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

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ABSTRACT

It is very important to distinguish the spatial variability in soil fertility for site specific nutrient application. To know the status, 25 soil samples were collected from Vandurga Village, Yadgir District, Karnataka, India. Samples were analysed for electrical conductivity (EC), power of hydrogen (p^H), organic carbon (OC), Nitrogen (N), Phosphorous (P_2O_5) and Potassium (K_2O). 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 P^H 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, P_2O_5 and K_2O observed 215.3 kg/ha, 31.5 kg/ha, and 513.4 kg/ha, respectively. The SD and CV for EC was 0.031 and 16.69%, respectively, while for p^H, OC, N, P_2O_5 and K_2O it was found to be 0.56 and 7.04, 0.39 and 51.16, 100.9 and 46.86, 19.12 and 60.61, 160.88 and 31.33 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.

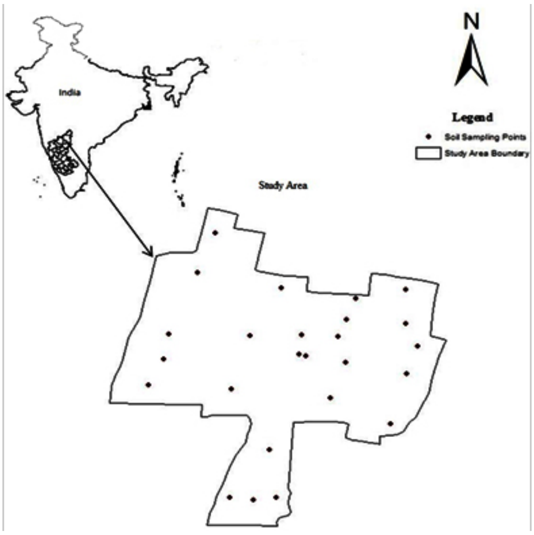

Fig. 1: Location of study area and sampling points

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

Table 1: Descriptive statistics of soil available nutrients

Parameters			Soil Available Nutrients			
Values	EC,dS/m	PH	OC,%	N, kg/ha	P_2O,kg/ha	K_2P5, 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*	*46.86*	*60.60*	*31.33*

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

Parameters	95% confidence interval for actual mean	IIIrd Quartile	Ist Quartile	Average Absolute deviation from median	Outliers values as per Jhon 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 semiarid climates with average annual rainfall 656 mm and minimum temperature of 21^{0}C, where maximum temperature is 35 ^{0}C.

Soil sampling and analysis

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

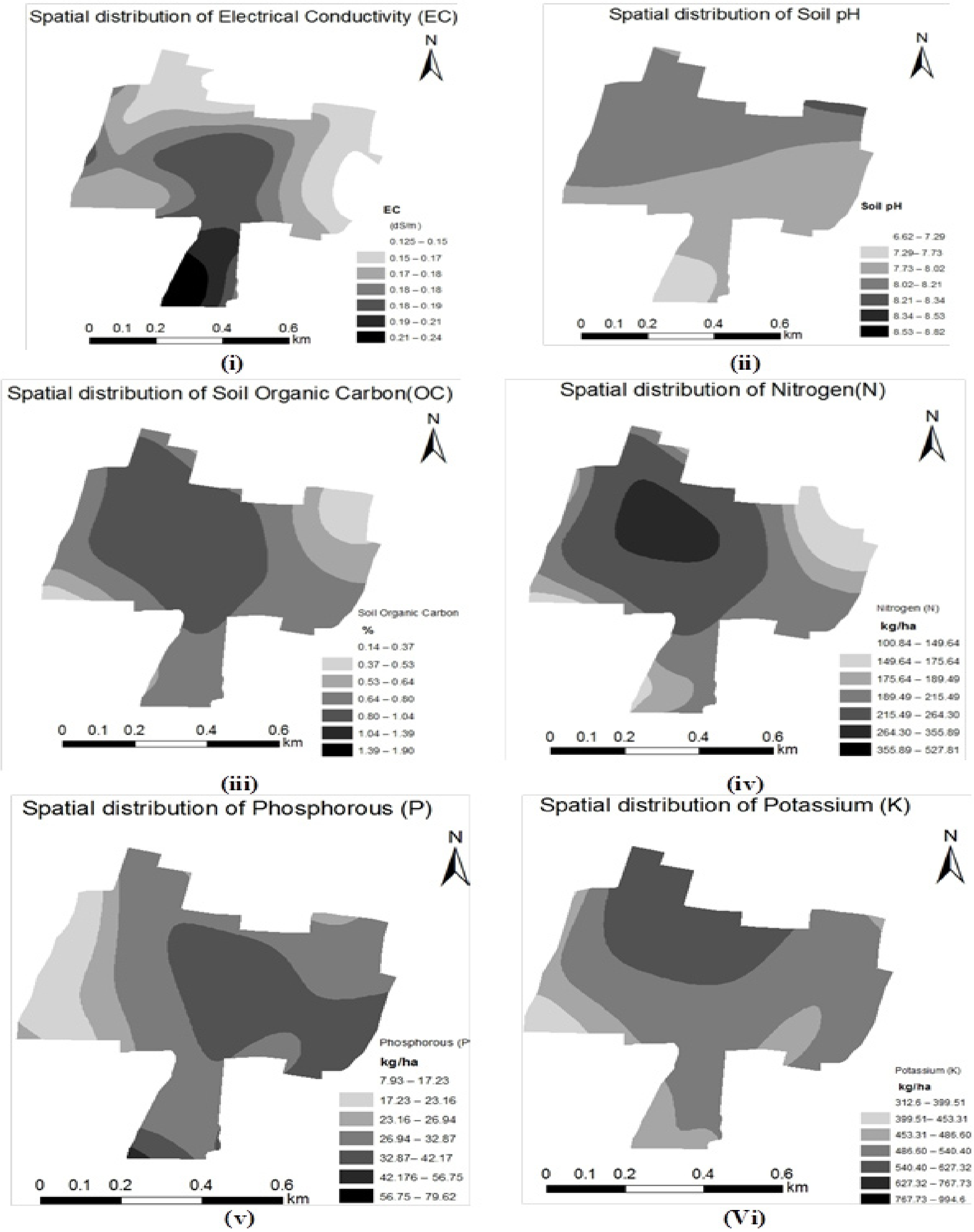

Fig. 2: Spatial distribution maps of soil available nutrients in study area

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	0.66	Consistent	0.39	7.90	1.09
EC	Consistent	0.88	0.18	3.42	Consistent	0.54	0.17	1.22
OC	Consistent	0.38	0.83	0.45	Consistent	0.30	0.64	2.16
N	Unlikely	0.01	242.8	115.3	Consistent	0.63	203.9	1.57
P2O5	Unlikely	0.01	35.58	20.59	Consistent	0.99	26.64	1.93
K2O	Unlikely	0.01	551.5	183.5	Consistent	0.60	506.8	1.37

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), p^H, soil organic carbon (OC), Nitrogen (N), Phosphorous (P_2O_5) and Potassium (K_2O)] 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[5,6,7,8,9]. 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.

RESULTS AND DISCUSSION

Descriptive statistics

The descriptive statistics values of all analyzed soil samples from study area for various soil available nutrients (EC, pH, OC, N, P_2O_5 and K_2O) are presented in the Table 1. Mean, maximum, minimum, standard deviation (SD) and coefficient of variation (CV) values for all the available soil nutrients have been calculated for 25 locations of the study area. The obtained results were found in close agreement with [10] in Mukona, Uganda study area. It was also observed that because of regular application of various nutrients in the past the mean values of N, P, K and OC elevated.

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 [11]. 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 [12] for OC, N, P_2O_5, and K_2O 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, P_2O_5 and K_2O. 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 viz[13]. used interpolation technique of kriging to prepare the landslide susceptibility analysis map of Kota Kinabalu in Malaysia to locate areas prone to landslides[14]. 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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