

Original Research Article

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GIS Based Mapping of Soil Fertility Status of Tehsil Jobat, District Alirajpur, Madhya Pradesh, India

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ABSTRACT

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The investigation was conducted in 2018-19 at Jobat Tehsil, District Alirajpur, to know the soil reaction, electrical conductivity, organic carbon content and status of primary nutrients. Surface soil samples were collected grid wise by using cadastral map of the study area and were analyzed for their fertility status. The value of pH, electrical conductivity, and organic carbon was ranged 6.15 to 8.48, 0.08 to 0.74 dSm⁻¹, and 0.20 to 0.81% respectively. The available nitrogen, phosphorus, potassium ranged from 96 to 315 kg ha⁻¹, 0.60 to 25.20 kg ha⁻¹ and 114.46 to 472.64 kg ha⁻¹ respectively. The available nitrogen was in low, phosphorus content varied from low to medium and medium to high in potassium. Using the field survey and laboratory analysis results, the soil heterogeneity units were determined using Arc-GIS 10.5.1. Based on data obtained after analysis; the maps of all parameters were prepared which will be successfully used in the future for site-specific nutrient management.

Introduction

Soil is the basic requirement of all life on earth. The origin of life has been attributed to soil along with other basic elements. Soil is the source of life and is passionate. An excessive or imbalanced application of fertilizers not only wastes these limited costly resources, but also pollutes the environment. In the face of economic and environmental concerns, farmers face an increasing challenge of

effective soil fertility management (Singh *et al.*, 2020). An approach towards justifying such concerns is site-specific nutrient management, which takes into account spatial variations in nutrients status, thus cutting down the possibility of over or under use of fertilizer.

Fertility assessment is the process of estimation of soil susceptibility in processing plant nutrients required for optimal growth.

This assessment includes a number of processes using field and laboratory diagnostics and a number of mathematical models that link the relationship between soil nutrient level and plant responsiveness. It is necessary to know the proper way to evaluate the soil fertility status and to identify the nutrient deficiency (Pawar *et al.*, 2020). There are various techniques for soil fertility evaluation, among them soil testing is an indispensable tool in soil fertility management for sustained soil productivity (Havlin *et al.*, 2010). Soil analysis is helpful for better understanding of the soils to increase the crop production and obtaining sustainable yield.

Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site-specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. Under this context, prepare a fertility map and of such map as a decision support tool for nutrient management, will not only be helpful for adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization, but will also reduce the necessity for elaborate plot-by-plot soil testing activities. Geographic information system (GIS) is a powerful tool, which helps to integrate many types of spatial information such as agroclimatic zone, land use, soil management, etc. to derive useful information (Singh *et al.*, 2017) Furthermore, GIS generated soil fertility maps may serve as a decision support tool for nutrient management.

Materials and Methods

Description of study area

Alirajpur district of Madhya Pradesh, is situated 22°18'19" latitude and 74°21'09" longitude and at an altitude of 315m above MSL. Jobat Tehsil situated at 22.42°N 74.54°

E. It has an average elevation of 292 meters (958 feet). Jobat is located on the banks of Dohi river. Jobat is about 184 km away from Indore (Fig. 1).

Soil sampling and processing

GPS based one hundred surface soil samples collected from different location of Jobat Tehsil. Approx. 1.0 kg of representative composite soil sample was collected from and logged into properly labeled sample bag. Then soil samples were air dried and crushed with wooden pestle and mortar and sieved through 2 mm sieve. These samples were used for determination of various characteristics of soil.

Laboratory analysis of soil samples

Soil pH was determined in a 1:2 soil: water suspension by glass electrode Beckman pH meter (Piper, 1950). The soil suspension used for pH determination was allowed to settle down and electrical conductivity (EC) of supernatant liquid was determined by using conductivity meter (Piper, 1950). The results are expressed in dSm^{-1} at 25°C. Organic carbon content in soil was determined by Walkley and Black's rapid titration method. Five gram of soil sample was taken to which 10 ml potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) and 20 ml commercial sulphuric acid (H_2SO_4) were mixed. Available nitrogen was determined by modified alkaline permanganate method as described by Subbiah and Asija (1956), Available phosphorus was determined by using Olsen's extractant (0.5 N Sodium Bicarbonate solution of pH 8.5) Olsen *et al.* (1954) and available potassium was extracted with Neutral Normal Ammonium Acetate (pH 7.0) and the content of potassium in the solution was estimated by Flame Photometer (Jackson, 1973).

Preparation of soil fertility maps

Soil fertility maps were prepared using Arc-GIS 10.5.1 employing kriging as the interpolation method.

Category defined

The categories were defined based of sample analyzed values obtained and presented in Table 1.

Statistical analysis

Variability of data was assessed using mean and standard deviation for each set of data.

Results and Discussion

Soil reaction/pH

The pH of soils of Jobat Tehsil range from 6.15 to 8.48 with a mean value of 7.67 standard deviation 0.56 and coefficient of variation 7.42% (Table 2). Out of 100 soil, sample 28% soil samples were neutral in pH and 64% samples were slightly alkaline (Table 3). The extent of spatial distribution of soil pH is shown in Fig. 2.

The variability Map (Fig. 2) of soil pH revealed that the maximum area falls under the category Class IV (7.5 to 8.5) followed by category III (6.5 to 7.5) and minimum area under category I (6.0 to 6.5) (Table 1). Neutral to slightly alkaline reaction might be due to the parent material, which is basic in nature with high or moderately high content of calcium and magnesium in a form that is readily released with weathering (Dudal, 1965).

Electrical conductivity

The electrical conductivity of soil water suspension (1:2) ranged between 0.08 to 0.74

dSm⁻¹ at 25°C with mean value of 0.37 dSm⁻¹, It showed a considerable variation with type of topography of soils.

It is evident from the maximum area falls under the category III (0.2 -0.4) followed by category IV (0.4–0.8); Category II (0.1-0.2) and minimum area under category I (<0.1) (Table 1). Most of the soil samples were normal for total soluble salt concentration. The extent of spatial distribution of soil electrical conductivity (EC) is shown in Fig. 3. The EC was existed as normal in Jobat < 1 dSm⁻¹ at 25°C. Similar results were reported by Dilliwar *et al.*, (2014) and Singh *et al.*, (2014).

Organic carbon (OC)

The organic carbon content of the soils of Jobat Tehsil ranged from 0.20 to 0.81 % with an average value of 0.43 % with standard deviation 0.158 % and coefficient of variation (CV) 36.45% (Table 2). Considering the soil test rating for organic carbon the soils of Jobat Tehsil fall under all the four rating classes of available OC content. In general out of 100 samples, 11% samples fall under very low status, 61% samples were categorized under low OC status, 23% samples under medium OC status and 5% samples were under high organic carbon status (Table 3). In this way, about 95% soil samples were low to medium in OC status.

Presence of higher concentration of organic carbon of surface samples was due to incorporation of organic matter on the upper layer of the soil, through roots and other plant residues and manures. Singh *et al.*, (2014) and Shrivastava *et al.*, (2020) reported almost similar result. Area falls under low to medium status of organic carbon, which requires immediate attention to sustain the soil health of Jobat tehsil. The lower contents of organic carbon apparently resulted because of high

temperature and good aeration which induced rapid rate of organic matter oxidation, while the declining trend towards to accumulation of crop residues every year, without substantial downward movement (Singh *et al.*, 2016).

Spatial variability Map of organic carbon of the soils of Jobat Tehsilis depicted in Fig. 4. To prepare the organic carbon variability map

soils were divided in to four categories (Table 1). It is evident from the Map that the maximum area falls under the category II (0.25 to 0.5) followed by category III (0.5-0.75); Category I (0.2 to 0.25) and minimum area under category IV (>0.75) area falls under low to Medium status of organic carbon which requires immediate attention to sustain the soil health of Jobat Tehsil.

Table.1 Category of various parameters and their range

Category	Parameters and range					
	pH	EC (dSm ⁻¹)	OC (g kg ⁻¹)	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
I	<6.0	<0.1	0.20-0.25	<120	<5	<120
II	6.0-6.5	0.1-0.2	0.25-0.5	120-150	5-10	120-150
III	6.5-7.5	0.2-0.4	0.5-0.75	150-250	10-15	150-250
IV	7.5-8.5	0.4-0.8	>0.75	250-400	15-20	250-400
V	-	-	-	-	>20	>400

Table.2 Minimum, maximum, mean, standard deviation and coefficient of variance values of all the samples

Particulars	pH	EC(dSm ⁻¹)	OC (%)	N(kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
MIN	6.15	0.08	0.20	96.00	0.60	114.46
MAX	8.48	0.74	0.81	315.00	25.20	472.64
MEAN	7.671	0.371	0.434	188.41	13.62	243.17
SD	0.569	0.127	0.158	52.914	3.805	73.697
CV (%)	7.42	34.23	36.45	28.08	27.94	30.31

Table.3 Percentage of pH, EC and OC samples falls under various range

Soil pH	Samples (%)	EC (dS m ⁻¹)	Samples (%)	Organic carbon (%)	Samples (%)
Strongly acid (<5.0)	-	<0.8	100%	Very Low (<0.25)	11%
Moderately acid (5-6.0)	-	0.8-1.6	-	Low (0.25-0.50)	61%
Slightly acid (6.0-6.5)	8%	1.6-2.5	-	Medium (0.50-0.75)	23%
Neutral (6.5-7.5)	28%	>2.5	-	High(>0.75)	5%
Slightly alkaline (7.5-8.5)	64%	-	-	-	-

Table.4 Percentage of NPK samples falls under various range/rating

Available-N (kg ha ⁻¹)	Samples (%)	Available-P (kg ha ⁻¹)	Samples (%)	Available-K (kg ha ⁻¹)	Samples (%)
Low (<250)	88 %	Low(<10.0)	18%	Low (<250)	52 %
Medium (250-400)	12 %	Medium (10-20)	78%	Medium (251-400)	43 %
High (>400)	-	High (>20)	4%	High (>400)	5 %

Fig.1 Sampling point as per GPS location of Jobat Tehsil

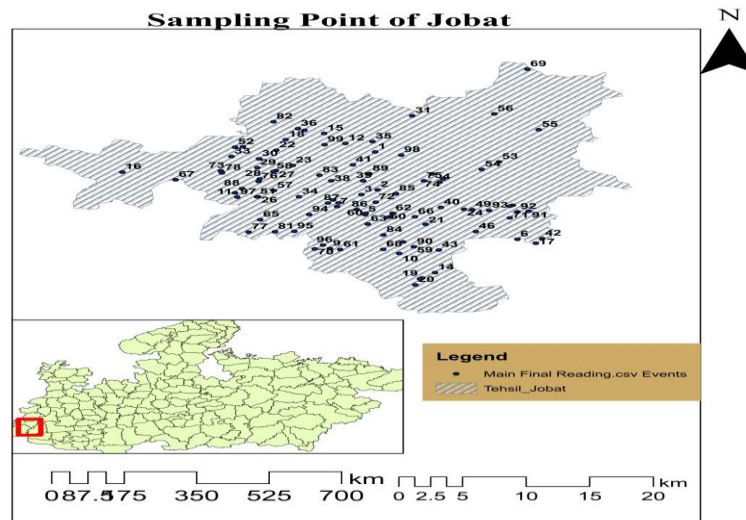


Fig.2 Spatial distribution of pH in the soils of Jobat Tehsil

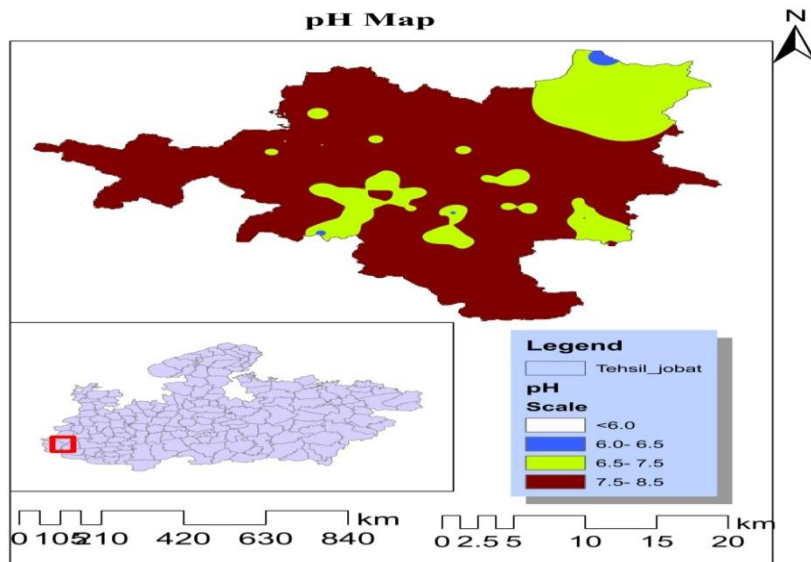


Fig.3 Spatial distribution of EC in the soils of Jobat Tehsil

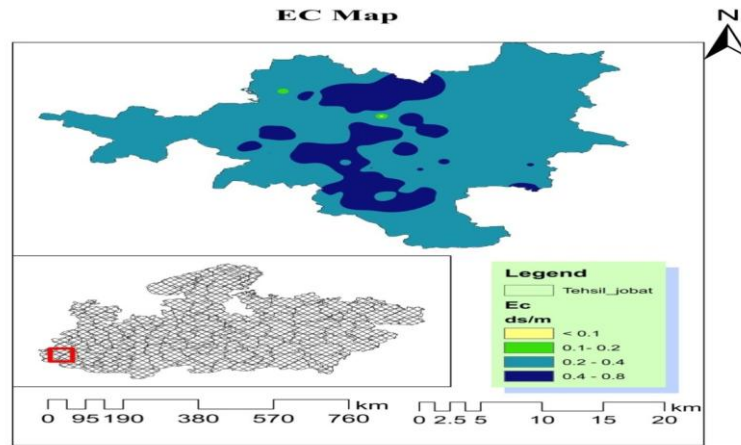


Fig.4 Spatial distribution of organic carbon in the soil of Jobat Tehsil

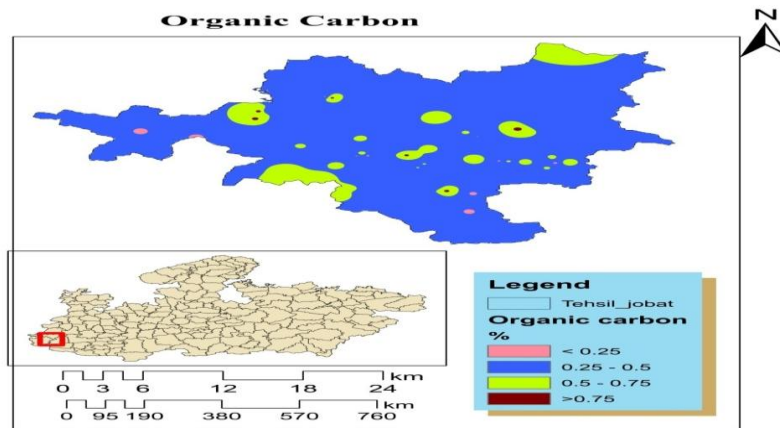


Fig.5 Spatial distribution of available -N in the soils of Jobat Tehsil

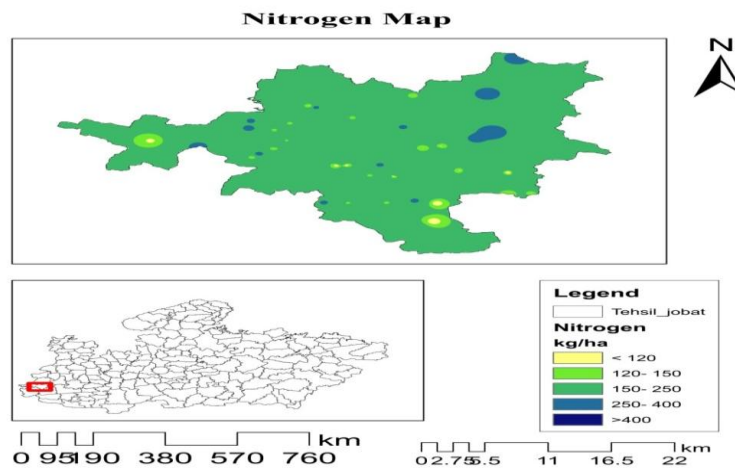


Fig.6 Spatial distribution of available–P in the soils of Jobat Tehsil

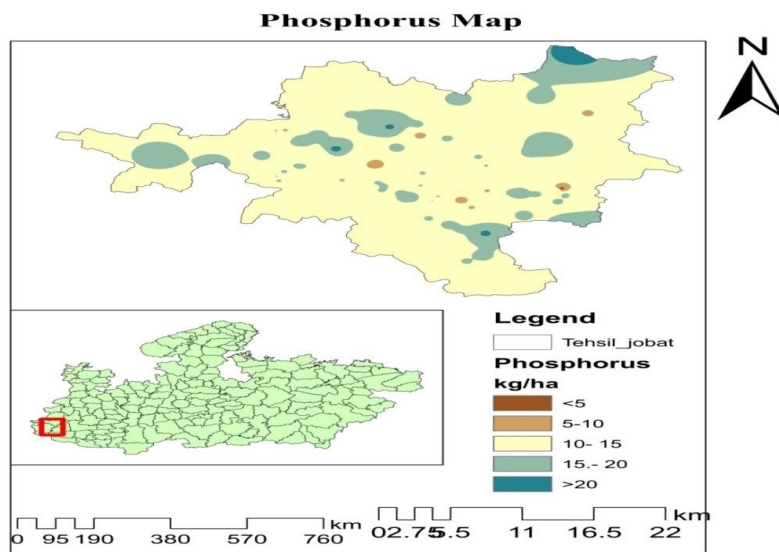
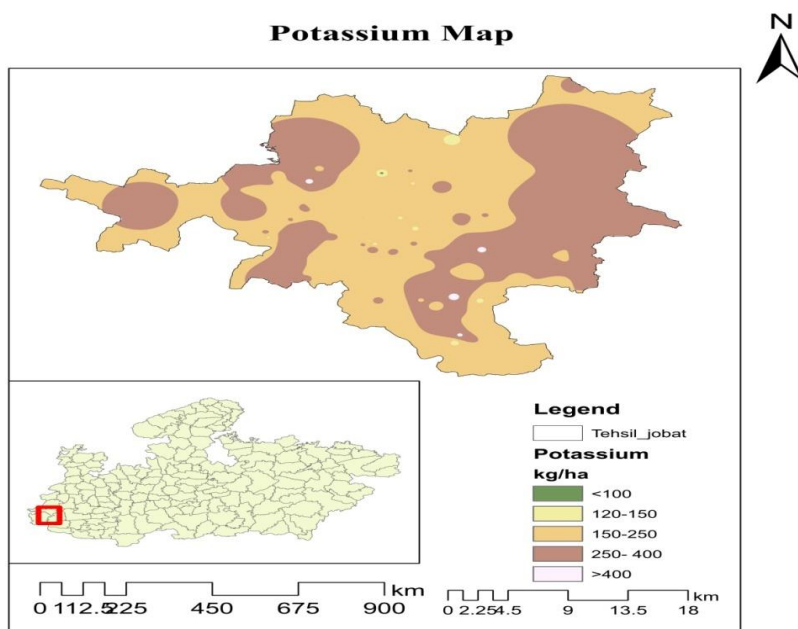


Fig.7 Distribution of available K status in the soils of Jobat Tehsil



Available macronutrients

Available nitrogen

The available N content (Table 2) of the soils of Jobat Tehsil ranged from 96 to 315 kg ha⁻¹ with an average value of 188.41 kg ha⁻¹ with standard deviation 52.91 kg ha⁻¹ and

coefficient of variation (CV%) 28.08 %. In general out of 100 samples 88% fall under low status and 12% samples were categorized under Medium N status (Table 4).

The soils of Jobat Tehsil fall under low to medium status (<250-400 kg ha⁻¹) in available N content. Which might be due the medium to

low organic matter content of these soils. The reason for low content of available nitrogen might be due to the fact that N is lost through various mechanism like volatilization, nitrification, denitrification, microbial fixation, leaching and runoff which resulted in low amount of available N in soil.

The medium nitrogen status was noticed in some area may be due to application of N fertilizer coupled with high vegetative cover. Kumar *et al.*, (2009) in Dumka and Lachimpur series and Ashok *et al.*, (2006) in Auraiya district of Uttar Pradesh observed a similar trend of nutrient status in their study area soils.

It is evident from the map that the Maximum area falls under the category III (150 to 250 kg ha⁻¹) followed by category II (120 to 150 kg ha⁻¹) and category IV (250-400kg ha⁻¹). Minimum area under category I (<120 kg ha⁻¹) (Table 1). This kind of Map will help the farmers for site specific nutrient management on the basis of soil test value.

Available phosphorus

The available P content (Table 2) of the soils of Jobat Tehsil ranged from 0.60 to 25.20 kg ha⁻¹ with an average value of 13.62 kg ha⁻¹ with standard deviation 3.80 kg ha⁻¹ and Coefficient of Variation (CV%) 27.94. The soils of Jobat Tehsil fall under low to medium in available P content. 18% samples were low P status, 78% samples under medium P status and 4% samples were high in P status.

A low to medium range of soil available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture various soil management and agronomic practices (Verma *et al.*, 2005).

To prepare the P variability map soils were divided in to five categories (Table 2). Fig. 6

showed spatial variability Map of available-P of Jobat Tehsil. It is observed that the maximum area falls under the category III (10 to 15 kg ha⁻¹) followed by category IV (15-20 kg ha⁻¹); category (5-10kg ha⁻¹); (<20 kg ha⁻¹) and minimum area under category III (<5 kg ha⁻¹) (Table 1).

Available potassium

The data in Table 2 indicated that available K content of the soils of Jobat Tehsil ranged from 114.46 to 472.64 kg ha⁻¹ with an average value of 243.17 kg ha⁻¹ with, standard deviation 73.69 kg ha⁻¹ and coefficient of variation (CV) 30.31%. The soils of Jobat Tehsil fall under low to medium status in available K content. In general out of 100 samples, 43% samples fall under medium status and 52% samples were Low in K status (Table 4).

The spatial variability map of available-K of soils of Jobat Tehsil (Fig. 7). Indicated that the maximum area falls under the category III (150-250 kg ha⁻¹) followed by category IV (250-400 kg ha⁻¹); category V(>400kg ha⁻¹); (120-150kg ha⁻¹) and minimum area under category I (<100 kg ha⁻¹). Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium-rich minerals like *Illite* and *Feldspars* (Sharma *et al.*, 2008).

In conclusion the soli of Jobat Tehsil of Alirajpur District has neutral to slightly alkaline soil reaction, normal EC, OC was found in very low to high range, however, the majority of samples falls under low range. With respect to primary nutrients majority of the of Jobat was low in available N, medium in available P and also low in available K. Based on data obtained after analysis; the maps of all parameters were prepared which will be successfully used in the future for site specific nutrient management.

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