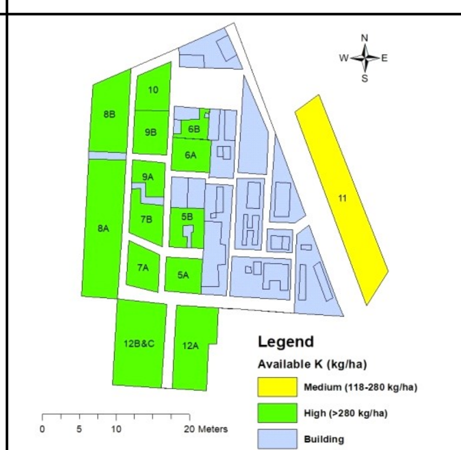

Soil electrical conductivity ($dS/m^{-1}$) map of red soil farm



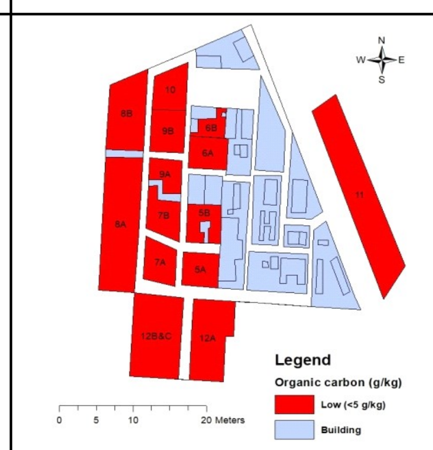

Soil available nitrogen (kg/ha) map of red soil farm




Soil available phosphorus (kg/ha) map of red soil farm




Soil available potassium (kg/ha) map of red soil farm



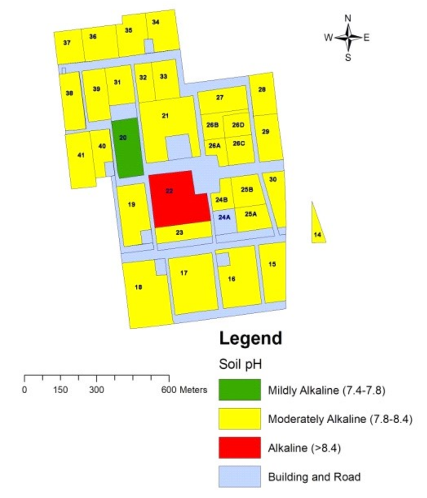

Soil organic carbon (g/kg) map of red soil farm

(Hoyle *et al.,* 2011). Regarding organic carbon status, it ranged from 3.10 to 3.74 g/kg. It indicates the lower level of soil organic carbon status in the red soil farm.

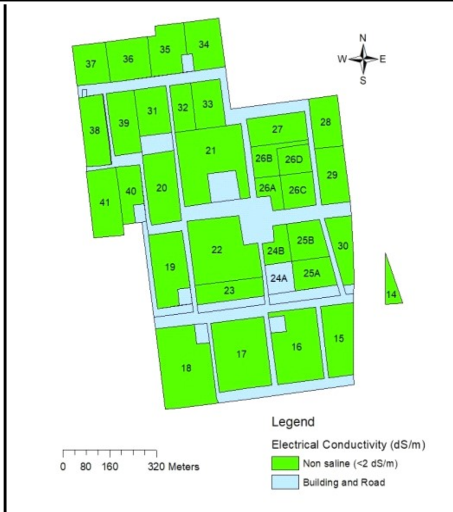
In black soil farm, the soil pH ranged from 7.78 to 8.46. The distribution of the soil pH extended from mild alkaline to moderate alkaline. The variation on the soil management practices as well as crop allocation in different sites of the farm from the longer period might be the cause of variation of soil pH. The soil EC ranged from 0.25 to 1.23 $dSm^{-1}$. The distribution of the soil EC was non - saline in nature. In general, calcareous rock is found under five feet depth, due to gravity and capillary force action salts present in rock deposited in the surface layer (Plough layer) of the soil. High salinity due to irrigation purpose salts deposits on the surface of the soil. The soil available nitrogen ranged from 103 to 163 kg/ha. Every year the applied nitrogen has been depleted by the crop during the crop growth stages. The soil available phosphorus ranged from 7.7 to 12.7 kg/ha. The distribution of the available soil phosphorus was low to

**Table 2: Soil fertility status and digitalization of black soil farm of soil physic-chemical properties**

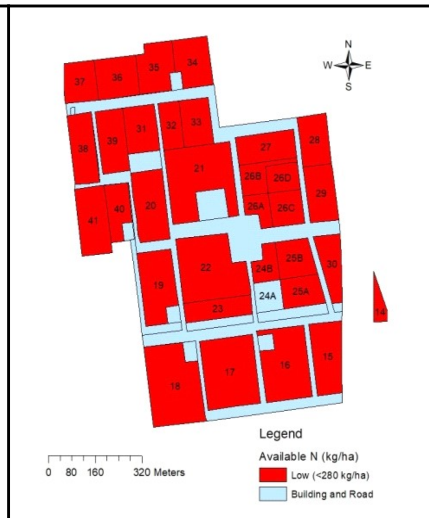
| Sr. No. | Field No. | Latitude | Longitude | pH | EC ($dSm^{-1}$) | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) | Availab OC (g/k |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 14 | N09?12.223 | E077?52.879 | 7.94 | 0.86 | 125 | 10.5 | 447 | 4.5 |
| 2. | 15 | N09?12.275 | E077?52.786 | 8.08 | 0.40 | 132 | 10.3 | 360 | 4.09 |
| 3. | 16 | N09?12.269 | E077?52.701 | 8.07 | 0.50 | 120 | 12.7 | 416 | 4.17 |
| 4. | 17 | N09?12.278 | E077?52.598 | 8.07 | 0.50 | 132 | 10.7 | 443 | 4.13 |
| 5. | 18 | N09?12.272 | E077?52.487 | 8.04 | 0.41 | 132 | 9.8 | 436 | 3.92 |
| 6. | 19 | N09?12.377 | E077?52.472 | 8.09 | 0.46 | 131 | 8.8 | 426 | 4.10 |
| 7. | 20 | N09?12.443 | E077?52.791 | 7.78 | 0.44 | 126 | 11.9 | 382 | 4.06 |
| 8. | 21 | N09?12.436 | E077?52.568 | 8.14 | 0.49 | 126 | 11.0 | 437 | 4.08 |
| 9. | 22 | N09?12.414 | E077?52.634 | 8.46 | 0.25 | 103 | 8.1 | 402 | 3.20 |
| 10. | 23 | N09?12.390 | E077?52.563 | 8.14 | 0.61 | 152 | 10.9 | 508 | 4.00 |
| 11. | 24 A | N09?12.340 | E077?52.688 | 8.16 | 0.88 | 158 | 9.8 | 538 | 4.04 |
| 12. | 24B | N09?12.388 | E077?52.666 | 8.10 | 0.54 | 125 | 11.2 | 560 | 4.60 |
| 13. | 25A | N09?12.329 | E077?52.755 | 8.08 | 1.23 | 163 | 11.2 | 504 | 4.17 |
| 14. | 25B | N09?12.365 | E077?52.743 | 8.09 | 1.19 | 160 | 9.1 | 540 | 3.88 |
| 15. | 26A | N09?12.408 | E077?52.692 | 8.06 | 1.19 | 149 | 10.0 | 518 | 3.89 |
| 16. | 26B | N09?12.441 | E077?52.685 | 8.13 | 0.62 | 153 | 7.8 | 516 | 3.90 |
| 17. | 26C | N09?12.401 | E077?52.754 | 8.16 | 0.61 | 160 | 8.7 | 427 | 3.84 |
| 18. | 26D | N09?12.437 | E077?52.753 | 8.02 | 0.67 | 139 | 8.7 | 442 | 3.90 |
| 19. | 27 | N09?12.472 | E077?52.754 | 8.25 | 0.38 | 115 | 9.1 | 412 | 3.91 |
| 20. | 28 | N09?12.464 | E077?52.843 | 8.20 | 0.37 | 136 | 9.8 | 431 | 3.86 |
| 21. | 29 | N09?12.392 | E077?52.840 | 8.20 | 0.34 | 120 | 9.1 | 434 | 4.16 |
| 22. | 30 | N09?12.342 | E077?52.825 | 8.18 | 0.45 | 136 | 10.2 | 404 | 3.97 |
| 23. | 31 | N09?12.531 | E077?52.439 | 8.19 | 0.32 | 135 | 10.2 | 393 | 3.86 |
| 24. | 32 | N09?12.532 | E077?52.506 | 8.15 | 0.50 | 117 | 10.5 | 421 | 6.54 |
| 25. | 33 | N09?12.524 | E077?52.562 | 8.19 | 0.42 | 131 | 9.0 | 431 | 3.85 |
| 26. | 34 | N09?12.589 | E077?52.564 | 8.17 | 0.45 | 130 | 10.6 | 379 | 3.83 |
| 27. | 35 | N09?12.584, 604 | E077?52.498, 492 | 8.19 | 0.33 | 123 | 9.1 | 386 | 3.80 |
| 28. | 36 | N09?12.605 | E077?52.384 | 8.20 | 0.40 | 126 | 8.9 | 393 | 3.85 |
| 29. | 37 | N09?12.602 | E077?52.293 | 8.16 | 0.40 | 131 | 8.6 | 379 | 4.00 |
| 30. | 38 | N09?12.525 | E077?52.285 | 8.16 | 0.45 | 121 | 10.8 | 409 | 3.87 |
| 31. | 39 | N09?12.513 | E077?52.352 | 8.16 | 0.37 | 135 | 10.0 | 403 | 3.83 |
| 32. | 40 | N09?12.451 | E077?52.346 | 8.17 | 0.41 | 109 | 9.2 | 382 | 3.86 |
| 33. | 41 | N09?12.444 | E077?52.288 | 7.96 | 0.40 | 119 | 7.7 | 367 | 3.97 |



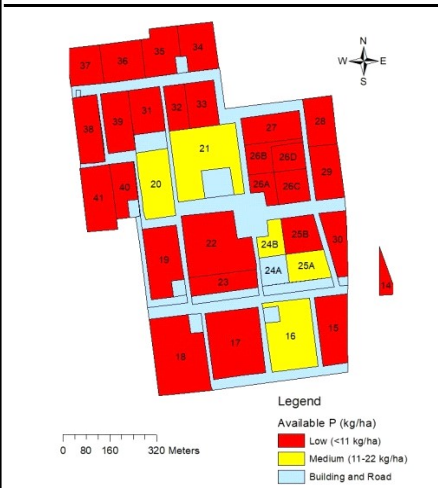

**Soil pH map of black soil farm**



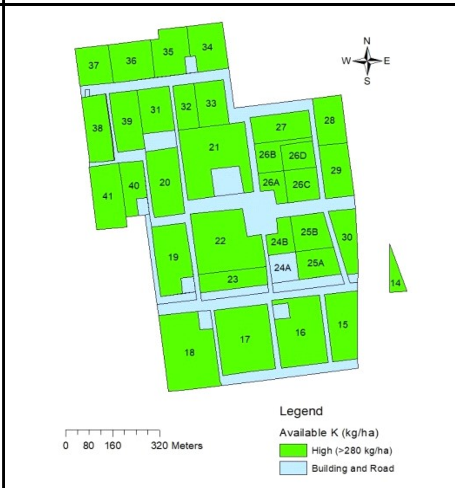

**Soil electrical conductivity (dS/m) map of black soil farm**



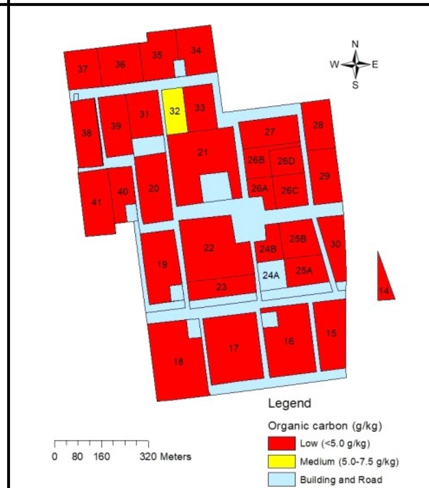

**Soil available nitrogen (kg/ha) map of black soil farm**




**Soil available phosphorus (kg/ha) map of black soil farm**




**Soil available potassium (kg/ha) map of black soil farm**




**Soil organic carbon (g/kg) map of black soil farm**

medium in condition. In spite of soil available potassium ranges between 360 to 560 kg/ha. The distribution of the soil available potassium is high in black soil farm.

Potassium exists in soil in different forms, *viz.,* water-soluble K, which is taken up directly by plants; exchangeable K, held by negative charges on clay particles and is available to plants and fixed K, which is trapped between layers of expanding lattice clays. The knowledge of various forms of K *viz.,* water-soluble, exchangeable and non-exchangeable and an understanding of conditions controlling the availability to growing crops is important for the appraisal of the available K in the soil. The available K constitutes only 1-2 per cent of total K and exists in soil in two forms *i.e.* water-soluble and exchangeable K adsorbed on soil colloidal surface (Brady and Well, 2002). These forms remain in a dynamic equilibrium with one another. The readily available or water-soluble K has been reported to be a dominant fraction in the initial stage while exchangeable and non exchangeable K contribute more in the later stages of plant growth. Regarding soil organic carbon, it ranged from 3.20 to 4.60 g/kg and recorded low in status except field no. 32 which recorded soil organic carbon content of 6.5 g/kg due to dumping of FYM in the particular field for a long time.

## Conclusion:

The determined soil test data can be used mainly in two aspects. First one is for sustainable soil management, while another for developing research strategy as being a farm of research station. The fertilizer should be applied for each crops based on the determined nutrient distribution status shown in the prepared maps of farm. The plants may suffer from deficiency stress of low, and toxicity stress of very high status of nutrients. The proper care should be taken for such types of nutrients. For enhancing research efficacy of the station, the future research strategy should be built based on the determined soil fertility status and their distribution.

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## REFERENCES

**Brady, N.C. and Well, R.R. (2002).** *The nature and properties of soils*.13th Ed. Pearson Education (Singapore) Pvt.Ltd, New Delhi, India.

**Havlin, H.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (2010).** Soil fertility and fertilizers: An introduction to nutrient management. 7th Ed., PHI Learning Private Limited, New Delhi. India. 516pp.

**Hoyle, F.C., Baldock, J.A. and Murphy, D.V. (2011).** Soil organic carbon – role in rainfed farming systems: with particular reference to Australian conditions. In: Rainfed farming systems. Tow, P., Cooper, I., Partridge, I., Birch, C., (Eds.). Springer, New York, USA. pp. 339–361.

**Jones, Jr, J.B. (2012).** *Plant nutrition and soil fertility manual*. 2nd Edition, CRC Press. New York, USA. 299p.

**Liu, Z.P., Shao, M.A., Wang, Y.Q. (2013).** Spatial patterns of soil total nitrogen and soil total phosphorus across the entire Loess Plateau region of China. *Geoderma.,* **197-198**: 67-78.

**Mandal, A.K. and Sharma, R.C. (2009).** Computerized database of salt affected soils for Peninsular India using GIS. *Geocarto International,* **24**(1): 64-85.

**Mishra, A., Das,D. and Saren, S. (2013).** Preparation of GPS and GIS based soil fertility maps for Khurda district, Odisha. *Indian Agriculturist,* **57**(1): 11-20.

**Panda, S.C. (2010).** *Soil management and organic farming.* Agrobios, Bharat Printing Press, Jodhpur, India. 462p.

**Sharma, L.K., Bali, S.K. and Zaeen, A.A. (2017).** A case study of potential reasons of ýncreased soil phosphorus levels in the Northeast United States. *Agronomy,* **7**(4): 85.

**Song, G., Zhang,L. Wang, K. and Fang, M. (2013).** *Spatial simulation of soil attribute based on principles of soil science*. 21st International Conference on Geoinformatics. 20-22 June 2013. Kaifeng, China.

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