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Evaluation of Soil Nutrient Status of Dargahan Village of Kanker District of Chhattisgarh

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Abstract

The study was conducted during the *kharif* season (June–November, 2024) in Dargahan village, Kanker district, Chhattisgarh, India to assess the soil fertility. A total of 145 soil surface samples (0–15 cm) were collected. The samples were analyzed for pH, electrical conductivity (EC), organic carbon (OC), macronutrients (N, P, K, S), and micronutrients (Fe, Mn, Cu, Zn, B). The soil pH ranged from 4.33 to 7.57, with a mean of 5.56, indicating Strongly acidic to neutral soil. EC ranged from 0.03 to 0.9 dS m^{-1} (mean 0.12 dS m^{-1}), suitable for all crops. OC varied from 3.1 to 8.0 g kg^{-1}, with 49% classified as low, 50% as medium, and 1% as high. Nitrogen (N) levels were low, ranging from 100.35 to 263.42 kg ha^{-1} (mean 173.88 kg ha^{-1}). Phosphorus (Olsen P) ranged from 8.6 to 37.5 kg ha^{-1} while Phosphorus (Bray P^{-1}) ranged from 20.35 to 67.89 kg ha^{-1} (mean 45.44 kg ha^{-1}), and potassium ranged from 107.29 to 547.68 kg ha^{-1} (mean 190.53 kg ha^{-1}). Sulfur content ranged from 18.16 to 39.76 kg ha^{-1} (mean 28.34 kg ha^{-1}). Micronutrients showed varying levels: Fe ranged from 5.44 to 42.43 mg kg^{-1} (mean 25.24 mg kg^{-1}), Mn from 2.06 to 21.17 mg kg^{-1} (mean 9.67 mg kg^{-1}), Cu from 0.81 to 2.9 mg kg^{-1} (mean 1.64 mg kg^{-1}), Zn from 0.12 to 0.96 mg kg^{-1} (mean 0.36 mg kg^{-1}), and B from 0.14 to 1.77 mg kg^{-1} (mean 0.75 mg kg^{-1}). According to the nutrient index value (NIV), the soils were low in N and Zn, medium in P, K, S, and B, and high in Fe, Mn, and Cu.

Keywords: Soil fertility status, nutrient index value (NIV)

1. Introduction

Soil is the "Soul" of infinite life and biodiversity and its quality affects nutrient cycling and human well- being (Bogunovic et al., 2017). As a terrestrial ecosystem component, soil performs various functions, including storage of plant-available water, supply of adequate oxygen to roots, provision of favourable seedling establishment conditions, storage of nutrients, suppression of plant pathogens, and immobilization of contaminants, all of which are essential to plant growth (Khatoon, 2020). Soil is a complex system comprised of minerals, soil organic matter (SOM), water, and air (Vishal et al., 2009; Flores-Magdaleno et al., 2011). Soil fertility refers to the interactions of soil's physical, chemical and biological properties and it is directly related to agricultural production (Rakesh et al., 2012). Evaluation of soil fertility is now becoming routine for sustainable soil management and crop production. There are various techniques for soil fertility evaluation; among them, soil testing is an indispensable tool in soil fertility management for sustained soil productivity (Havlin et al., 2010). The fertility of the agricultural soil of Depalpur block can reveal a lot about its productivity potential. Soil fertility testing of Depalpur block helps the farmer to get an idea about the properties of their soil and based on testing results, we can make fertilizer recommendations which will help in minimizing the fertilizer input without any yield loss (Yadav et al., 2018). Farmers may adjust fertility by regulating the plant's nutritional condition, which is an advantageous move (Nafiu et al., 2012). Evaluation of soil fertility is essential to provide nutrients for optimum crop growth (Nafiu et al., 2012).

Macronutrients (N, P, K, and S) and micronutrients (Zn, Cu, Fe, and Mn) are important soil elements that control soil fertility. Soil fertility is one of the key factors controlling crop yield. Soil characterization in relation to evaluating the fertility status of an area or region is crucial in the context of sustainable agriculture production. The soil fertility status under different cropping sequence can also be assessed by using nutrient index approach (Singh et al. (2016). Soil fertility refers to the availability status of status of essential macro micronutrients in the soil (Tisdale et al. (1993). The unscientific use of fertilizers (nutrient imbalances, incorrect amount is a serious threat to sustainable agriculture production system . Soil-test based fertility management is an effective toll for increasing productivity of agricultural soils that have a high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes (Goovaerts, 1998). However, major constraints impede wide-scale adoption of soil testing in most developing countries. In India, these include the prevalence of smallholding system of farming as well as lack of infrastructural facilities for extensive soil testing (Sen et al. (2008).

Soil are most valuable natural resources on which the agriculture production is based. The production of food, fodder, and fuel to fulfil the ever growing needs of human being and animal are depends on Agriculture and allied per suits, based on exploration of the soil resources. Further , the varieties of industrial products are also dependent on farm and forest products directly derived from the soil Familiarity with the potentiality of soil, knowledge of their limitation and their use and method of management of soil without deterioration are important for sustained production. It is further important to bring the deteriorated land in the use after due reclamation. Knowledge of such kind of soil and their extent is important for proper planning and optimum use for maximization for agriculture production. Soil survey is the only tool making the inventory of soils (Upadhyay et al. (2014).

2. Materials and Methods

The experiment was conducted during *kharif* (June–November, 2024) at study area in Dargahan village, Kanker district, Chhattisgarh, India. The study area was situated at latitude 81.3698°E and longitude 22.4896°N. Rice is the primary crop grown in this region.

2.1. Collection of soil samples and preparation

Samples of the surface soil (0–15 cm) were taken from every field in the study area. Using a spade, randomly chosen spots from each field were used to gather soil samples. One sample was created by completely mixing the collected soil from the point. The gathered soil samples were meticulously combined on a polythene sheet and stored securely in packets labeled with the field's specifics for additional planning and examination.

2.2. Preparation of sample for analysis

After the gathered soil samples were allowed to air dry, unwanted elements such as stones, pebbles, leaves, and other organic wastes that had not yet broken down were extracted. Additionally, a wooden hammer was used to smash the air-dried soil samples, and a 2 mm sieve was used to filter the samples. After that, the completed soil samples were labeled appropriately and put in the polythene bags.

The pH was determined by glass electrode method in soil water suspension (1:2.5) Piper (1966) and the salt-bridge conductivity meter for EC analysis Black (1965), the wet oxidation method for estimating organic carbon Walkley and Black (1934). Available nitrogen was estimated by alkaline $KMnO_4$ method, Available phosphorus was extracted by 0.5M $NaHCO_3$ solution buffer at pH 8.5 Olsen et al. (1954) is used for neutral- alkaline soils while the Bray and Kurtz P1 methods Bray (1945) is used for acid soils, the neutral 1N NH_4OAc method for potassium analysis Hanway and Heidal (1952), the $CaCl_2$ extractable method for sulphur analysis Williams and Steinbergs (1969), the DTPA extraction method for accessible Fe, Cu, Mn, and Zn analysis with 0.005 N Di-ethylene Triamine Penta Acetic acid (DTPA), 0.01 M calcium chloride dehydrates and 0.1 M Tri ethanol amine buffered at adjusted pH 7.3 using an atomic absorption spectrophotometer Lindsay and Norvell (1978) and the hot water extraction method through ammonium acetate and EDTA used as buffer masking solution and azomethine-H for boron analysis Berger and Troug (1939).

2.3. The nutrient index values and fertility classes

According Parker et al. (1951), the nutrient index values (NIV) for various soil nutrients were determined from the amount or proportion of samples with low, medium, or high status and classified into different fertility groups. The formula for calculating NIV is

NIV=(1×PL+2×PM+3×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.

3. Results and Discussion

3.1. Soil chemical characteristics

3.1.1. Soil reaction (pH)

The pH of soils of Dargahan village of Kanker district exhibited a pH range of 4.33 to 7.57, with a mean value of 5.56 and a standard deviation of 0.65. Among the 145 soil samples, 1% were categorized as very acidic, 52% as moderately acidic, 38% as slightly acidic, and 9% as neutral. This indicates that 91% soils of the study area show a predominantly acidic pH range. The majority of the study area's soil exhibits moderately to slightly acidic conditions. The study area is characterized by parent materials such as igneous rocks, which contribute to soil acidity through weathering and decomposition by vegetation. Additionally, acidic soil conditions may result from leaching and the loss of basic cations from the soil surface due to high rainfall.

Similar findings were reported by Sahu et al. (2023) in soil of College of Agriculture and Research station Katghora, Korba. They discovered that the pH of the research farm ranged from 4.31 to 5.42, with an average of 4.79±0.25. These results were further supported by Vaisnow et al. (2014), who examined the soil pH status of the Dhamtari Block and also similar reported by Mahla et al. (2014) were pH ranged from 4.5 to 7.2 (mean-5.73).

3.1.2. Soil electrical conductivity (dS m^{-1})

Soil electrical conductivity has a ranged from 0.03 to 0.9 dS m^{-1}, with standard deviation of 0.12 and a mean value of 0.12 dS m^{-1}. Regarding total soluble salt content, all of the majority of soil samples exhibited normal levels. 100% of the samples fell within the low range and were rated as "Good," indicating that no remedial action is necessary in these soils and that all crops in the area are safe.

The results were supported by the research work done previously by Sahu et al. (2023), in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh. He concluded that the EC ranged between 0.04–0.11 d Sm^{-1} with an average of 0.07±0.01 dS m^{-1}. All samples were under good class i.e., <1.0 dS m^{-1}. Similar findings were also reported by the Annepu et al. (2017) in Mid- Himalayan region, Himachal Pradesh with the EC of entire study area remained below 1 dS m^{-1} and similar results by Jena et al. (2021) Soil fertility status of different blocks in Balasore district of coastal Odisha, India were electrical conductivity was found to be less than 1 dS m^{-1}.

3.1.3. Soil organic carbon (g kg^{-1})

Organic carbon content ranged from 3.1 g kg^{-1} to 8.0 g kg^{-1} with an average of 5.27 g kg^{-1} ±0.82 g kg^{-1} Based on the soil test ratings for organic carbon. the soils in the study area fall into all three organic carbon content rating classes. Specifically, out of the 145 samples, 49% were classified as low, 50% as medium, and 1% as high in organic carbon. the overall low to medium organic carbon content in the study area may be attributed to improper nutrient management techniques, inadequate incorporation of crop residues and other bulky organic manures, high temperatures, and intensive cropping practices, all of which accelerate the oxidation of soil organic carbon into the atmosphere.

The results were supported by the research work done previously by Sahu et al. (2023), in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh. who found that soil organic carbon content ranged from were 0.28 to 0.64% with an average of 0.43±0.98%. Similar finding were also reported by Devdas et al. (2021) in Block of Gariyaband district Chhattisgarh. with the soil OC Varied from 0.21–0.76%,

3.2. The available macro-nutrients status

3.2.1. Available nitrogen status in soil

Available nitrogen content in the soils ranged from 100.35 to 263.42 kg ha^{-1}, with an average of 173.88 kg ha^{-1} and a standard deviation of 28.26 kg ha^{-1}. all soils in the study area exhibit low available nitrogen content. It should be noted that the majority of the study area falls under the category of nitrogen deficiency. The primary reason for low nitrogen supply may be due to low organic carbon content. This suggests that to achieve adequate crop production, nitrogen requirements of the crops must be met by applying both organic and inorganic fertilizers. Nitrogen is the most scarce nutrient in black soils, which can be lost through volatilization and leaching.

Similar finding was also reported by several researchers viz. Malo et al. (2023) soil fertility status Using soil nutrient index of Jabalpur block in Jabalpur district, MP, India were Available N ranged from 90 to 320 kg ha^{-1} . These results are in conformity with the findings of Rajeshwar et al. (2009).

3.2.2. Available P status of the soils

3.2.2.1. (Olsen P)

The soils exhibited available phosphorus content ranged from 8.6 to 37.5 kg ha^{-1}. The average value was 22.57 kg ha^{-1}, with a standard deviation of 7.38 c. the study area indicated 7% in low P status, 53% in medium P status, and 40% in high P status. of the examined area showing medium levels and 37% showing high levels. Phosphorus is present in the soil as a solid phase with varying degrees of solubility.

Similar findings were reported by Das et al. (2020) for the soils of Ri Bhoi district of Meghalaya. This is also reported by Singh et al. (2016) available phosphorous content in these soils were varied from 12.9 to 35.9 kg ha^{-1} with a mean value of 26.03 kg ha^{-1}.

3.2.2.2. (Bray P^{-1})

available phosphorus ranged from 20.35 to 67.89 kg ha^{-1}, with an average of 45.44 kg ha^{-1} and a standard deviation of 12.50, it was noted that 79% of soil fell into the medium category and 21% into the low category. The low organic carbon content and the fixation of phosphorus in kaolinite clay minerals and Al and Fe oxides found in the acidic soils of the study area may be the reasons for the poor phosphorus status.

The similar results were reported by Sahu et al. (2023) in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh with P content ranged from 20.51 to 93.32 kg ha^{-1} with a mean value of 224.28 kg ha^{-1}.

3.2.3. Available potassium status in soil

Available K ranged from 107.29 to 547.68 kg ha^{-1}, with an average of 190.53 kg ha^{-1} and a standard deviation of 92.56 kg ha^{-1}. out of the 145 samples, 27% were classified as having low K status, while 63% showed medium K status overall. Additionally, 10% of the samples exhibited high concentrations of K. This distribution is influenced by the presence of minerals with low to medium K crystal lattices, such as micaceous clay and kaolinite.

The results confirmed the finding as reported by several researchers viz. Dadsena et al. (2021) assessed the fertility status of Bamhanidih village, Janjgir-Champa district of Chhattisgarh. They reported that the available K ranges from 202.5–293.7 kg ha^{-1}, with a mean value of 255.3 kg ha^{-1}. Similar results were also reported by Vaisnow et al. (2014) the available K ranges from 23.52–566.04 kg ha^{-1}, with a mean value of 262.11 kg ha^{-1}.

3.2.4. Available sulphur status in soil

Available sulfur content varied from 18.16 to 39.76 kg ha^{-1}, with a mean value of 28.34 kg ha^{-1} and a standard deviation of 5.93 kg ha^{-1}. 25% exhibited low S status, 75% showed medium S status. The study area's S status falls within the low to medium range, possibly due to the soil's limited organic carbon reserves and losses of sulphate ions through leaching and surface runoff in the study area.

These findings were in line with Ramana et al. (2015) in the soils of Sri Ganganagar district of Rajasthan where available S were found to be low in fertility ratings.

3.2.5. Available micro-nutrients status

3.2.5.1. Available iron status in soil

Available Fe content ranged from 5.44 to 42.43 mg kg^{-1} with an average value of 25.24 mg kg^{-1} with standard deviation 8.82 mg kg^{-1}. Out of 145 samples, 100% samples fall under sufficient Fe status. these soils had no major limitation of Fe in crop production and soil sustainability.

Similar results were also reported by Sahu et al. (2023) in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh. And Kingsley et al. (2019) studied the status and distribution of available soil micronutrients along a hillslope of Ekpri Ibami. Results showed that The DTPA extractable iron content in the soils ranged from 69.5 to 109 mg kg^{-1} (mean 92.8 mg kg^{-1}).

3.2.6. Available manganese status in soil

Available Mn concentrations ranged from 2.06 to 21.17 mg kg^{-1}, with a mean value of 9.67 mg kg^{-1} and a standard deviation of 4.51 mg kg^{-1} out of 145 samples, 25% exhibit sufficient Mn status, 64% show high Mn status, and 11% display poor Fe status, study area of Mn ranges from sufficient to excessive.

Similar finding were also reported by Sahu et al. (2023) in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh. Were Available Mn content ranged from 4.10 to 16.95 mg kg^{-1} with an average value of 10.82 mg kg^{-1} and a standard deviation of 2.71 mg kg^{-1}.

3.2.7. Available copper (Cu) status in soil

The available copper content ranges from 0.81 to 2.9 mg kg^{-1}, with an average of 1.64 mg kg^{-1} and a standard deviation of 0.36 mg kg^{-1}. 100% sample showed high Cu status.

Similar finding results by and Sahu et al. (2023) in the soils of College of Agriculture and Research station, Katghora, korba, Chhattisgarh. Were Available Cu content ranged from 0.38 to 3.58 mg kg^{-1} with an average value of 1.82 mg kg^{-1} and a standard deviation of 0.99 mg kg^{-1}. Dadsena et al. (2021).

3.2.8. Available zinc status in soil

Available zinc content ranged from 0.12 to 0.96 mg kg^{-1}, with an average of 0.36 mg kg^{-1} and a standard deviation of 0.19 mg kg^{-1}. The study area is classified as deficient to sufficient in terms of accessible zinc content. It was found that out of 145 samples analyzed, 87% were found to be deficient in Zn and only 19% in sufficient range for available Zn. Zn was related to the important soil characteristics. The Zn deficiency increased with increase in pH and decrease with increase in organic C. Here it can be noted that the dominant portion of the area seems Zn sufficient which might be due to the low soil pH which renders Zn in soil solution and makers it available for crops.

Similar result was reported by Motghare et al. (2019) who evaluate the soil fertility status of soil in Arang block under Raipur district of Chhattisgarh and reported available Zn content ranged from 0.12–1.13 mg kg^{-1} with an average value of 0.33 mg kg^{-1}.

3.2.9. Available boron status in soil

Available boron concentration ranged from 0.14 to 1.77 mg kg^{-1}, with an average of 0.75 mg kg^{-1} and a standard deviation of 0.42 mg kg^{-1}. Study area is classified as deficient to sufficient in available B content. Among the 145 samples analyzed, 34%

Table 1: Overall fertility classes based on the nutrient index value of Dargahan, Kanker

Sl. No.	Soil characteristics	Range	Average	% Sample category			NIV	Fertility class
				Low	Medium	High		
1.	N (kg ha^{-1})	100.35–263.42	173.88	100	0	0	1	Low
2.	Olsen P (kg ha^{-1})	8.6–37.5	22.57	11	52	37	2.26	Medium
	Bray P (kg ha^{-1})	20.35–36.89	45.44	21	79	0	1.79	
3.	K (kg ha^{-1})	107.29–547.68	190.53	27	63	10	1.83	Medium
4.	S (kg ha^{-1})	18.16–39.76	28.34	25	75	0	1.95	Medium
5.	Fe (mg kg^{-1})	5.44–42.43	25.24	0	4	96	2.96	High
6.	Mn (mg kg^{-1})	2.06–21.17	9.67	11	25	64	2.53	High
7.	Cu (mg kg^{-1})	0.81–2.9	1.64	0	0	100	3	High
8.	Zn (mg kg^{-1})	0.12–0.96	0.36	87	13	0	1.13	Low
9.	B (mg kg^{-1})	0.14–1.77	0.75	34	41	25	1.91	Medium

had deficient in B status, 41% had a sufficient B status, and 25% had a high B status. This may be attributed to continuous cereal-cereal cropping without supporting B fertilizers which resulted in mining of from soil reserve.

Similar finding was reported by Mishra et al. (2014) in the Dhenkanal Sadar block of Dhenkanal district, Odisha and found that available Boron status was deficient and Pal et al. (2021) the soil fertility status of Kalahandi, Nayagarh and Boudh district of Odisha were available boron status varied from 0.05–7.62 ppm.

4. Conclusion

The soils of Dargahan village were strongly acidic to neutral in reaction with normal EC and organic carbon in lower categories. As per NIV, Macronutrients levels were low for N, medium for P, K, and S. Micronutrient levels were high for Fe, Mn, and Cu, medium for B, and low for Zn. Lime application is recommended due to soil acidity, and extra nitrogen and sulfur fertilizers should be applied, along with boron and zinc fertilizer for micronutrient deficiencies.

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