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Comprehensive Study on Macronutrient Status and Physicochemical Characteristics of Lateritic Soils of Bankura District, West Bengal, 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 present study's objective was to evaluate the content of macronutrients (N, P, K, S) in relation to some physicochemical properties of lateritic soils of Bankura district of West Bengal, India. Altogether 99 soil surface samples were collected from nine blocks namely Bankura II, Onda, Bisnupur, Barjora, Raipur, Sarenga, Bankura I, Gangajalghati, and Chatna of Bankura district of West Bengal. These soil samples were analyzed for some soil fertility parameters like particle size distribution, pH, EC, organic carbon (OC) and available macronutrients contents using standard methodology. The research area's soils are characterized by sandy clay loam to sandy loam in texture with few samples having loamy sand texture and with soil pH raging from very strongly acidic to neutral. The EC was found to be very low (<1.0 dSm^{-1}) indicating the safe limit for soils

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where OC content was ranging from low to medium. The content of available N, K of soil samples were low to medium while their content in available P was medium to high. The content of available S was deficient, medium and high for 25, 32 and 43 per cent of research area's soils respectively. There was significant positive correlation of soil pH with available K content whereas non-significant with available S content. There was a strong and positive correlation between available N and OC levels. It will help the farmers to obtain balanced fertilizer doses for different crops and soils.

Keywords: Co-relationship; distribution; lateritic soil; macronutrients; soil properties.

1. INTRODUCTION

Soil, as a natural medium for the growth and development of plants, is crucial in influencing an agricultural ecosystem for long-term sustainable production. Soil fertility is the inherent capacity of soil to supply sufficient quantities and proportions of essential plant nutrients for optimum growth and development of specified plants.

Lateritic soils are those in which laterization i.e. the eluviation of silica and enrichment with Fe and Al oxides, is the major soil formation process. Such soils are deeply weathered soils rich in secondary forms of iron (Fe) or aluminium (Al) or both, low in humus, and, depending on their topographic position, may have a clay-rich B horizon. They were formed in situ or from decomposed rock elements washed down to a lower level by rain from granites, gneiss, and other metamorphic rocks.

All lateritic soils are well-drained and porous and typically have a low pH. The soils get more acidic as the elevation increases. The predominant clays in the soil are kaolinite, with traces of illite. The CECs are likewise quite low [2–7 cmol (p+) kg^{-1}] [1]. They are hard or capable of being hard (when subjected to drying after wetting) and turning into a brick-like material that is cut to size and used as bricks for building construction.

Typically, these soils produce less due to various soil-related constraints, including excessive rainfall and leaching, coarse texture, low water retention capacity, low soil pH, deficiency in N, P and K, low OC content.

The deficiencies of macronutrients have become major constraints to the productivity, stability and sustainability of these soils. Traditional practices of fertilization lead towards uneven distribution, adsorption, absorption and uptake of plant nutrients with damage of land resources [2].

Considering these and the paucity of knowledge on various macronutrient statuses in order to determine whether the soils of Bankura district are becoming toxic or lacking in certain macronutrients a comprehensive study was designed to obtain a general picture of different macronutrient statuses and how they relate to physicochemical characteristics in the soils of Bankura, West Bengal, India. It will be helpful to the farmers of Bankura to obtain balanced fertilizer doses for different crops and soils.

2. MATERIALS AND METHODS

2.1 Study Area

The soils of different blocks of district Bankura of West Bengal, India was used for the current investigation. The total geographic area of studied district is 6882 sq. kilometres. It is triangular in shape and lies between 23° 38' N latitude and 86° 36' to 87° 46' E longitude. The studied district is generally lower in fertility because of its lateritic soils and undulating topography. This district shares a border with Midnapore and Hooghly in the east, Purulia in the west, Burdwan in north and Purulia in south. It has a hot and humid climate with a variety of temperatures. Summer is defined by oppressive heat and high humidity, with average daily maximum temperatures ranging from 26°C to 39°C. Winters are typically cold and dry, with average winter temperatures hovering around 15 degrees. In comparison to the western areas, the eastern portions receive more rainfall. The annual average rainfall ranges between 1300 to 1400 mm. The relative humidity is generally high throughout the year. About 78 per cent of annual rainfall mainly occurs during the monsoon month, June to September.

2.2 Soil Sampling

Representative samples were collected at a soil depth of 0-15 cm from the farmer's field in the Bankura district covering nine blocks namely Bankura I, Bankura II, Onda, Bisnupur, Raipur, Sarenga, Gangajalghati, Barjora and Chatna.

Eleven samples were obtained from each selected block. The soil samples were then dried under shade, powdered utilizing a wooden pestle and mortar, then put through a 2 mm sieve and kept for later examination in plastic bags.

2.3 Soil Analysis

Using a digital glass electrode pH meter, soil samples were tested for soil pH in a 1:2.5 soil:water suspension [3]. Electrical conductivity was measured using a conductivity meter by standard method as per Jackson [3]. Organic matter was determined by the Walkley and Black procedure [4]. The texture of the soil was ascertained through hydrometer method [5]. Available nitrogen was estimated by alkaline potassium permanganate method of Subbiah and Asija [6]. Available K was estimated using ammonium acetate–extractable K using a flame photometer. Available phosphorus was extracted with Bray's No. 1 solution as extractant and the amount of P in the extract was estimated by chloro-stannous reduced phosphomolybdate blue colour method using a spectrophotometer at the wavelength of 660 nm as described by Bray and Kurtz [7]. Available sulphur in soil sample is extracted by using $CaCl_2$ solution (0.15 %) as described by Williams and Steinbergs [8]. The concentration of Sulphur in the extractant is determined by the turbidimetric method of Chesnin and Yien [9] in which the turbidity produced because of precipitation of sulphate as barium sulphate is determined through a spectrophotometer at a wavelength of 420 nm using a blue filter. A simple Pearson correlation coefficient study between the macronutrients and physicochemical properties was conducted in the studied soils from the research regions using SPSS 20.0 version.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Soil

The range and average values of the physiochemical soil properties for the different blocks of the studied district are presented in Table 1. Results regarding the particle size distribution of the selected soil samples revealed that these soils have a sandy clay loam to sandy loam texture with few samples having loamy sand texture.

The overall soil pH values of all the blocks ranged from 4.83 to 7.39 with the average of 5.75 which represents very strongly acidic to neutral in soil pH. The lowest soil pH (4.83) was recorded in Sarenga Block's soil whereas its highest value was noted in Bisnupur Block's soil. This could be because of the kind of parent content from which these soils have been derived, soil texture and leaching of the basic cations. Chakravarti and Chakravarti [10] also reported results that were similar.

Normal electrical conductivity was discovered, and the soils in the research area did not exhibit any notable soluble salt build-up.

The OC content in different Blocks of the Bankura District ranged from 0.09 to 1.08% with 0.49% as its average value. The highest value of OC (1.08 per cent) was noted in the Sarenga Block and the lowest (0.09 per cent) in Chatna Block of Bankura district. Out of total samples, 49.49 per cent were low, 36.36 per cent were medium and the remaining 14.14 per cent were high in OC. The proportion of OC in most of the soils was low to medium which may be the result of improper ago-management techniques such monocropping and traditional tilling combined with insufficient application of organic manure. An additional explanation could be linked to the prevalence of high temperature which caused the organic materials to burn quickly, resulting in a low to medium OC content. Similar trend of OC was additionally testified by Deshmukh [11], Pandit et al. [12] and Das et al. [13].

3.2 Status of Available Macronutrients

The range and average values of the macronutrient status for the different blocks of the studied district are presented in Table 1. The available N content in surface soils (0-15 cm) of Bankura extended from 90.72 kg ha^{-1} to 508.55 kg ha^{-1} with 228.62 kg ha^{-1} as its average value. Its lowest content was noted in the Bankura II Block whereas in Sarenga there was its highest content. Its content in analysed soils showed significant differences with locations.

Considering the rating chart (Table 2) for available N (<280 kg ha^{-1} as low, 280 -560 kg ha^{-1} as medium and >560 kg ha^{-1} as high) as proposed by Ramamoorthy and Bajaj [14], the research area's soils had low nitrogen availability in 73.73 percent of cases, and medium nitrogen availability in the remaining 26.27%. The probable cause of the available N's low to medium condition is poor soil management, and scarce application of FYM to the soil. Growing heavy nitrogen feeder crops like cotton, rice, and

Table 1. Physicochemical characteristics in the soils of Bankura district

Block		pH	EC (dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Available S (kg/ha)	Textural Class
Bankura I	Range	5.83-6.27	0.04-0.11	0.10-0.81	103.60-294.82	38.55-102.92	121.00-256.16	3.71-44.14	SL to LS
	Mean	6.06	0.07	0.38	190.17	61.98	193.05	19.39	
Bankura II	Range	5.53-6.06	0.04-0.08	0.23-0.78	90.72-396.78	26.6-85.19	82.36-304.04	1.59-44.15	SCL to SL
	Mean	5.72	0.06	0.48	245.08	51.52	172.01	13.03	
Onda	Range	5.20-6.34	0.03-0.11	0.15-0.69	102.98-388.82	28.25-112.25	104.25-269.51	3.66-21.28	SCL to SL
	Mean	5.55	0.06	0.44	245.69	51.98	171.76	12.67	
Bisnupur	Range	5.81-7.39	0.04-0.12	0.32-0.92	103.07-401.70	31.61-86.36	99.22-375.24	8.72-56.39	SCL
	Mean	6.27	0.08	0.62	249.75	54.87	218.09	28.16	
Raipur	Range	5.18-5.83	0.05-0.28	0.12-0.95	107.33-471.78	31.61-105.38	92.17-277.43	10.64-37.24	SCL to LS
	Mean	5.52	0.11	0.55	247.86	62.11	189.30	23.04	
Sarenga	Range	4.83-6.1	0.04-0.30	0.16-1.08	100.49-508.55	35.78-173.11	111.81-223.68	8.20-33.21	SL to LS
	Mean	5.59	0.11	0.56	269.83	78.64	178.02	21.98	
Gangajalghati	Range	5.67-6.21	0.04-0.14	0.23-0.97	141.85-301.57	23.35-73.67	92.65-211.60	4.24-43.51	SCL to SL
	Mean	5.91	0.08	0.56	210.57	49.18	136.60	14.21	
Barjora	Range	5.03-5.55	0.03-0.12	0.18-0.61	125.72-238.56	20.61-101.11	75.20-174.19	5.64-42.89	SCL to SL
	Mean	5.34	0.07	0.37	191.44	43.99	133.69	19.29	
Chatna	Range	5.48-6.51	0.03-0.17	0.09-0.69	129.93-276.80	20.44-77.29	88.71-408.20	12.93-50.55	SCL to SL
	Mean	5.80	0.07	0.45	207.16	45.98	198.18	26.52	
Overall Range		4.83-7.39	0.03-0.30	0.09-1.08	90.72-508.55	20.44-173.11	75.20-408.20	1.59-56.39	
Overall mean		5.75	0.08	0.49	228.62	55.58	176.74	19.81	

Table 2. Rating limits for soil test values used in India (Ramamoorthy and Bajaj [14])

Nutrient	Rating of the soil test values		
	Low	Medium	High
Organic carbon (%)	< 0.50	0.50-0.75	> 0.75
Available N (kg/ha)	< 280.0	280.0-560.0	> 560.0
Available P_2O_5 (kg/ha)	< 22.4	22.4-56.0	> 56.0
Available K_2O (kg/ha)	< 135.0	135.0-335.0	> 335.0
Available S (kg/ha)	< 10.0	10.0-20.0	> 20.0

maize with limited addition of nitrogen through organics like FYM could be a factor which has accountability for poor nitrogen availability in the studied area. An additional explanation could be linked to the prevalence of tropical climatic conditions which were responsible for the rapid decomposition of organic matter which may cause low to medium content of available N in these soils. Similar findings were also reported by Das et al. [13].

The content of available P_2O_5 in the soils of different Blocks of the Bankura District ranged from 20.44 kg ha^{-1} to 173.11 kg ha^{-1} (Table 1). Among the different Blocks, the highest (173.11 kg ha^{-1}) available P_2O_5 content was documented in Sarenga Block and the lowest (20.44 kg ha^{-1}) was observed in Chatna Block. Considering the rating chart (Table 2) out of 99 samples, 3 per cent soils were deficient, 57 per cent were medium and the remaining 40 per cent were high in available phosphorus status. These soils' low available P status could be caused by the fixation of released phosphorus with oxides of iron and aluminium and clay minerals [13]. High available phosphorus status perhaps ascribed to the indiscriminate use of high analysis fertilizers especially DAP to the soils without knowing crop requirements. Comparable outcomes were also reported by Deshmukh [11], Pandit et al. [12] and Das et al. [13].

The status of available K in the soils Bankura District ranged from 75.20 to 408.20 kg ha^{-1} with 176.74 kg ha^{-1} as the average value (Table 1). Among studied blocks, the highest (218.09 kg ha^{-1}) mean available K was noted in Bisnupur Block and the lowest (133.69 kg ha^{-1}) was detected in Barjora Block.

Considering the rating chart (Table 2) it was noted that 28.28 per cent of studied soil samples were low, 68.68 per cent were medium and the remaining 6.6 per cent were high in available K status. The existence of low available K in the soils could be caused due to slow weathering of mica and fixation of released K. The low amounts of available K can result from the rare application of potassium fertilizers during cultivation and application of K through compound fertilizers [15]. High available K status possibly because of the release of labile K from organic residue, applied K fertilizers, intense weathering and potassium's upward translocation along with upward rise of capillary water.

The content of available S in soils of different Blocks of the Bankura varied between 1.59 and 56.39 6 kg ha^{-1} with 19.81 kg ha^{-1} as its average content. The lowest value of available S was noted in Bankura II Block and that of its highest value in Bisnupur Block. Considering the rating chart (Table 2) the data further revealed that 25 % of soils were low, 32 per cent were medium and the remaining 43 per cent showed high available S.

The estimated available S showed significant differences with locations which ranges from low to high in the district. The sulphur availability largely depends on the parent material, texture, moisture regime, type and level of management and amount of OC present in soil.

Table 3. Correlation between Macronutrients and soil physicochemical properties in soils of Bankura district

	pH	EC	OC	Available N	Available P_2O_5	Available K_2O	Available S
pH	1.000						
EC	-0.129	1.000					
OC	0.131	-0.040	1.000				
Available N	0.043	-0.057	0.846**	1.000			
Available P_2O_5	-0.049	0.167	0.035	-0.130	1.000		
Available K_20	0.263**	0.081	0.050	0.025	0.072	1.000	
Available S	0.066	0.001	0.132	0.034	0.143	0.376**	1.000

*** Significant at 1% level of significance*

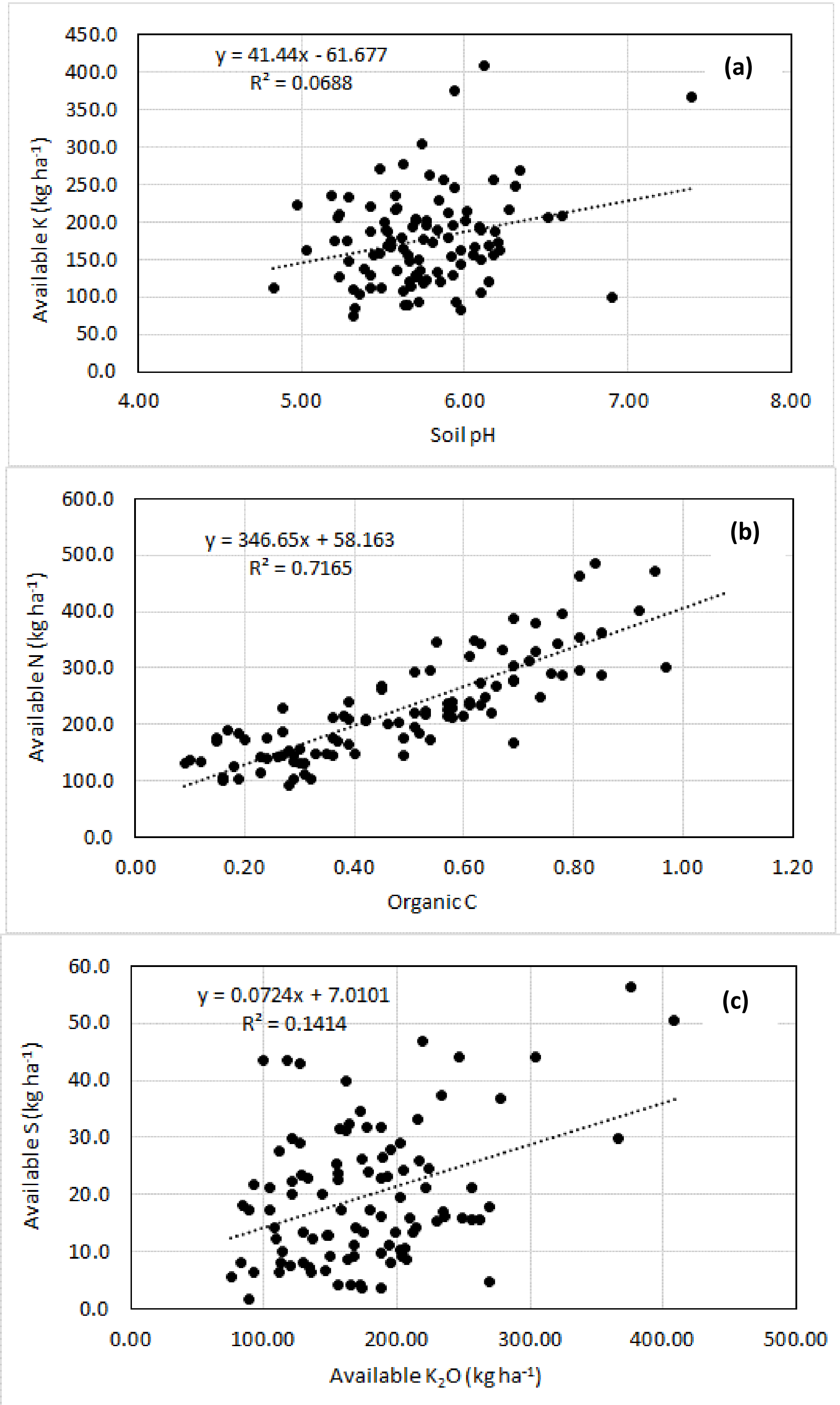

Fig. 1. Correlation between soil pH and available K (a); organic C and available N (b); and available K_2O and available S (c) content of soils of Bankura district of West Bengal, India

3.4 Correlation between Macronutrients and Physicochemical Properties in Soils of Bankura District

Between available N and OC, a strong positive correlation (r = 0.846**) was discovered (Table 3, Fig. 1). The results indicate that the rise in OC would also lead to an increase in soils' available N status. A similar relationship was also reported by Singh and Mishra [16]; Sachan and Deeksha [17]. In Ujjain Tehsil of Ujjain District of Madhya Pradesh, India, a substantial positive association was discovered between OC and available N by Gehlot et al. [18].

Available potassium and pH of soil had a positive, significant correlation (r= 0.263**). These results agree with the findings of Athokpam et al. [19] and Hossain [20]. A similar significant and positive correlation between pH and available K (r=0.557**) was also obtained by Paudel et al. [21]. These results agree with the findings of Manasa et al. [22].

Available sulphur and available K_2O had a highly significant and positive correlation (r=0.376**). The outcomes agreed with the conclusions drawn by Rajkonwar et al. [23]. The available S would climb together with the rise in OC content, as per the non-significant positive connection between the two variables.

4. CONCLUSION

It can be resolved that soils of nine blocks (Bankura I, Bankura II, Onda, Bisnupur, Raipur, Sarenga, Gangajalghati, Barjora and Chatna) of Bankura of West Bengal, India is characterized by soil pH of strongly acidic to neutral, having EC values less than 1.0 dSm^{-1}. The content of OC was categorized under low to medium group. The available N and K content were low to medium while available P_2O_5 content was ranged between medium and high. The available S was deficient, medium and high for 25, 32 and 43 % of analyzed soils. According to the correlation analysis, soil pH had a non-significantly positive link with available sulphur content but a significant, positive correlation with available K. There was a strong and favourable correlation between available N and OC. The information will be helpful to the farmers of Bankura District to obtain balanced fertilizer doses prescribed for different crops and soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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