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Assessment of Micronutrient Content and Strategies for Improvement of Micronutrient Status in the Soils of Bhandara Tehsil, Maharashtra, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was undertaken to determine the available micro-nutrient 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 from paddy growing fields. Samples were analyzed at the Soil Science and Agricultural Chemistry Section, College of Agriculture, Nagpur. The results revealed that soils were clay loam to sandy clay loam in texture. The study area was slightly acidic to slightly alkaline and non-saline in reaction. The mean values of 0.42 mg kg^{-1}, 5.44 mg kg^{-1}, 6.39 mg kg^{-1}, 0.98 mg kg^{-1}, and 0.90 mg kg^{-1} for Zn, Fe, Mn, Cu and B respectively, were recorded. The soil nutrient index values showed that available Zn was low; available Fe was moderate; available Mn and B were moderately high;

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and available Cu was high. 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 micronutrient management in soil has been given. To address this problem, farmers of Bhandara tehsil may use micronutrient fertilizers or implement soil management practices that promote the uptake and availability of micronutrients to plants.

Keywords: Micronutrients; Bhandara; soil nutrient index; Decision Support System (DSS).

1. INTRODUCTION

Nutrients play a vital role in increasing crop production, soil upgradation, and increase in profitability. Micronutrients, such as iron, zinc, manganese, copper, and boron are essential for plant growth and they are found in trace amounts in tissues but play an imperative role in plant metabolism and development. Lately, in India micronutrient deficiencies have become major constraints, particularly in areas with intensive agriculture. These deficiencies can lead to potential declines in plant productivity, sustainability of soil, and increased susceptibility to diseases. Therefore, it is important to maintain an adequate level of micronutrients in the soil to ensure optimal plant productivity and growth.

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 [1]. This emphasizes the need for soil fertility assessment for better nutrient management in the area. Therefore, the study was undertaken to assess the micronutrient status of the Bhandara tehsil of Maharashtra.

2. MATERIALS AND METHODS

The study was carried out by collecting soil samples from 21 villages of Bhandara tehsil of Bhandara district, Maharashtra during 2021-22 from paddy growing fields. The area of the Bhandara tehsil is 649 km square and there are 147 villages. The tehsil lies between 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. A total of 105 (5 samples per village) soil samples were collected from 21 selected villages and analyzed for the micronutrient status of the soil.

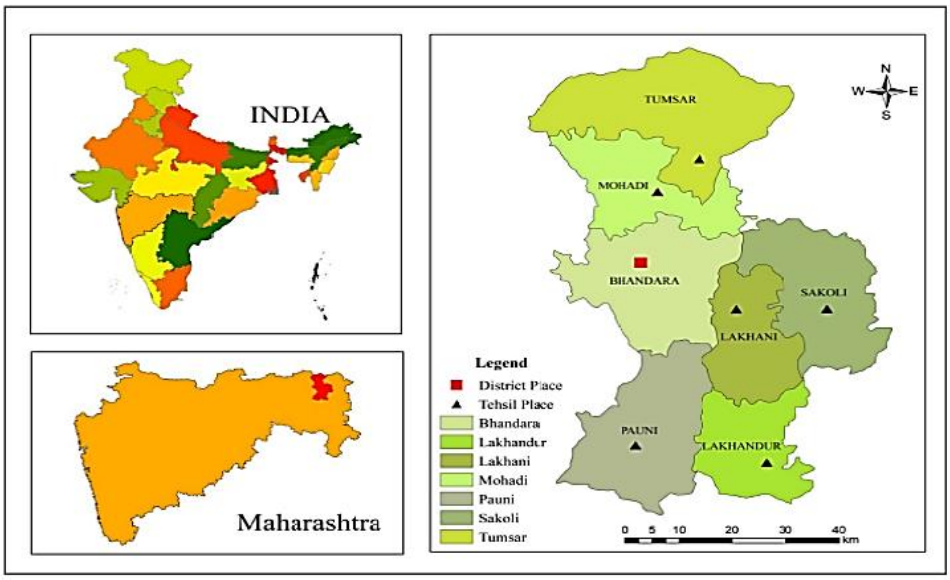

Fig. 1. Location map of Bhandara tehsil in Maharashtra

The estimation of pH was done by a glass electrode pH meter, and electrical conductivity by an electrical conductivity meter [2]. The micronutrients like zinc, iron, copper, and manganese were estimated using DTPA extractant [3]. The boron was estimated using the Azomethine H method by a spectrophotometer [4]. The nutrient indices of soils were worked out and soil nutrient indices were assessed as per a six-tier system and index rating formula [5].

$$\mathbf{NI} = \frac{[\mathbf{NVL}\times 0.5+\mathbf{NL}\times 1+\mathbf{NM}\times 1.5+\mathbf{NMH}\times 2+\mathbf{NH}\times 2.5+\mathbf{NVH}\times 3]}{\text{Total number of samples}}$$

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.

3. RESULTS AND DISCUSSION

3.1 Physicochemical 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 a 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 was 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.

3.2 Available Macronutrient Status in the Soils of Bhandara Tehsil

The results presented in Table 1. show that available Zn in soils of Bhandara tehsil ranged between 0.23 to 0.73 mg kg^{-1} with a mean of 0.42 mg kg^{-1}, whereas the available Fe varied from 4.06 to 7.49 mg kg^{-1} with a mean of 5.44 mg kg^{-1}. The available Mn varied from 4.49 to 9.57 mg kg^{-1} with a mean of 6.39 mg kg^{-1} and the available Cu varied from 0.58 to 1.60 mg kg^{-1} with a mean of 0.98 mg kg^{-1}. The available B varied from 0.27 to 1.89 mg kg^{-1} with a mean of 0.90 mg kg^{-1}.

From these values, it can be inferred that the maximum soil samples were very low to medium in zinc content and needed attention. The low

Table 1. Micro-nutrient status (mean values) in soils of Bhandara tehsil

Sr No.	Village Name	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	B (mg kg^{-1})
1	Mandvi	0.36	4.67	5.82	0.61	0.56
2	Jakh	0.23	4.06	5.52	0.70	1.40
3	Hattidohi	0.34	4.71	5.77	0.65	0.56
4	Khamari	0.43	5.66	6.76	1.33	1.02
5	Sitepar	0.52	5.04	6.21	0.88	1.65
6	Ganeshpur	0.65	6.14	4.49	1.60	0.27
7	Kawalewada	0.30	4.80	5.96	0.64	0.58
8	Tekepar	0.45	6.15	7.12	1.58	1.27
9	Dighori	0.73	5.66	6.70	1.22	0.50
10	Bhilewada	0.30	4.78	6.28	1.36	0.58
11	Shahapur	0.40	5.83	6.69	1.25	0.83
12	Nimgaon	0.49	7.49	9.57	0.91	1.45
13	Khurshipar	0.31	4.79	5.86	0.61	1.57
14	Chandori	0.31	4.83	5.79	0.61	0.55
15	Pahela	0.35	5.24	6.32	1.02	0.62
16	Sahuli	0.43	5.21	6.86	1.18	0.80
17	Kawadshi	0.40	6.05	6.79	1.36	1.89
18	Silli	0.35	5.03	5.80	0.68	0.61
19	Garada	0.44	5.89	6.11	0.85	0.60
20	Borgaon	0.47	6.33	7.07	1.08	0.89
21	Pandraboli	0.52	5.87	6.75	0.58	0.75

content of Zn might be due to the low organic carbon content of the soil, the use of zinc-free fertilizers, and the leaching of nutrients. Similar results were obtained by Kore et al. [6] in Amgaon tehsil of Gondia district. In the case of Fe, samples were under the low to medium category and Mn was in the moderately high to high category. These showed the sufficiency of Fe and Mn content. The sufficiency levels indicative of these soils might be due to the neutral to low pH and nature of the parent material. Similar results were obtained by Swati et al. [7] in the soils of selected villages in the Nagpur district of Maharashtra. The available Cu was found to be medium to very high and was sufficient. Whereas, boron falls under the very low to very high category and needs proper management practices. Similar results were noticed by Palani et al. [8] in the Mambutta village of Tamil Nadu, India. The reason behind available B deficiency might be due to improper water or fertilizer management, high calcium levels, or low organic matter content in the soils.

3.3 Soil Nutrient Index of Soils of Bhandara Tehsil

Considering the nutrient index values of the six-tier system of available Zn (0.98), the nutrient index value was low. For Fe the nutrient index value was moderate (1.47). In the case of Mn and B the nutrient index value was moderately high (2.02 and 1.94, respectively) and for Cu the nutrient index value was high (2.44).

Table 2. Soil nutrient index of soils of Bhandara tehsil

Nutrient	Fertility index	Category
Available Zn	0.98	Low
Available Fe	1.47	Moderate
Available Mn	2.02	Moderately high
Available Cu	2.44	High
Available B	1.94	Moderately high

3.4 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.

3.4.1 Available Zn

Following measures can be adopted to manage Zn content in soil:

- Use fertilizers that generate acidity (e.g., replace some urea with ammonium sulphate).
- Apply organic manure before seeding or transplanting or can be applied to the nursery seedbed a few days before transplanting.
- Broadcast $ZnSO_4$ in a nursery seedbed.
- Dip seedlings or pre-soak seeds in a 2-4% ZnO suspension (e.g., 20-40 g ZnO L^{-1}) [9].

3.4.2 Available B

The deficiency of B might be due to improper drainage as B is very mobile in flooded paddy soils and can be easily leached down. The B content could be managed in soil by avoiding excessive leaching or drainage of water. By application of B in soluble forms (Borax 0.5 to 3 kg ha^{-1}) before transplanting or foliar spray during the vegetative growth stage. Note: Do not mix borax and fertilizer borates with ammonium fertilizers [10].

3.4.3 Available Fe and Mn

- Liming: Adding lime to acidic soils can increase the availability of Fe and Mn to plants, as high acidity can make iron and manganese less soluble and less available to plants.
- Organic matter: Incorporating organic matter, such as compost or manures or paddy straw incorporation, can improve the overall fertility of the soil and increase the availability of micronutrients.
- Micronutrient fertilizers: Applying micronutrient fertilizers such as chelated iron, chelated manganese, and manganese sulphate can provide an immediate boost to the plants, but it should be used judiciously as overuse can create imbalances in the soil.

- Proper pH level: Iron is more available to plants in neutral soil, having a Ph between 6-7 whereas, Mn is more available to plants in slightly acidic soil, having pH 6-6.5 and maintaining the pH level can help in better Fe and Mn uptake.
- Avoiding high levels of Phosphorus fertilization: High levels of phosphorus in the soil can decrease the availability of manganese, so it is important to avoid over-fertilization with phosphorus.

3.4.4 Available Cu

- Dip seedling roots in 1% $CuSO_4$ suspensions for 1 h before transplanting.
- Avoid over-liming of acid soils because it may reduce Cu uptake.
- On Cu-deficient soils, apply CuO or $CuSO_4$ (5−10 kg Cu ha^{-1} at 5-year intervals) for long-term maintenance of available soil Cu (broadcast and incorporate in soil [9].

Beyond these solutions, many other practices are both cost-effective and have a positive impact, such as better manure management, integrated crop-livestock management, use of renewable energy, use of legumes or cover crops, and practices that increase soil carbon Kalpana et al. [10].

4. CONCLUSION

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. Based on per cent samples deficient or likely to be deficient nutrients in near future were zinc (89 per cent), and boron (53 per cent). Whereas other nutrients were medium to moderately high. Hence, the tehsil was categorized as with intermediate fertility status. And the reason behind it might be the farmers of the study area who mostly adopt improper nutrient management practices which might have resulted in a deficiency of certain micronutrients in the area. Singh & Mishra [11] reported a similar impact in the soils of the Chiraigaon block of district Varanasi (UP). However, for sustaining agriculture productivity and improving the micronutrient status of paddy growing soils of Bhandara tehsil from sufficient to a high level, the corrective measures were suggested in data driven DSS.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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