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ASSESSMENT OF MACRONUTRIENT STATUS OF BHANDARA TEHSIL, MAHARASHTRA

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ABSTRACT

The study was undertaken to "assess the available macronutrient status of the Bhandara tehsil of Maharashtra" with the help of GPS-based one hundred-and-five soil samples during the period of 2021-2022. The results recorded that soils were clay loam to sandy clay loam in texture. The soils of the study area were slightly acidic to slightly alkaline, non-saline in reaction, non-calcareous in nature and low in organic carbon (59.04 per cent samples). The soil nutrient index values showed that organic carbon and available N were low; available P and S were medium; available K was high. Organic carbon, available nitrogen, potassium and sulphur had a significantly positive correlation with the yield of paddy. Based on per cent samples deficient or likely to be deficient nutrients in near future were organic carbon (85 per cent), followed by sulphur (73 per cent) and available N (66 per cent). The farmers of the study area mostly adopt improper nutrient management practices which might have resulted in poor fertility status in the area. Taking these things into consideration, a data-driven Decision Support System (DSS) on nutrient management in soil has been given.Green manures are an ideal method of sustaining soil fertility and increasing the organic carbon and nitrogen content of soil. Considering the yield potential and nutrient availability, the different combinations of organic (legumes, green manure, and farmyard manure) amendments with inorganic fertilizers would be the best treatment. Management of sulphur in the soil can be done by applying S to the seedbed, incorporating straw instead of completely removing or burning it.

(Key words: Fertility status, Bhandara, macronutrient, Soil Nutrient Index, Decision Support System)

INTRODUCTION

Soil health has a very sound relationship with the rural ecosystem. Healthy soils give nutritious food which is related to healthy people, a good environment and an ecosystem. Soil fertility is a dynamic natural property that can change under the influence of natural and human-induced factors. The soil plays a prime role in agriculture and supports all the living organisms on earth by supplying various food, fuel, fiber, and essential things required. In the current 21st century the excessive growth in the population has pushed the farmer's community toward the intensive cultivation of high-yielding varieties for increasing food production but it has tremendously declined the soil fertility status in the Indian soils. In India, the low fertility of soils is the major constraint to achieving high productivity goals. In many parts of the country, soil fertility fluctuates throughout the growing season each year due to alterations in the quantity and availability of mineral nutrients through the addition of fertilizers, manure, compost, mulch, and lime in addition to leaching.

Bhandara district is one of the backward districts in the Vidarbha region of Maharashtra. The rural population (80.5%) mostly depends on agriculture and forest by-products.

This area comes under a hot, moist, sub-humid with shallow to deep loamy to clay mixed red and black soil, ESR 10.4. The rice productivity in this area showed a negative trend since 1995-96 (Suryawanshi *et al.,* 2013). This emphasizes the need for soil fertility assessment for better nutrient management in the area. Therefore, the study was undertaken to assess the physicochemical properties and available macronutrient status of the Bhandara tehsil of Maharashtra.

MATERIALS AND METHODS

The study was carried out by collecting soil samples from 21 villages of Bhandara tehsil of Bhandara district (5 soil samples from each village), Maharashtra during 2021-22. The area of the Bhandara tehsil is 649 km square and there are 147 villages. The tehsil lies between

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21°15'55.63" N to 20°58'0.0624" N latitude and 79°29'11.22" E to 79°50'7.11" E longitude. The soil samples were taken from 0-20 cm depth at a 4 km grid interval, after harvesting of *kharif* crops.

The estimation of pH was done by a glass electrode pH meter, electrical conductivity by an electrical conductivity meter (Jackson, 1973), organic carbon by wet oxidation method (Walkley and Black, 1934), calcium carbonate by rapid titration method (Piper, 1966), nitrogen by alkaline $KMnO_4$ method (Subbiah and Asija, 1956), phosphorus by Bray's method (Bray and Kurtz, 1945) and Olsen's method (Olsen, 1954), potassium by Ammonium Acetate method by using flame photometer (Jackson, 1973) and sulphur by the turbidimetric method using Morgan's extractant solution by using a spectrophotometer (Chesnin and Yien, 1951). The nutrient indices of soils were worked out and soil nutrient indices were assessed as per a six-tier system and index rating formula (Ramamoorthy and Bajaj, 1969)

$$NI = \frac{[NVL\times0.5+NL\times1+NM\times1.5+NMH\times2+NH\times2.5+NVH\times3]}{\text{Total number of samples}}$$

Where, NVL, NL, NM, NMH, NH and NVH are the number of samples in very low, low, medium, moderately high, high, and very high classes of nutrients, respectively.

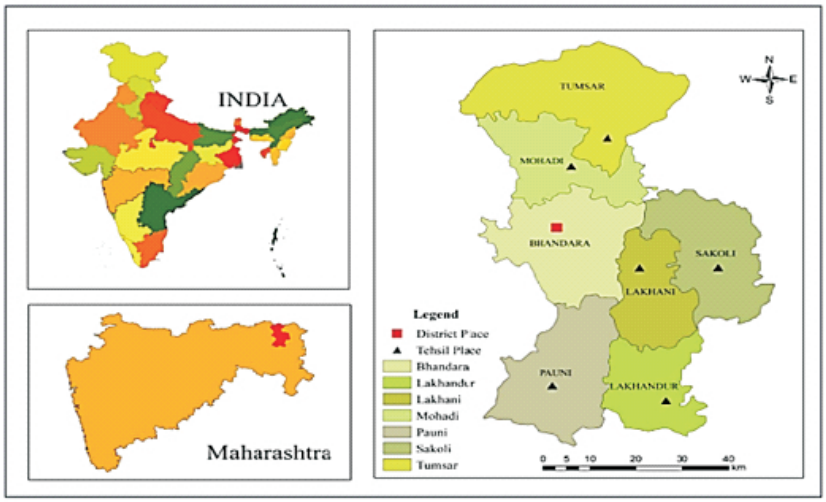

Fig. 1. Location map of Bhandara tehsil in Maharashtra

RESULTS AND DISCUSSION

Physico-chemical properties of soils

Soils of the Bhandara tehsil were clay loam to sandy clay loam in texture..The pH of the soils of the Bhandara tehsil was in the range of 6.3 to 8.0, indicating slightly acidic to slightly alkaline reaction. The lowest average pH was observed in the Dighori village (6.4) whereas, the highest average pH was found in the Jakh village (7.9).The electrical conductivity of soils was in the range of 0.19 to 0.49 dS m^{-1}, which is within the acceptable limit and the soils were non-saline (EC < 1.0 dS m^{-1}). The normal EC might be due to the leaching of salts to lower horizons.

The organic carbon content of the soils ranged from 2.1 to 6.9 g kg^{-1} with an average value of 4.02 g kg^{-1}. The lowest average OC was observed in the Jakh village (2.24 g kg^{-1}) whereas, the highest average OC was observed in the Kawadshi (6.46 g kg^{-1}). The very low to medium content of organic carbon might be due to different management practices and manuring.

Available macronutrient status in the soils of Bhandara tehsil

The available N status in soils of the Bhandara tehsil varied from 120.4 to 489.2 kg ha^{-1} and the average available nitrogen content was 268.4 kg ha^{-1}. The lowest nitrogen content was found in the Silli village (190.0 kg ha^{-1}) whereas, the highest nitrogen content was observed in the Kawadshi (450.0 kg ha^{-1}). This showed that all the samples analyzed were found to be low to moderately high in available nitrogen. As the organic carbon content in soils was low to moderate and therefore nitrogen availability was also low. The low N content in soils was mainly due to its low addition, higher mobility, and losses through ammonia volatilization, leaching, runoff, denitrification, a microbial and chemical fixation. Swati *et al.* (2020) reported low nitrogen content in the major portion of Nagpur district (107.8 to 347.6 kg ha^{-1}).

The magnitude of available phosphorus content in soils was found in a range of 23.06 to 51.75 kg ha^{-1}. The mean value of available phosphorus content in soils was 38.04 kg ha^{-1}. By considering the mean value of the villages, the lowest phosphorus content was found in the soils of Mandvi (24.55 kg ha^{-1}) while the highest phosphorus content of soils was found in Silli (49.70 kg ha^{-1}). This reveals that the soils were low to moderately high in available phosphorus. The low amount of P in some soils might be due to the fixation of P on clay minerals surfaces with the time elapsed between fertilizer application and crop uptake.

The available K content of soils of the Bhandara tehsil ranged from 201.9 to 517.0 kg ha^{-1} with a mean value of

361.3 kg ha^{-1}. The lowest potassium content was found in the soils of Jakh (222.3 kg ha^{-1}) whereas, the highest was found in the soils of Silli (462.0 kg ha^{-1}). This reveals that the soils were high in K content. Kore *et al.* (2017) reported that the soils were medium to very high in available K (227.40 to 406.60 kg ha^{-1}) in the Amgaon tehsil of Gondia district, Maharashtra. This high level of available K might be due to the presence of potassium-rich parent material and clay minerals biotite and smectite in the soils.

The available S content of soils ranged from 4.52 to 39.54 mg kg^{-1} with a mean value of 12.06 mg kg^{-1}. The lowest sulphur content was found in the soils of Mandvi village (4.68 mg kg^{-1}) whereas, the highest sulphur content was found in the soils of Garada village (34.08 mg kg^{-1}). This revealed that the soils were very low to very high in S content. The lack of sulphur addition and intensive cultivation of crops might be the reason for the low content of sulphur in the area. Katkar *et al.* (2017) in the Bhandara district also reported low to very high sulphur (7.94 to 36.49 mg kg^{-1}) showing deficiency in 86.6 per cent of samples.

Soil nutrient index of soils of Bhandara tehsil

Considering the nutrient index values (Table 2 of the six-tier system of soil organic carbon, the nutrient index value was low i.e., 1.22. The nutrient index value for available nitrogen was 1.19, which falls under the low category. The nutrient index value of available phosphorus and available sulphur was moderate. The nutrient index value of available potassium was in the high category.

Correlation between soil properties and yield of the crop (n = 105)

The yield data collected from farmers showed a mean value of 4.4 t ha^{-1}, ranging from 3.7 to 5.5 t ha^{-1}. The relation between the yield of paddy with OC, N and S was found to be positive and highly significant with r values of 0.790**, 0.720** and 0.454** respectively. Available K (r = 0.316*) was found to be positive and significant (Table 3). This correlation study indicated that yield of paddy was increased with the increase in availability of OC, available N, available K and available S.

Data-driven Decision Support System

A Decision Support System (DSS) is based on the soil nutrient status of soil and provides several management recommendations to improve soil fertility. Herein, the farmers get advice for fertilizer application based on the information provided by soil test values. Red color indicates deficient samples, orange color indicates samples that are on the verge of being deficient shortly, yellow color indicates samples having a moderate amount of nutrients, and green indicates enough nutrients.

A. Soil organic matter: A total of 53% of samples were deficient and 32% of samples were likely to be deficient if not taken management decisions.Green manures are an ideal method of sustaining soil fertility and increasing organic carbon content. One of the most abundant lignocellulose wastes is the paddy straw which is readily available to farmers. *Gliricidia sepium* as green manure and paddy straw in combination with inorganic fertilizers was found to be more advantageous (Dongarwar *et al.* 2015).

B. Available N: Adding FYM, green manure, adopting crop rotation with legumes, and providing balanced inorganic fertilizers such as DAP, urea and mixed fertilizer NPKS in the ratio of 20:20:00:13. Considering the yield potential and nutrient availability, the different combinations of organic (legumes, green manure, and farmyard manure) amendments with inorganic fertilizers would be the best treatment. The study by Manish *et al.* (2022) revealed that a foliar spray of nitrogen on paddy at the seedling stage helped in the improvement of yield-attributing parameters.

C.Available S: Management of S in the soil can be done by applying S to the seedbed, incorporating straw instead of completely removing or burning it. Replace some urea with ammonium sulphate or application of S-containing fertilizers like single superphosphate (SSP), gypsum and potassium sulphate. Manure (livestock and poultry manure) is an excellent source of sulphur.

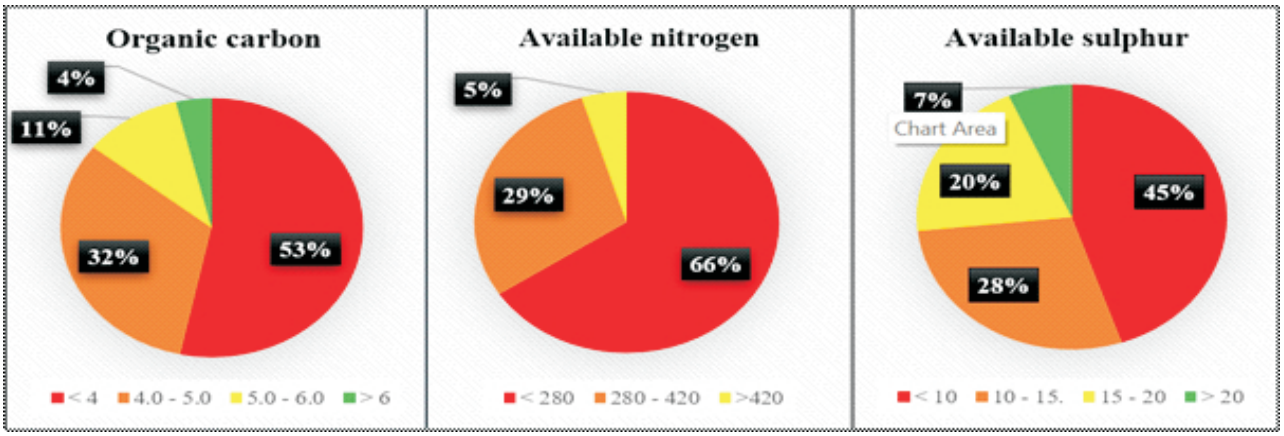

Figure 2. Per cent of samples in different categories of available soil nutrients

Table 1.Physico-chemical properties and available macronutrient status (mean values) in soils of Bhandara tehsil

Sr. No.	Village Name	pH	EC(dS m^{-1})	N	P	K	S
				(kg ha^{-1})			(mg kg^{-1})
1	Mandvi	7.07	0.35	245.4	24.55	387.1	4.68
2	Jakh	7.93	0.44	265.3	37.60	222.3	8.33
3	Hattidohi	7.64	0.25	222.2	36.47	248.7	6.47
4	Khamari	6.98	0.35	277.7	40.97	267.1	6.41
5	Sitepar	7.43	0.35	385.2	47.43	443.0	12.58
6	Ganeshpur	6.69	0.24	226.4	38.88	323.8	13.92
7	Kawalewada	7.53	0.35	284.1	31.44	334.9	15.40
8	Tekepar	6.72	0.33	160.5	44.86	235.1	10.50
9	Dighori	6.49	0.33	253.3	41.81	425.2	12.59
10	Bhilewada	7.64	0.24	338.6	36.63	453.5	4.78
11	Shahapur	7.01	0.31	297.3	36.76	433.8	7.052
12	Nimgaon	6.91	0.25	222.2	36.12	344.5	12.91
13	Khurshipar	7.54	0.40	291.9	41.02	413.6	9.24
14	Chandori	7.52	0.24	236.9	35.18	410.7	17.93
15	Pahela	7.19	0.31	227.8	33.52	408.5	5.13
16	Sahuli	6.95	0.34	255.8	30.58	420.2	22.69
17	Kawadshi	7.57	0.35	450.0	36.45	447.6	16.28
18	Silli	7.54	0.43	190.0	49.70	462.0	7.27
19	Garada	7.09	0.45	345.4	35.05	358.2	34.08
20	Borgaon	7.61	0.24	256.7	43.30	245.8	9.94
21	Pandraboli	6.98	0.25	203.5	40.68	302.1	15.13

Table 2. Values and category of soil nutrient index

Nutrient	Fertility Index	Category
Organic Carbon	1.22	Low
Available N	1.19	Low
Available P	1.44	Medium
Available K	2.57	High
Available S	1.42	Medium

Table 3. Correlation between soil properties and yield of crop (n = 105)

Soil Properties	Yield
pH	0.190
EC	0.053
Bulk density	-0.275
Organic carbon	0.790**
C_aCO_3	-0.057
Available N	0.720**
Available P_2O_5	0.076
Available K_2O	0.316*
Available S	0.454**

***Significant at 5% level (r = 0.192)**

**** Significant at 1% level(r = 0.251)**

The soils of the Bhandara tehsil were clay loam to sandy clay loam in texture, slightly acidic to slightly alkaline in nature, and under the safe limit of soluble salts. The soil fertility index was low for organic carbon and available N. Whereas other nutrients were medium to moderately high. Based on per cent samples deficient or likely to be deficient nutrients in near future were organic carbon (85 per cent), followed by sulphur (73 per cent) and available N (66 per cent). The farmers of the study area mostly adopt improper nutrient management practices which might have resulted in poor fertility status in the area.

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