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Evaluation of soil fertility status of Bhatpal village, Bastar district, Chhattisgarh

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Abstract
The study "Evaluation of soil Fertility statsus of Bhatpal Village, Bastar district, Chhattisgarh" was conducted in 2024-25 to assess soil nutrient status. A total of 120 surface soil samples (0-15 cm) were analyzed for pH, EC, organic carbon, macronutrients (N, P, K), secondary nutrient (S), and micronutrients (Fe, Mn, Cu, Zn, B). Soils were moderately to slightly acidic (pH 4.41-7.52), with EC values indicating suitability for crops, (ranges 0.01-0.13dSm^{-1}). Organic carbon was medium in most samples, (ranges 0.37-0.72%). Most of the soil samples were found low in available N content varied from 163.07 to 250.88 kg ha^{-1} with mean 219.41 kg ha^{-1}. The available phosphorus (Olsen P) ranged from 8.96 to 28.28 kg ha^{-1} with mean 15.96 kg ha^{-1} while phosphorus (Bray P-1) was ranged from 28.28 to 54.32 kg ha^{-1} with mean 34.34 kg ha^{-1}. The available potassium ranged from 130.59 to 229.48 kg ha^{-1} with mean 199.52 kg ha^{-1}. The available sulfur ranged from 11.51 to 20.83 kg ha^{-1} with mean 15.83 kg ha^{-1}. The nitrogen content of the soil indicates that the entire study are region showed low level of available nitrogen, Olsen P content of the area was low, medium to high with 61 percent low, 27 percent of the examined area showing medium levels and only 12 percent were showing high levels of available phosphorus, while available phosphorus (Bray P-1), P content of the area was low to medium, with 57 percent low and 43 percent of the examined area showing medium levels. The potassium content of the area was low to medium with 12 percent of the examined area showing low levels and 88 percent showing medium levels of available potassium and sulfur content of the area was low to medium with 86 percent exhibited low and 14 percent showed medium levels of available sulphur. Among micronutrients iron (Fe) ranged from 7.32 to 39.92 mg kg^{-1} with mean 34.25 mg kg^{-1}, 6.96 to 27.98 mg kg^{-1} with mean 24.23 mg kg^{-1} for Mn, 0.98 to 1.56 mg kg^{-1} with mean 1.34 mg kg^{-1} for Cu, and 0.54 to 0.78 mg kg^{-1} with mean 0.66 mg kg^{-1} for Zn, respectively. The available B ranged from 0.31 to 1.74 mg kg^{-1} with mean 0.48 mg kg^{-1}. Micronutrients Fe, Mn, and Cu were sufficient; however, 18% samples were deficient in Zn and 80% in B. Based on Nutrient Index Value (NIV), N, P, and S were low, K was medium. Recommendations include liming acidic soils, applying 25% additional N, P, S, and K where deficient, and applying 25 kg/ha Zinc Sulphate and Borax where Zn and B are low.

Keywords: Soil fertility, nutrients, micronutrients, Bastar, nitrogen, phosphorus

1. Introduction

Soil fertility is the natural ability of soil to supply essential macro and micronutrients to plants. Physical and chemical analyses help determining the soil's potential to provide these mineral nutrients (Ganorkar and Chinchmalatpure, 2013) [4]. In contrast, soil productivity refers to the soil's ability to support crop production under a given management system, typically measured in terms of crop yield. Soil is a dynamic natural body that supports plant growth. Fertile soil provides balanced nutrients, good aeration, deep rooting, and water-holding capacity. For sustained productivity, soil testing is a vital tool to evaluate and manage soil fertility effectively (Havlin *et al.*, 2010) [6]. Bastar district, located in the southern part of Chhattisgarh, lies in the Dandakaranya region, characterized by hilly terrain and dense forests. The region falls under the Eastern Plateau and Hills agro-climatic zone. Climate: Sub-tropical monsoon type, Rainfall: High rainfall zone with an annual average of 1,200-1,600 mm, mostly received between June and September (kharif season). Cropping Patterns: Mono-cropping dominates due to rainfed nature of farming, Rice mono-cropping is prevalent in lowlands. In upland areas, mixed and intercropping systems are common, combining millets and pulses.

Soil types found in Bastar: Red and Yellow Soils, Laterite Soils, Alluvial Soils, Black Soils. Temperature Range Summer: 30-42 °C, Winter: 10-25 °C. The high rainfall and humid conditions support rainfed agriculture.

2. Materials and Methods

The survey was carried out on the soil of Bhatpal villages from Bastar tahsil of Bastar district. The Kharif season is the primary cropping period in the study area, with paddy being the dominant crop cultivated across the total geographical region other important crops commonly grown in the area are niger, kulthi, minor millets and vegetables. Total 120 surface soil samples (0-15 cm) were collected from the selected villages of Bastar district. The collected soil samples were air dried and grind with the help of wooden hammer and sieve through 2 mm sieve and for the determination of organic carbon, soil samples further passed through 0.2 mm sieve. These soil samples was stored in polythene bags and were subsequently analyzed for mechanical parameters such as Chemical parameters like pH (Piper, 1967) [9], EC (Black, 1965) [2], Organic-C (Walkley and Black, 1934) [13], available Nitrogen (Subbiah and Asija, 1956) [10], Phosphorus (Olsen, 1954, and Bray and Kurtz, 1948) [8, 3], Potassium (Hanway and Heidal, 1952) [5], and Sulphur (Williams and Steinbergs, 1969) [14] and micronutrients like Fe, Cu, Mn and Zn (Lindsay and Norvell, 1978) [7] and available B (Berger and Troug, 1939) [1].

3. The Nutrient Index values and Fertility Classes

Nutrient index value (Parker, 1952) [12] for the various soil parameters was calculated from the number or proportion of samples under low, medium and high available nutrient status and categorised in different fertility classes as per the method explained by Ramamoorthy and Bajaj (1969) [11].

$$NIV = \frac{1 \times PL \; + \; 2 \times PM \; + \; 3 \times PH}{100}$$

Where,
NIV = nutrient index value
PL=% samples fall under low category.
PM =% samples fall under medium category.
PH =% samples fall under high category.

Total no. of samples Where, NL, NM and NH are the number of samples in low, medium and high category of nutrient index by three tier system.

Table 1: Nutrient index values for nutrients

NIV for the nutrient	Fertility class based on NIV		
Macronutrient (N,P,K and S) and	<1.67	1.67-2.33	>2.33

Table 2: Ratings of soil test value for Soil Nutrients

Ratings of soil test value for Soil Available Macronutrients			
Parameters	**Low**	**Medium**	**High**
N (kg ha^{-1})	<280	280-560	>560
P (kg ha^{-1}) Olsen method	<12.5	12.5-25	>25
P (kg/ha) Bray method	<34	34-68	>68
K (kg ha^{-1})	<135	135-335	>335
S (kg ha^{-1})	<22.5	22.5-45	>45

Ratings of soil test value for Available Soil Micronutrients		
Parameters	**Deficient**	**Sufficient**
Fe (mg kg^{-1})	< 4.5	> 4.5
Mn (mg kg^{-1})	< 3.5	> 3.5
Cu (mg kg^{-1})	< 0.2	> 0.2
Zn (mg kg^{-1})	< 0.6	> 0.6
B (mg kg^{-1})	< 0.5	> 0.5

4. Results and Discussion

4.1 Soil reaction (pH)

The soils of Bhatpal village in Bastar district exhibited a pH range from 4.41 to 7.52, with an average pH of 5.59 and a standard deviation of 0.71. Out of the 120 samples analyzed, 46% were classified as moderately acidic, 44% as slightly acidic, and 10% as neutral. This distribution suggests that approximately 91% of the soils in the study area fall within the acidic range, as summarized.

4.2 Soil electrical conductivity (dSm^{-1})

Essentially, electrical conductivity reflects the concentration of soluble salts in the soil. In the study area, soil electrical conductivity ranged from 0.01 to 0.13 dS/m, with a mean value of 0.09 dS/m and a standard deviation of 0.02. In terms of total soluble salts, the vast majority of soil samples showed normal levels. These results suggest that soil salinity was negligible and hence, no threat to crop production in the region. all samples (100%) fell within the low salinity range and were classified as "Good," signifying that no corrective measures are required and that the soils are suitable for all types of crops.

4.3 Soil organic carbon (%)

The organic carbon content in the soils of Bhatpal village ranged from 0.37% to 0.72%, with a mean value of 0.56%. Based on standard soil test rating criteria, the samples were classified into two categories for organic carbon levels. Out of the 120 samples analyzed, 27% were found to have low organic carbon content, while 87% fell into the medium category.

4.4 Available Nitrogen (N) Status in Soil

In Bhatpal village, located in Bastar district, the available nitrogen content in soils ranged between 163.07 and 250.88 kg ha^{-1}, with an average of 219.41 kg ha^{-1} and a standard deviation of 24.55 kg ha^{-1}. Based on the soil test rating system, all the samples from the study area were classified under the low nitrogen category.

4.5 Available Phosphorus Status in Soils (Olsen Method)

In the soils of Bhatpal village, available phosphorus was determined using the Olsen extraction method, which is suitable for soils with a pH above 5.5, The phosphorus levels ranged from 8.96 to 28.28 kg ha⁻¹, with a mean value of 15.96 kg ha⁻¹ and a standard deviation of 6.68 kg ha⁻¹. According to the soil test classification system, 62% of the samples were found to be low, 26% medium, and 12% high in available phosphorus content.

4.5.1 Available Phosphorus Status in Soils (Bray-1 method)

For soil samples with a pH below 5.5, the Bray-1 extractant was used to determine available phosphorus levels. The available phosphorus ranged from 28.28 to 54.32 kg ha⁻¹, with an average of 34.34 kg ha⁻¹ and a standard deviation of 6.69. According to the classification, 43% of the soils fell within the medium phosphorus category, while 57% were in the low category. The generally low to medium phosphorus availability in the study area may be attributed to low organic carbon content and phosphorus fixation by kaolinite clay minerals, as well as aluminum and iron oxides present in the acidic soils.

4.6 Available Potassium Status in Soil

The available potassium (K) content in the soils of Bhatpal village, Bastar district, ranged from 130.59 to 229.48 kg ha⁻¹, with a mean value of 199.52 kg ha⁻¹ and a standard deviation of 19.71 kg ha⁻¹. Based on the soil test classification 12% of the 120 soil samples fell into the low potassium category, 88% were classified as medium levels.

4.7 Available Sulphur (S) Status in Soil

In the soils of Bhatpal village, the available sulphur (S) content ranged from 11.51 to 20.83 kg ha⁻¹, with an average of 15.83 kg ha⁻¹ and a standard deviation of 2.48 kg ha⁻¹. According to the soil test classification as analysis of 120 soil samples revealed that 86% samples showed low sulphur levelsand 14% in medium level. Overall, the sulphur status in the study area ranges low likely due to limited organic carbon content and the loss of sulfate ions through leaching and surface runoff.

4.8 Available Iron (Fe) in Soil

In Bhatpal village, Bastar district, available iron (Fe) levels in the soil ranged from 7.32 to 39.92 mg/kg, averaging 34.25 mg/kg with a standard deviation of 8.78 mg/kg. All 120 samples showed adequate iron content, indicating that Fe availability is more than sufficient and unlikely to limit crop growth or soil health in the area.

4.9 Available Manganese (Mn) in Soil

In Bhatpal village, Bastar district, soil Manganese (Mn) levels ranged from 6.96 to 27.98 mg/kg, with an average of 24.23 mg/kg and a standard deviation of 5.73 mg/kg, based on 120 samples. According to soil test ratingsall samples (100%) fell into the Sufficient Mn category, indicating that manganese is abundantly available and not a limiting factor for crop production.

4.10 Available copper (Cu) status in soil

In Bhatpal village, Bastar district, the available copper (Cu) content in the soil ranged from 0.98 to 1.56 mg/kg, with a mean of 1.34 mg/kg and a standard deviation of 0.12 mg/kg. Based on the soil test rating, all samples (100%) were categorized as having sufficient copper levels.

4.11 Available zinc (Zn) status in soil

In Bhatpal village, Bastar district, available zinc (Zn) levels in the soil ranged from 0.54 to 0.78 mg/kg, with an average of 0.66 mg/kg and a standard deviation of 0.06 mg/kg. According to standard zinc availability classifications the soils in this area ranges from deficient to sufficient. Out of 120 samples, 18% were found to be zinc-deficient, while 82% fell within the sufficient range.

4.12 Available boron (B) status in soil

In Bhatpal village of Bastar district, the available boron content in the soil ranged from 0.31 to 1.74 mg kg^{-1}, with an average of 0.48 mg kg^{-1} and a standard deviation of 0.19 mg kg^{-1}. According to the soil test classification for boron availability, 80% were deficient in boron and 20% were within the sufficient range.

Table 3: Salient Findings of the soil of village Bhatpal, Bastar

S. No.	Parameters	Range	Average	Standard (±) Deviation
1	Soil pH	4.55-7.52	5.59	0.71
2	EC (dSm^{-1})	0.01 -0.13	0.09	0.02
3	Organic carbon (%)	0.37-0.72	0.56	0.09
4	Nitrogen (kg ha^{-1})	163.07-250.88	219.41	24.55
5	Bray P-1 (kg ha^{-1})	28.28-54.32	34.34	6.69
	Olsen Method	8.96-28.28	15.96	6.68
6	Potassium (kg ha^{-1})	130.59-229.48	199.52	19.71
7	Sulphur (kg ha^{-1})	11.51-20.83	15.51	2.48
8	Iron (mg kg^{-1})	7.32-39.92	34.25	8.78
9	Manganese (mg kg^{-1})	6.96-27.98	24.23	5.73
10	Copper (mg kg^{-1})	0.98-1.56	1.34	0.12
11	Zinc (mg kg^{-1})	0.54-0.78	0.66	0.06
12	Boron (mg kg^{-1})	0.31-1.74	0.48	0.19

4.13 The overall fertility status based on the Nutrient Index Value

The nutrient index value (NIV) for available primary nutrients i.e., N, P and K; available secondary nutrient i.e., S of Bhatpal village of Bastar district was worked out by using the criteria of Parker *et al*. (1951) [12] the results showed that the nutrient index value for the soils of study area was low for N, P and S and K classified as medium fertility according to the NIV.

Table 5: Nutrient index value of soils of Bhatpal village, Bastar

S. No	Soil	Range	Average	% of samples caterory			NIV	Fertility class
				Low	Medium	High		
1	N kgha^{-1}	163.07-250.88	219.41	100	0	0	1.00	Low
2	P kg ha^{-1} (Bray)	28.14-54.32	34.34	57	43	0	1.43	Low
	P kg ha^{-1} (Olsen)	8.14-12.32	15.96	62	26	12	1.50	Low
4	K kg ha^{-1}	130.92-229.48	199.52	12	88	0	1.88	Medium
5	S kg ha^{-1}	11.51-20.84	15.51	86	14	0	1.14	Low

4.14 Recommendations
Apply 25% extra nitrogen and phosphorus over RDF. Use full dose of sulphur via bentonite sulphur or sulphur powder. Replace DAP/complex fertilizers with SSP to enhance sulphur. Apply 10 kg/ha Borax (for boron) and 25 kg/ha $ZnSO_4 \cdot 7H_2O$ (for zinc). Use lime to correct soil acidity.

5. Conclusion
120 soil samples from Bhatpal village, Bastar, Chhattisgarh showed pH ranging from moderately acidic to neutral. Organic carbon was mostly medium; 27.5% were low. Nitrogen, phosphorus, and sulphur levels were low, potassium medium. Micronutrients like boron and zinc were deficient.

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