Annals of Plant and Soil Research 20(1): 16–21 (2018)

Evaluation of soil fertility status of Alirajpur: A most backward tribal district of Madhya Pradesh, India

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Received: December 2017, Revised accepted: February 2018

ABSTRACT

Assessment of soil available nutrient status of a region is important for sustainable agricultural production. Nutrients in soil govern its fertility and control the yields of crops. Tribal dominated Alirajpur district of Madhya Pradesh, India was selected for the study. Geo-referenced surface soil samples (540 numbers) were collected from 90 representative villages across six administrative blocks (15 villages from each block) of the district and in each village, 6 samples were collected. Soil samples were analyzed for their physico-chemical properties and available nutrients status. Results revealed that texture of soils varied from sandy loam to clayey loam with neutral to alkaline soil reaction. The soil samples low in organic carbon, available N, P, K and S were 72.3%, 84.1%, 53.0%, 12.4% and 76.3%, respectively. Among DTPA extractable micronutrients, soils were mostly deficient in Zn and sufficient in Fe, Mn and Cu. More than 50% of soil samples were at least deficient in more than three nutrient elements. Considering nutrient index values of <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status, the soils of the study area were found to be in the category of low for OC, N, P and S; medium for Zn; and high with K, Mn, Cu, Fe and B. From the study, it is concluded that the soils of tribal dominated Alirajpur district is deficient in many numbers of nutrients. Therefore balanced and soil test based nutrient management practices should be followed to alleviate nutrient deficiencies of soils for sustainable crop production.

Keywords: Soil fertility, tribal area, physico-chemical properties of soil, available nutrients, nutrient index

INTRODUCTION

Soil characterization, particularly soil fertility assessment of an area or a region is an important aspect in view of sustainable agricultural production (Singh *et al.*, 2017). As soil nutrients, both macro- as well as micro-nutrients, governs the fertility of soil and controls the productivity of crops grown on to soil (Bharti *et al.*, 2017). Currently, crop productivity is declining or stagnating because of imbalanced and inadequate fertilizer application coupled with low efficiency of other inputs mostly in the tribal belt of the country. Also, response efficiency of chemical fertilizer nutrients has declined tremendously under an intensive agricultural system in recent years (Meena *et al.*, 2017). Nutrient supply (nitrogen, phosphorus, potassium, sulphur, zinc, iron, manganese, boron, copper) in soil is a natural phenomenon and varies soil to soil, and some of the nutrients may sufficient where others deficient (Dotaniya and Meena, 2013). The stagnation in crop productivity cannot be boosted without judicious use of the essential plant nutrients to overcome the existing deficiencies or imbalances (Lenka *et al.*, 2016). Alirajpur is new district that was carved out from Jhabua district in May 2008. Alirajpur district also lies in the western part of Madhya Pradesh. It lies in the Malwa region of Madhya Pradesh, near the border with Gujarat and Maharashtra. It is surrounded by Jhabua, Dhar and Badwani districts of Madhya Pradesh. It comes under Central Plateau and Hills Region Agro-Climatic Region (Planning Commission) and Madhya Bharat plateau, western Malwa Plateau, eastern Gujarat plain Vindhya Satpura range and Narmada valley Agro-Ecological Region (as per ICAR). It has a total geographical area of 3182 km^2; the terrain is hilly and undulating. The average annual rainfall in the district is about 850 mm. Alirajpur, Jobat, Udaigarh, Bhabra, Sondawa and Katthiwada are the six administrative blocks and tehsils of Alirajpur district. Alirajpur is also a predominant *Adivasi* district, and suffers from high rates of illiteracy and poverty. Most of the rural population in the district depend on agriculture for their livelihood. Its 56.1% total geographical area is under cultivation with 124% cropping

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intensity and area under irrigation is only 16.6% of cultivable area. The principal crops grown in this district are soybean, maize, wheat, gram, jowar, rice, urad, cotton and groundnut. The soils are grouped under Entisols, mainly alluvium, black cotton soil and sandy soil and nearly 85% of the soils are shallow to medium deep soils (as per NBSS&LUP). The agricultural productivity is very low compared to the national level, might be due to poor soil fertility levels in the tribal belt of Alirajpur district of Madhya Pradesh. In this study, soil samples were collected from farmers fields across the district and analyzed for plant nutrients. GIS and GPS based fertility maps were also developed for sustainable site specific nutrient management.

MATERIALS AND METHODS

Initial survey was carried out to identify villages for soil sampling. In Alirajpur, about fifteen representative villages were selected from each developmental block for soil sample collection. Further, in each village six soil samples were collected based on the socio-economic status particularly land holdings (two samples each from marginal and small, medium and large farmers). As these districts comprises of six blocks in total 540 geo-referenced soil (0-15 cm depth) samples were collected from the farmers fields in each district. District maps of Alirajpur with sampling points were presented in Figure 1. The soil sampling was done after harvest of *rabi* crops *i.e.* from March to June in 2013.

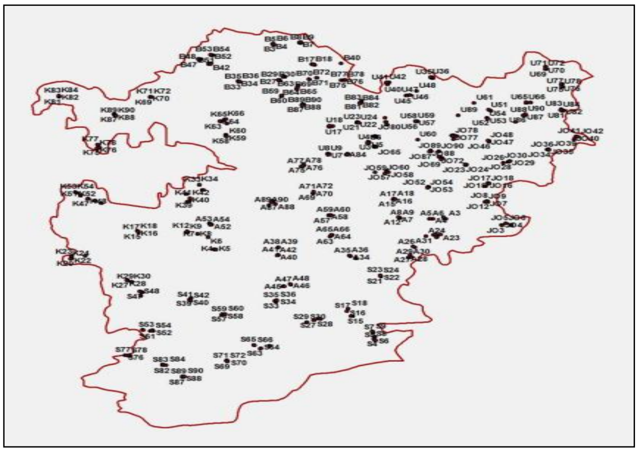

Fig. 1: District map of Alirajpur (N=540) with sampling points (N= Number of soil samples in each district)

The collected soil samples were air dried and processed to pass through 2 mm sieve and analyzed for pH, texture as per standard methods. Soil organic carbon, available nitrogen (0.32% alkaline $KMnO_4$), phosphorus (0.5*M* $NaHCO_3$), potassium (1 *N* neutral ammonium acetate extractable), sulphur (turbidimetric method), DTPA extractable micronutrients (Zn, Cu, Fe and Mn) and hot water soluble boron were determined. The soil fertility maps were prepared using GIS software-ArcInfo. Nutrient index (NI) was calculated using following equation:

Nutrient index = $(1xN_l+2xN_m\ 3xN_h)/N$……Eq. (1)

Where, N_l= Number of soil samples in low category; N_m= Number of soil samples in medium category; N_h= Number of soil samples in high category; and N= Total number of soil samples. Based on the nutrient index value, the soils are categorized into three classes as follow: NI value less than 1.67 meant for low fertility status; 1.67-2.33 for medium fertility status; and more than 2.33 is for high fertility status. The simple correlation of data was also carried out between available nutrient content and some physico-chemical properties of soil.

RESULTS AND DISCUSSION

The analysis of collected soil samples from Alirajpur district of MP. Analytical results showed that the pH of the samples from 6.0 to 8.5 (Table 1). The majority of the soil samples was categorized under 6.5 to 7.5 (47.7%). These soil pH values are good for the cultivation of most of the agricultural crops in Alirajpur. Less than 1 % area of Alirajpur, categorized under highly alkaline, needs soil reclamation as well as management of crop management strategies. Most of the soil samples fell under the sandy clay loam textural class; whereas, 22.2, 11.6, 7.2 and 5.2 were categorized under sandy loam, clayey loam and clay loam, respectively. The organic carbon content of soils in Alirajpur district ranged from 0.22-0.96%; and 72% soil samples were categorized under low; 19.6% as medium and 8.1% in the high category. However, overall soil samples fell under low category. The nutrient index for the organic carbon of Alirajpur district soil samples were 1.36 (Table 1). Soils in low organic carbon are possibly because of high temperature and good aeration in the soil, which increased the rate of oxidation of organic matter.

Table 1: Textural classes and pH of soils of Alirajpur district

Textural class	Percent samples	pH range	Class	Percent samples
Sandy Clay loam	53.7	6.0-6.5	Slightly acidic	12.4
Sandy loam	22.2	6.5-7.5	Neutral	47.7
Clayey	11.6	7.5-8.0	Slightly alkaline	21.8
Loam	7.2	8.0-8.5	Moderately alkaline	17.3
Clay loam	5.3	>8.5	Highly alkaline	0.8

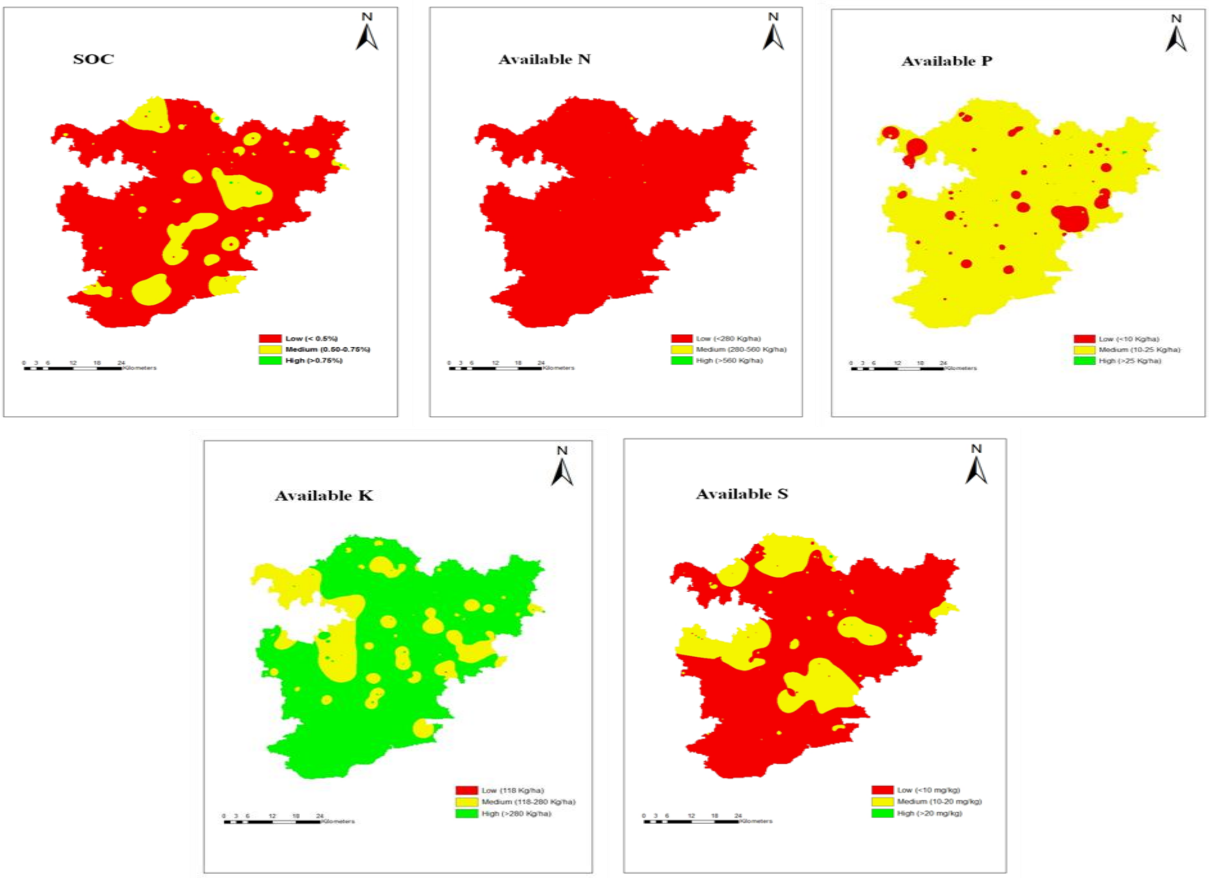

Fig. 2: GIS based soil fertility maps of organic carbon and macronutrients in Alirajpur district

Available macronutrient analyzed from the collected soil samples from the Alirajpur agricultural fields and the measured values were mentioned in Table 2. Available nitrogen status varied from 117.3-309.5 kg ha^{-1} with an average value of 218 kg ha^{-1}. Approximately 84.1% of the soil samples were found to be low (< 250 kg N ha^{-1}) and remaining in the category of medium (250-500 kg N ha^{-1}) (Table 2). Low nitrogen status in the soils could be due to low amount of organic carbon in the soils. Lower amount of available N in soil, promotes poor crop growth as well as lower crop yield in Alirajpur district agricultural fields. Since most of the soil nitrogen is found in organic form. The analyzed soil samples showed 53% soil samples under low phosphorus; 30.6% under medium and 16.4% under higher P categories. The available P ranged 4.29-32.7 kg ha^{-1} with a mean value of 12.7 kg ha^{-1}. Status of available potassium in the soils of Alirajpur ranged between 122 and 483 kg ha^{-1} with an average of 352 kg ha^{-1}. Further most of the soil samples (69.2%) were found to be under high K (>280 kg K ha^{-1}) range. This might be due to the presence of most of the mica (biotite and muscovite) in finer clay fractions. The analyzed soil samples were measured available S 3.89 to 22.7 mg kg^{-1} with an average value of 9.71 mg kg^{-1} in Alirajpur. Plant roots absorb sulphur in the form of SO_4^{2-} from the soil solution. It is more beneficial for the oil crops; drastically reduced crop yield under S deficiency.

Keeping this fact in view the soil under study may be classified as deficient (< 10 mg kg^{-1}), medium (10-20 mg kg^{-1}) and sufficient (>20 mg kg^{-1}) category. According to these categories, 76.3% of samples were found deficient and 18.5% samples were found medium remaining 5.2% under high fertility category in Alirajpur district. The low S in these soils was existed because most of the sulphur is associated with organic matter and the organic matter content of these soils is low (Bharti *et al.*, 2017).

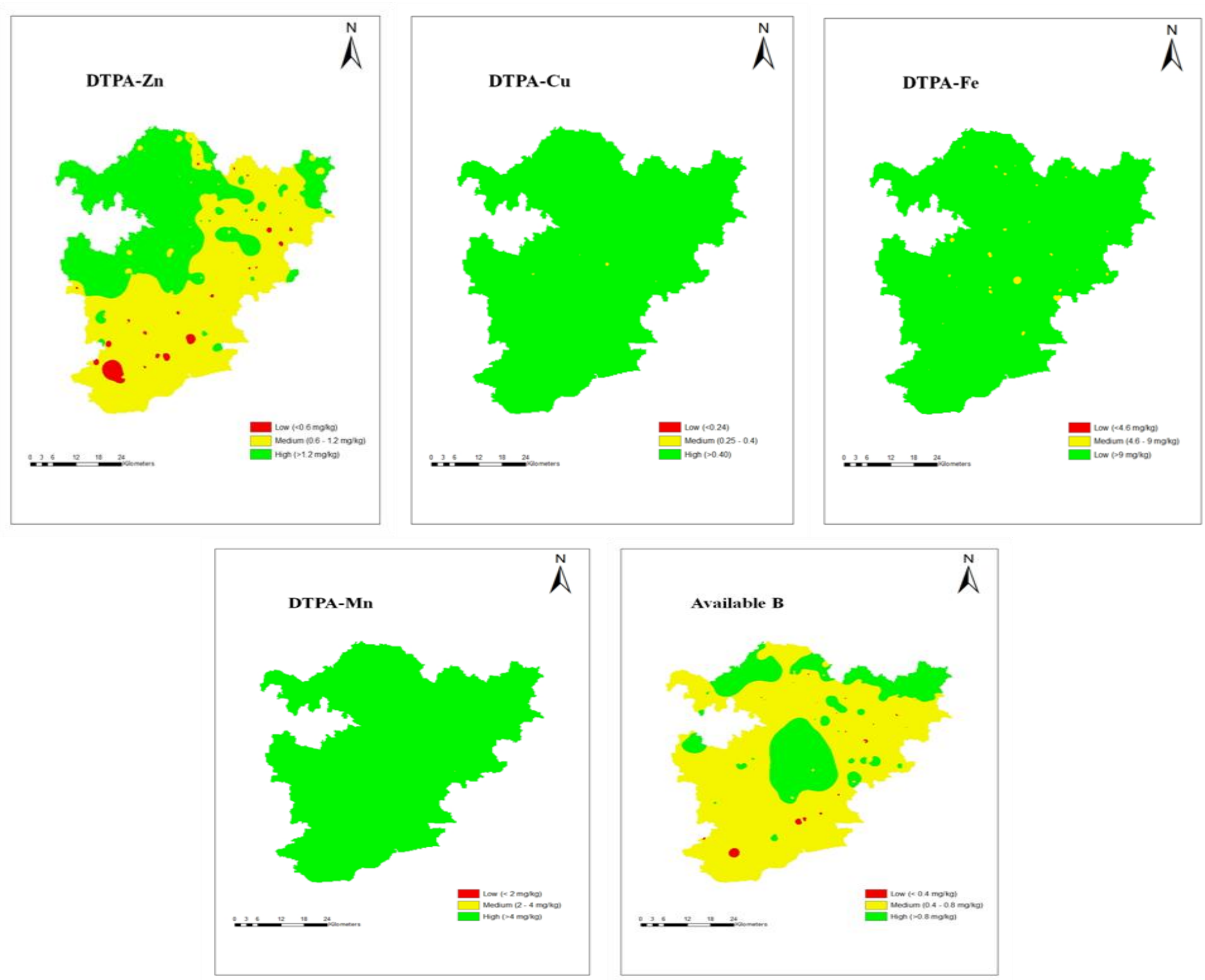

Fig. 3: GIS based soil fertility maps of micronutrients in Alirajpur district

Table 2: Soil fertility status and nutrient index of tribal dominated Alirajpur district

Parameters	Range	Percentage of samples in low category	Percentage of samples in medium category	Percentage of samples in high category	Nutrient index	Remarks
Organic Carbon (%)	0.22-0.96	72.3 (<0.5)	19.6 (0.5-0.75)	8.1 (>0.75)	1.36	Low
Available N (kg ha^{-1})	117.3-309.5	84.1 (<250)	15.9 (250-500)	Nil (>500)	1.16	Low
Available P (kg ha^{-1})	4.29-32.7	53.0 (<10)	30.6 (10-25)	16.4 (>25)	1.63	Low
Available K (kg ha^{-1})	122-483	12.4 (<125)	18.4 (125-280)	69.2 (>280)	2.57	High
Available S (mg kg^{-1})	3.89-22.7	76.3 (<10)	18.5 (10-20)	5.2 (>20)	1.30	Low
Available Zn (mg kg^{-1})	0.32-5.89	26.7(<0.6)	45.7 (0.6-1.2)	27.6(>1.2)	2.01	Medium
Available Mn (mg kg^{-1})	3.42-123	Nil (<2.0)	Nil (2.0-4.0)	100 (>4.0)	3.00	High
Available Cu (mg kg^{-1})	0.74-67.9	Nil (<0.2)	Nil (0.2-0.4)	100 (>0.4)	3.00	High
Available Fe (mg kg^{-1})	4.9-82.1	Nil(<4.5)	22.4 (4.5-9.0)	77.6 (>9.0)	2.78	High
Available B (mg kg^{-1})	0.29-1.67	2.1(<0.4)	18.2 (0.4-0.8)	79.7 (>0.8)	2.77	High

Note: Values in the paranthesis are critical limits for respective category

The DTPA extractable micronutrients in Alirajpur soils varied from 0.32-5.89 mg Zn; 3.42-123 mg Mn, 0.74-67.9 mg Cu and 4.9-82.1 mg Fe per kg soil; and hot water soluble boron (B) varied from 0.29-1.67 mg kg^{-1} (Table 2 and Fig. 3). All the DTPA extractable micronutrients in Alirajpur soils were found sufficient except Zn as per the critical limits given by Singh *et al.* (2008). The percentage of soils deficient in available Zn found to be 26.7% for Alirajpur. In case of B, 2.1% samples were deficient. Deficiency of micronutrients reduced the soil fertility and also crop yield (Dotaniya and Meena, 2013). Nutrient index (NI) value for some of the available nutrients in the soils of the study area is depicted in Table 2. From the NI values, it was observed that soils of Alirajpur area were found to be in the category of ‘low fertility status’ for OC, available N, available P and available S; ‘medium fertility status’ for only for Zn; and ‘high fertility status’ with respect of available K; and micronutrients, *i.e.* Mn, Cu, Fe and B. The NI values for OC, N, P, K, S, Zn, Mn, Cu, Fe and B were 1.36, 1.16, 1.63, 2.57, 1.30, 2.01, 3.00, 3.00, 2.78 and 2.77, respectively against the NI values given by various researchers were <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status (Ravikumar and Somashekar, 2013).

The soils of the study area were deficient in many numbers of nutrients. The percent of soil samples at least deficient one, two, three, four, five nutrient elements were 98.37%, 85.43%, 52.09%, 13.59% and 0.93%, respectively and only about 1.63% soil samples were observed to be sufficient in respect to all the available nutrients studied (Table 3). Similar results were reported by Singh (2017). Most of the soil samples were showed poor soil fertility status and need additional application of fertilizers for crop production.

Table 3: Percent of samples deficient in number of nutrients

Deficient in at least	%
None	1.63
One element	98.37
Two elements	85.43
Three elements	52.09
Four elements	13.59
Five elements	0.93

Fertilizers are the key components for the healthy crop production in plant nutrient deficient conditions (Meena *et al.*, 2017). Poor soil fertility levels produce poor crops mostly in tribal belt of Alirajpur. Additional application of crop residues (Dotaniya *et al.*, 2014) or FYM enhances the soil fertility levels (Bharti *et al.*, 2017). Increasing organic matter in soil enhance the concentration of available plant nutrient in soil. Thus balanced application of fertilizers can improve the crop yield in these areas. The generated GIS based soil fertility maps will be very useful for sustainable sitespecific nutrient management of the study area and also for the planning of soil fertility improvement programs in the districts.

ACKNOWLEDGEMENTS: Authors are very thankful to the staff of KVK, Jhabua and Farmers Welfare and Agriculture Development Department workers of the district for their support and needful help for identification of the village and soil sample collection.

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