Application of Geographical Information System to Understand Spatial Variability of Soil Available Nutrients in Northern Karnataka, India

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1Department of Agricultural Engineering, College of Agriculture Bheemarayanagudi-585287, University of Agricultural sciences Raichur, Raichur, India. Samples were analysed for electrical conductivity (EC), power of hydrogen (pH), organic carbon (OC), Nitrogen (N), Phosphorous (P2O5) and Potassium (K2O). Further, SPSS (ver. 19) was used to execute conventional statistical analysis and ArcGIS to get the information about distribution and spatial variability of soil available nutrients. The analysis results showed that the EC of soil varied from 0.13 to 0.25 dS/m with a mean of 0.18 dS/m. The pH ranged from 6.62 to 8.82 with an average of 7.89. Available OC ranged from 0.14 % to 1.90 % with mean of 0.78 %. Similarly mean values for N, P2O5 and K2O observed 215.3 kg/ha, 31.5 kg/ha, and 513.4 kg/ha, respectively. Spatial variability maps for various nutrients prepared shows the huge variation in the soil nutrients availability. This variability appeared due to lack of balanced application of fertilizers. It was suggested that an appropriate applications of nutrients necessary for selected land based on soil nutrients.

Keywords: Soil fertility, Kolmogorov–Smirnov (K-S) test, Dukey data Adequacy test, Inverse Distance Weighted (IDW).

INTRODUCTION

The conventional method of soil fertility management consider entire fields as a single group of soil and also while calculating requirement of fertilizer as a single field. Recitation of soil spatial variability in the field has a huge difficulty, in the use of latest advanced tools and technologies Viz. Global Positioning Systems (GPS), Geographic Information Systems (GIS) and many others were commenced. Many scientists demonstrated in studies conducted at various locations, GIS is an effective set of tools for to collect, store, retrieve, transform and display spatial data[1]. It is also seen that the scientists working in natural resource management groups has extensively used GIS for the production of soil fertility map of an area that helps to understand the soil fertility status spatially and temporally, which will be useful to calculate the site-specific suggestion for application of the appropriate quantity of fertilizers. Technologies like GPS and GIS allow fields to be mapped precisely and to help in understanding the complex spatial relationships between soil fertility factors[2]. Noticeably, a prepared soil fertility status map of selected location can help in guiding the various stakeholders such as the people from farming community, manufacturers from industrial sectors and planners in deciding the need of...
various soil available nutrients in a different cropping seasons in the year and making predictions for increased demand based on intensity of crops and cropping pattern\(^2,3\) stated that the soil properties can vary spatially due to a range of factors viz. parent material, topography, climate, vegetation, and land management. It is also revealed that the spatial variability in soil is essential to pinpoint the nutrient limit zones in relation of production area to lessen the use of nutrients. Therefore, the precision agriculture is mainly depends on the management of spatial variability in soil fertility in agriculture and which is a major constraint for food production \(^4\). Therefore, in the present study conventional statistical analysis and ArcGIS tool has been applied to get the information about distribution and spatial variability of soil available nutrients.

**MATERIALS AND METHODS**

**Study Area**

The study carried out in Vandurga Village of Shahapur taluk as geographically lies between 16.64 N to 16.65 N latitude and 76.69 E to 76.70 E longitudes (Fig. 1). The total study area is 40 ha. This village come under the north-east dry zone (Zone-2) of Karnataka and partly irrigated from Krishna River by Shahapur Branch Canal Study area is characterized by undulating to rolling topography and geographically the rock system is granite-genesis complex belongs to Archean period. It's

![Fig. 1: Location of study area and sampling points](image)

| Parameters    | Soil Available Nutrients |
|---------------|--------------------------|
| Values        | EC, dS/m | PH | OC, % | N, kg/ha | P\(_2\)O\(_5\), kg/ha | K\(_2\)P\(_5\), kg/ha |
| Mean          | 0.18     | 7.98 | 0.77  | 215.31    | 31.55                | 513.47               |
| Maximum       | 0.24     | 8.82 | 1.90  | 527.81    | 79.62                | 994.6                |
| Minimum       | 0.12     | 6.62 | 0.14  | 100.84    | 7.93                 | 312.6                |
| Median        | 0.178    | 8.135| 0.701 | 181.4     | 24.62                | 478.0                |
| SD            | 0.03     | 0.56 | 0.39  | 100.9     | 19.12                | 160.88               |
| CV%           | 16.68    | 7.04 | 51.16 | 48.68     | 60.60                | 31.33                |

| Parameters | 95% confidence interval for actual mean | 3rd Quartile | 1st Quartile | Average deviation from median | Outliers values as per John Tukey define |
|------------|----------------------------------------|--------------|--------------|-------------------------------|-----------------------------------------|
| pH         | 7.74 thru 8.21                         | 8.40         | 7.49         | 0.43                          | -                                       |
| EC         | 0.17 thru 0.19                         | 0.20         | 0.17         | 2.42                          | -                                       |
| OC         | 0.61 thru 0.94                         | 1.01         | 0.51         | 0.29                          | 1.91                                    |
| N          | 173.7 thru 257.0                       | 101.00       | 270.00       | 140.00                        | 528                                     |
| P2O5       | 23.66 thru 39.45                       | 39.40        | 17.80        | 14.00                         | 79.6                                    |
| K2O        | 447.1 thru 579.9                       | 574.00       | 397.00       | 115.00                        | 995                                     |
also enjoys semi-arid climates with average annual rainfall 656 mm and minimum temperature of 21°C, where maximum temperature is 35°C.

**Soil sampling and analysis**

A total of 25 soil samples (0-20 cm depth) were collected from farmer’s fields randomly 2 km

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Fig. 2: Spatial distribution maps of soil available nutrients in study area
radius. Concurrently, from all the sampling point’s global positioning data was recorded by GPS (Trimble Juno-3D) device before sowing of Kharif (onset of south –west monsoon) crops to assess the spatial variability in the soil fertility status. All collected soil samples from different locations were taken for laboratory analysis. Before analysis of soil available nutrients [Electrical conductivity (EC), pH, soil organic carbon (OC), Nitrogen (N), Phosphorous (P₂O₅) and Potassium (K₂O)] all the collected soil samples were air dried and sieved through a 2 mm size brass sieve of BSS(8) and ASTM(10) by following the standard laboratory procedures. The laboratory analysis was done to know the fertility status of all soil samples for chemical characteristics.

Database preparation
The entire analysed data were further processed using SPSS and ArcGIS. Initially, conventional statistical analysis was performed using SPSS (version 19) and spatial analysis was carried out using ArcMap GIS (version 9.2). The various maps produced in ArcMap GIS are presented in Fig. 1 and 2. The specific distribution of soil available nutrients was evaluated for normality using Kolmogorov–Smirnov (K-S) test.

Table 2b: Kolmogorov-Smirnov (K-S) test report

| items     | Normal Distribution | Log Normal Distribution |
|-----------|---------------------|-------------------------|
|           | KS Says P mean SD   | KS Says P mean SD       |
| pH        | Consistent 0.49 7.93 | Consistent 0.39 7.90 1.09 |
| EC        | Consistent 0.88 0.18 | Consistent 0.54 0.17 1.22 |
| OC        | Consistent 0.38 0.83 | Consistent 0.45 0.64 2.16 |
| N         | Unlikely 0.01 242.8  | Consistent 0.63 203.9 1.57 |
| P₂O₅      | Unlikely 0.01 35.58  | Consistent 0.99 26.64 1.93 |
| K₂O       | Unlikely 0.01 551.5  | Consistent 0.60 506.8 1.37 |

Some outlier’s values were removed as per definition of for OC, N, P₂O₅, and K₂O to achieve the more precise outcome from study. K-S Test found consistent for pH, EC, and OC for normal distribution with 0.49, 0.88 and 0.38 probability, respectively and unlikely consistent for N, P₂O₅ and K₂O. It is also observed that for log normal distribution K-S test is consistent for all available nutrients evaluated for study area.

Test of Distributional Adequacy
The Kolmogorov-Smirnov (K-S) test applied to decide if the analyzed soil samples come from datasets with a specific distribution. The applied test is based on the empirical distribution function (ECDF). K-S Test reports has been presented in the Table 2 (a and b). Some outlier’s values were removed as per definition of for OC, N, P₂O₅, and K₂O to achieve the more precise outcome from study. K-S Test found consistent for pH, EC, and OC for normal distribution with 0.49, 0.88 and 0.38 probability, respectively and unlikely consistent for N, P₂O₅ and K₂O. It is also observed that for log normal distribution K-S test is consistent for all available nutrients evaluated for study area.

Spatial variability maps of all soil available nutrients were prepared after interpolation of point values by Inverse Distance Weighted (IDW) method and which is presented in Fig. 2 (i to vi). To classify the spatial variability of soil available nutrients in specific locations in study area spatial variability maps prepared and it clearly shows where management of nutrients is required. Similar results also observed by various scientists used interpolation technique of kriging to prepare the landslide susceptibility analysis map of Kota Kinabalu in Malaysia to locate areas prone to landslides reported that the degree of accuracy of kriging technique in the prediction of soil properties and the descriptive tools of semi variogram to characterize the spatial patterns of continuous and categorical soil attributes.
CONCLUSIONS

In the present study, the spatial variability in soil fertility were analysed for Vandurga Village, Yadgir district of Karnataka. This study showed that huge spatial variability in available nutrients in most of the farmer’s field. Few farmers field found deficient in nutrients availability and some found with adequate. This appeared due to lack of balanced application of nutrients by the farmers. Thus suggesting that, the appropriate nutrients applications needed for based of soil test values. The present study reveals that usefulness of GIS to know the spatial variability of soil available nutrients in the study area as well for spatial interpolation and mapping.

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