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Soil Fertility Evaluation Using Nutrient Index Approach

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ABSTRACT

A detailed soil fertility status of Krishi Vigyan Kendra (KVK), farm was investigated during 2019 to prepare fertility map and fertilizer recommendations for different crops. Total 37 numbers of geo-referenced (GPS based) composite surface soil samples (0-15cm) were collected from 4 soil unit of KVK farm located at Bharari, Jhansi. Soils were analyzed for pH, EC, organic carbon, available phosphorus, potassium, sulphur and micronutrients *i.e.,* B, Fe, Mn, Cu, Zn. The soil reaction was found slightly acidic to slightly alkaline in nature while EC was found to be in safe range for crop production. About 11 per cent of samples were very low, low (54 %) and medium (35 %)in category of soil organic carbon. The mean available soil P, K and S was found to be 20, 267 kg/ ha and 21ppm, respectively. Soil micronutrient content such as Fe, Mn, Cu, Zn and B were found to be sufficient. The maps indicate the fertility status of KVK farm based on which fertilizer recommendation for crops are made leading to economy of fertilizer and balanced applications and serve as the decision making tool for successful raising of field crops in Bundelkhand region.

Key Words: Nutrient, Soil fertility, Nutrient index, Micro nutrients.

INTRODUCTION

Soil fertility is an inherent property and it can change under the influence of natural and human induced factors. As population of human and animals continue to increase, it disturbs the earth's ecosystem to produce food, fodder and fibre will place greater demand on soils to supply essential nutrients. Continuous cultivation for maximum crop yield removes substantial amount of plant nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, faulty irrigation and various cultural practices also deplete the soil quality rapidly. Soil fertility is an important factor, which determines the growth and yield of plants (Singh *et al,* 2018). However, Soil testing assess the current fertility status and provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields and to maintain the optimum fertility in soil year after year. Therefore, an attempt has been made in present investigation to prepare soil fertility maps for the KVK farm in order to find out the recommendation of organic and inorganic fertilizer to the crops of Bundelkhand region.

MATERIALS AND METHODS

Study area

The study was carried out at Agriculture Research Farm, KVK, Bharari, Jhansi. The district Jhansi comes under Bundelkhand Agro climatic Zone - 06 of Uttar Pradesh and located at latitude of 25.32088^0 N and longitude of 78.034458^0 E. The average annual rainfall of the district is about 885 mm and 90 % of it's received during monsoon season. Droughts and long dry spells occur during rainy season is the common feature in this region which directly affect the *kharif* and *rabi* production. The KVK spreads in an area of 18 ha, out of which 17 ha of area is cultivable land and remaining area is waste land and covered by infrastructure.

Soils of Bundelkhand are characterized by their varying depth, soil texture, colour and topographic

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situations. There are two main soil groups *i.e.,* Red and Black soils classify into four local soils known as Parwa, Rakar, Kabar and Mar. Unfortunately, these all type of soils are found in this study area. The total cultivated area of farm is divided into three blocks namely A, B and C covering 37 small plots. In this farm, Rakar soils cover twelve plots namely 6, 7, 8, 15, 16, 17, 18, 19, 20, 30, 31, 32 and indicate by SU-1, Parwa soil covers seven plots namely 4, 5, 9, 14, 27, 28, 29 and indicate by SU-2, Kabar soil cover fifteen plots 1, 2, 3, 10, 11, 12, 13, 21, 22, 23, 24, 25, 26, 33, 34 and indicate by SU-3, Mar soil cover three plots namely 35, 36, 37 and indicate by SU-4 (Fig:a).

Soil Sampling and Analysis

Altogether 37 numbers of surface soil samples (0-15 cm depth) were collected from KVK, Farm which includes 12, 07, 15 and 03 samples from SU-1, SU-2, SU-3 and SU-4 respectively during May, 2019. The coordination points were recorded by GPS instrument. Quartering technique was used for preparation of soil sample. The samples were air dried and passed through 2 mm sieve and stored in cloth bag. The processed soil samples were analyzed for soil pH with pH meter (1:2 soil water suspension), electrical conductivity by conductivity meter (Jackson, 1973), organic carbon by Walkley and Black method (Walkley and Black, 1934), available phosphorous by spectrophotometer, available potassium using flame photometer, Sulphur by $CaCl_2$ extraction method. Micronutrient analysis was carried out by AAS.

Fig a: Soil map of agriculture research farm, KVK, Bharari, Jhansi

RESULTS AND DISCUSSION

Soil pH

Soil pH (1:2) of surface soil samples of the entire study area was slightly acidic to slightly alkaline in reaction ranged from 6.10 to 8.05pH. The soil pH of SU-1, SU-2, SU-3 and SU-4 varied between 6.10-7.18, 6.45-7.90, 6.28-8.05 and 7.44-7.77 with average value 6.5, 7.2, 7.3 and 7.6 respectively (Table 1). The data showed that a gradual increase in soil pH observed from SU-1 towards SU-3, which could be attributed to the removal of basic cations with runoff water from upland units and medium land units during intensive rainfall and their subsequent deposition in the low land units *i.e.,* SU-3. Similar finding was observed by Priyadarshini *et al* (2017).

Electrical Conductivity

Electrical Conductivity (1:2.5) of surface soil samples were varied from 0.12 to 0.92 dSm^{-1} that is less than 2 dSm^{-1}. Hence, all the soils of the study area are safe for all types of crop production with respect to the soluble salt content (Table 1).

Organic Carbon

Soil organic carbon of surface soil samples ranged between 0.17 to 0.73 %. The organic carbon in SU-1, SU-2, SU-3 and SU-4 varied between 0.17-0.41, 0.22-0.52, 0.21-0.73 and 0.63-0.67 % with mean of 0.20, 0.40, 0.50 and 0.60 % respectively (Table 1, Fig: b). The highest SOC was found in SU-3 (0.73 %) whereas; the minimum organic carbon content was recorded in SU-1 (0.17%). The results clearly showed a gradual increase in average SOC from SU-1 towards SU-3 surface soil samples which could be attributed to higher cropping intensity followed by crop residue incorporation in the low land (Dash *et al,* 2018). The wide variation in organic carbon content in the tested soil might be because of decomposition rate of substrate and different crops to be grown in Agriculture farm (Patil *et al,* 2017).

Available phosphorus

The available phosphorus content in SU-1 and SU-2 varies from 15.14- 19.37 kg/ ha and 12.45-

Table 1. Physico-chemical and macronutrient content in soils of KVK, Bharari.

Sr. No.	Name of soil-unit	No of samples	pH		EC (dSm^{-1})		OC (%)		P ($Kg\ ha^{-1}$)		K ($Kg\ ha^{-1}$)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	SU-1	12	6.10-7.18	6.5	0.14-0.47	0.3	0.17-0.41	0.2	15.14-19.37	17.3	190-287	233
2	SU-2	7	6.45-7.90	7.2	0.12-0.57	0.3	0.22-0.52	0.4	12.45-22.19	17.9	192-319	234
3	SU-3	15	6.28-8.05	7.3	0.18-0.92	0.5	0.21-0.73	0.5	18.22-27.15	21.7	204-337	288
4	SU-4	3	7.44-7.77	7.6	0.56-0.65	0.6	0.63-0.67	0.6	23.12-24.25	23.7	277-338	315

Table 2. Available secondary and micronutrient content in soils of KVK, Bharari

Sr. No.	Name of soil-unit	No of samples	S (ppm)		Zn (ppm)		Fe (ppm)		Mn (ppm)		Cu (ppm)		B (ppm)	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	SU-1	12	7.98-27.13	16.0	0.80-2.0	1.4	8.10-16.4	12.6	3.0-6.7	4.4	0.3-1.0	0.6	0.6-1.9	1.2
2	SU-2	7	7.98-36.91	20.5	0.4-1.6	1.2	8.10-14.3	11.2	4.0-9.2	6.5	0.4-1.3	0.9	0.6-1.60	1.1
3	SU-3	15	5.90-34.62	17.5	0.6-1.5	1.0	10.2-15.5	12.1	3.9-11.9	6.7	0.6-1.6	0.8	0.5-1.40	0.9
4	SU-4	3	18.62-36.65	29.4	1.1-1.4	1.2	8.1-14.5	10.4	5.1-8.0	6.9	0.6-1.3	1.0	0.6-1.4	1.1

22.19 kg/ha and means value is 17.3 and 17.9 kg/ ha, respectively indicating low available phosphorus content. However, SU-3 (18.22-27.15 kg/ha) and SU-4 (23.12-24.25 kg/ha) soil unit indicating 21.7 and 23.7 kg/ha medium available phosphorus respectively (Table 1, Fig: b). The highest available phosphorus was found in SU-3 (27.15 kg/ha) whereas; the lowest available phosphorus content was recorded in SU-2 (12.45 kg/ha). Low to medium range of phosphorus in soil shows that more fixation of phosphorus with Fe, Al and Ca ions.

Available potassium

The available potassium content in SU-1 and SU-2 unit varies from 190-287 kg/ ha and 192-319 kg/ ha and means value is 233 and 234 kg/ ha, respectively indicating medium available potassium content. However, SU-3 (204-337 kg/ha) and SU-4 (277-338 kg/ha) soil unit indicating 288 and 315 kg/ha high mean value of available potassium (Table 1, Fig: b). This fact may be explained as the soils have been developed from the potash bearing parent materials such as feldspars. Similar results were also observed by Mishra *et al* (2017).

Available Sulphur

The available sulphur content was found in the range of 5.9 to 36.91 ppm (Table 2). In SU-1, SU-2, SU-3 and SU-4 varied between 7.98-27.13, 7.98-36.91, 5.90-34.62 and 18.62-36.65 ppm with average mean of 16.0, 20.5, 17.5 and 29.5 ppm respectively. The maximum value was found in SU-4 (36.65 ppm) whereas; the minimum was recorded in SU-3 (5.90 ppm). A gradual increase in organic carbon, available P and S was observed from SU-1 towards SU-4 soils, which could be attributed to increase in organic matter content in the low land as these nutrients are released from the soil organic matter through mineralization by the activity of micro-organisms (Dash *et al,* 2018).

Micronutrients

The available micronutrient status of agriculture farm, KVK, Bharari was represented in Table 2. Zinc content of surface soil samples was found highest in SU-1 (2.0ppm) and lowest in SU-2 (0.4 ppm). Zinc in SU-1, SU-2, SU-3 and SU-4 varied from 0.80-2.0, 0.4-1.6, 0.6-1.5 and 1.1-1.4 ppm with mean of 1.4, 1.2, 1.0 and 1.2 ppm respectively. The available iron content in SU-1, SU-2, SU-3 and SU-4 unit varies from 8.10-16.4, 8.10-14.3, 10.2-15.5 and 8.10-14.5 ppm means value were 12.6, 11.2, 12.1, and 10.4 ppm, respectively indicating high available iron content. The maximum iron content value was 16.4 in SU-1 and minimum value 8.10 in SU-1, 2 and 4. However, in the entire study area available Fe status was found to be sufficient. Mn content in surface soil samples of the entire study area was found to vary in between 3.0 to 11.9 ppm. The available Mn in SU-1, SU-2, SU-3 and SU-4 ranged from 3.0-6.7, 4.0-9.2, 3.9-11.9 and 5.1-8.0 ppm with mean of 4.4, 6.5, 6.7 and 6.9 ppm, respectively. The maximum available manganese was found in SU-3 (11.9 ppm) whereas; the minimum available manganese content was recorded in SU-1 (3.0 ppm). The available cupper in SU-1, SU-2, SU-3 and SU-4 varied from 0.3-1.0, 0.4-1.3, 0.6-1.6 and 0.6-1.3 ppm with mean of 0.6, 0.9, 0.8 and 1.0 ppm, respectively. The maximum available cupper content was found in SU-3 (1.6 ppm) whereas; the minimum available cupper content was recorded in SU-1 (0.3 ppm). The data showed that, available Mn and Cu contents were increased gradually from SU-1 towards SU-4, which could be attributed to increase in organic carbon content in the low land, as metallic cations form chelates with organic matter. This type of result was in close conformity with results obtained by Mishra (2014) and Pattanayak (2016). The average value of available Boron content in soil of SU-1, SU-2, SU-3 and SU-4 were found 1.2, 1.1, 0.9, 1.1 and 1.0 ppm respectively. The maximum available Boron content was found in SU-1 (1.9 ppm) whereas; the minimum available Boron content was recorded in SU-3 (0.5 ppm).

Delineation of nutrients deficient and sufficient area

In order to compare the levels of soil fertility of

Table 3. Availability of macro nutrients and their nutrient index (NI).

Sr. No.	Soil Unit	Total No of samples	Availability of primary nutrients												Nutrient Index (NI)			
			Organic carbon				Available P				Available				N	P	K	Fertility Code
			VL	L	M	H	VL	L	M	H	VL	L	M	H				
1	SU-1	12	04	08	-	-	-	12	-	-	-	-	10	02	1.66	2.00	3.16	123
2	SU-2	07	-	06	01	-	-	06	01	-	-	-	06	01	2.14	2.14	3.14	223
3	SU-3	15	-	06	09	-	-	03	12	-	-	-	01	14	2.60	2.80	3.93	334
4	SU-4	03	-	-	03	-	-	-	03	-	-	-	-	03	3.00	3.00	4.00	334
Total samples		37	04	20	13	-	-	21	16	-	-	-	17	20	2.35	2.48	3.55	224

Hints: VL-Very low, L-Low, M-Medium, H-High

Table 4. Availability of secondary & micronutrients and their nutrient index (NI)

Sr. No.	Soil Unit	No of Samples	Availability of secondary & micro nutrients																	Nutrient Index (NI)					
			Sulphur			Zn			Fe			Cu			Mn			B			S	Zn	Fe	Cu	Mn	B
			L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H						
1	SU-1	12	04	02	06	-	06	06	-	-	12	-	01	11	-	06	06	-	-	12	2.5	2.5	3.0	2.92	2.5	3.0
2	SU-2	07	-	01	06	-	04	03	-	-	07	-	-	07	-	-	07	-	-	07	2.85	2.42	3.0	3.0	3.0	3.0
3	SU-3	15	05	02	08	01	09	05	-	-	15	-	-	15	-	02	13	-	-	15	2.2	2.26	3.0	3.0	2.86	3.0
4	SU-4	03	-	-	03	-	02	01	-	-	03	-	-	03	-	-	03	-	-	03	3.0	2.33	3.0	3.0	3.0	3.0
Total samples		37	09	05	23	01	21	15	-	-	37	-	01	36	-	08	29		-	37	2.63	2.37	3.0	2.98	2.84	3.0

Hint: L-Low, M-Medium, H-High

Fig b: Availability of OC, available P, K at M-5, M-6, M-7 respectively in Agriculture Farm, KVK, Bharari, Jhansi

one area with those of another it was necessary to obtain a single value for each nutrient. The whole agriculture field of KVK, Bharari was divided into 04 soil units i.e. SU-1, SU-2, SU-3 and SU-4 on the basis of their soil texture, colour and other physical and chemical parameters. The nutrient deficit or sufficient status of each soil unit is expressed in Table 3. According to soil fertility index, out of 37 soil samples of cultivated field, 11per cent samples in were found in very low content of organic carbon, 54 per cent were low and 35 per cent were medium in category. This distribution of organic carbon represented low nutrient index (2.35). As the organic matter content in the study area was found low in range, the plant available nitrogen content in soils was observed consequently low. Phosphorus exists in soils in both inorganic and organic forms. In reference to available phosphorus, 57 % soil samples was low; while 43% in medium category. Thus, agriculture field showing also low category of nutrient index (2.48). Potassium is one of the three major plant nutrient elements.

The level of available potassium has been found to be medium in 46 per cent and high in 54 per cent of representative area. Because soils of India are rich in potassium so that application of potassic fertilizer should be minimal. Here also the overall nutrient index (NI) of potassium was high (3.55).

The available soil samples and nutrient index for Primary nutrients in Table 3 and for secondary and micro nutrients is depicted in table 4. The number of samples in each of the three classes *i.e.,* low, medium and high is multiplied by 1, 2 and 3, respectively. The sum of the figures thus obtained was divided by total number of samples using following equation:

$$\textbf{Nutrient Index (NI)} = \frac{\text{No. of Samples (Low) X 1 + No of Samples (Medium) X 2 + No. of Samples (High) X 3}}{\text{Total Number of Samples}}$$

Ramamurthy and Bajaj (1969) modified the index classification as low 1.67, medium 1.67 -2.33 and high above 2.33. According to these categories, nutrient index of available S, Zn, Fe, Cu, Mn are 2.63, 2.37, 3.0, 2.98, 2.84, 3.0 respectively and all were found in high categories. On the basis of NI, fertility code for each soil unit has been prepared to recommendation of organic and inorganic fertilizers to different crops (Fig c). The code 1, 2, 3 and 4 indicates very low, low, medium and high category of different nutrients respectively. The overall fertility status of N, P and K is low, low and high (224), respectively.

Fig c: Soil fertility map of agriculture farm based on nutrient index of N, P and K

CONCLUSION

Based on the above study it was concluded that soil fertility status of KVK, Bharari, Jhansi considering the concept of nutrient index value of the soil of investigated area were found in low fertility status for organic carbon, available phosphorus, and high with respect of available potassium, sulphur and micronutrients. The nutrient index value for Nitrogen (N), Phosphorus (P), and Potassium (K), were 2.35, 2.48 and 3.55, respectively while 2.63, 2.37, 3.0, 2.98, 2.84, 3.0 for Sulphur, Zn, Fe, Cu, Mn, respectively. Thus 64.86 percent of soils of KVK, Bharari, Jhansi are likely to respond to nitrogenous and phosphorus fertilization.

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