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Fertility Status of Some Lateritic Soils of Birbhum District with Special Reference to Nitrogen, Phosphorus, Potassium and Sulphur

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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

A laboratory experiment was conducted to study soil fertility status of some selected soils of Birbhum district of West Bengal with one hundred soil samples collected from five blocks *viz.,* Mayureswar, Nalhati-1, Bolpur, Md Bazar and Rajnagar. The soils of this zone are characterized by sandy loam to sandy clay loam in texture and strong to moderately acidic in reaction. Total soluble salt content (EC as dSm^{-1}) was found to be under very low level (<1.0) indicating the safe limit for soils, where low to medium organic carbon contents, low to medium in available N, P and K content, while available Sulphur content of all the soil samples was low.

Keywords: Available sulphur; EC; organic carbon; lateritic soil.

1. INTRODUCTION

Macronutrients and micronutrients are important soil elements that control their fertility. Soil characterization about the evaluation of the fertility status of the soil of an area or region is an important aspect in the context of sustainable agricultural production [1]. Because of

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imbalanced and inadequate fertilizers use coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizers (nutrients) declined tremendously under intensive cultivation in recent years [2]. Indian soils are generally poor in fertility, as these have consistently been depleted of their finite nutrient resources due to continuous cultivation for many centuries without proper replacement of nutrients. Soil-test summaries indicate that 98 per cent Indian soils have low to medium available P and 60 per cent soil are low to medium in K status, whereas N continues to be universally deficient [3]. In last one and half decades, a phenomenal increase in S deficiency has been witnessed under intensive cropping system where high-analysis fertilizers devoid of S are used Red and Lateritic soils represent 70 million ha of the land area in India and 27% geographical area of West Bengal [4]. Soils are coarse in texture, highly drained with honeycomb type of ferruginous concretion at a depth of 15 to 30 cm, erosion-prone and acidic (pH 5.5 to 6.2). These soils are usually less productive due to various soil-related constraints, including coarse texture, low water holding capacity, acidity, poor availability of N, P and K, low organic C status, both excessive and inadequate levels of several secondary and trace elements [5].

Given this, it may be worthwhile to evaluate the fertility status of some lateritic soils covering selected Moujas under Birbhum district of West Bengal with special reference of N, P, K and S.

2. MATERIALS AND METHODS

Surface soil from different Mouzas of five different blocks namely Mayureswar, Nalhati-1, Bolpur, Md Bazar and Rajnagar of Birbhum district, were sampled randomly to a depth of 0-15 cm in V shape with the help of Khurpi. Each soil sample was mixed thoroughly and about a half kilogram of the composite sample. The soil samples were dried under shade, powdered using wooden pestle and mortar and passed through 2 mm sieve and preserved in polythene bags for further analysis. For organic carbon analysis, the 2 mm sieved samples were subjected to further grinding and passed through 0.2 mm sieve [6]. Particle size analysis was carried out by Hydrometer method using sodium hexametaphosphate as a dispersing agent as described by Bouyoucos [7]. The pH, EC and organic carbon were determined as per the standard methods. Available nitrogen was estimated by alkaline $KMnO_4$ method where Available phosphorus was extracted with Bray No 1 solution as extractant [8] and the amount of P in the extract was estimated by chlorostannous reduced phosphomolybdate blue colour method using a spectrophotometer at the wavelength of 660 nm. Available sulphur content in soil was determined by turbidity method using 0.15% $CaCl_2$ extractant on a colourimeter using blue filter or spectrophotometer at 440 nm [9].

3. RESULTS AND DISCUSSION

Results about the particle size distribution of the selected soil samples (Tables 1-5) observed that these soils have a sandy loam to sandy clay loam texture with few samples having clay loam texture. The sand was the dominant fraction in these soils, which might be due to high rainfall and the parent material from which the soil was derived. The results of the study conformed with the findings of Sathyanarayana and Biswas (1970) who reported that soils developed from granite type of parent material had a coarse texture [10]. Similar results were also found in soils of Chamarajanagar district, Karnataka by Kumar [11].

The pH of the surface (0-15 cm) soils under present investigation in Mayureswar, Nalhati-1, Bolpur, Md Bazaar and Rajnagar blocks (Tables1-5) ranged from 4.85 to 6.01, 5.19 to 7.04, 4.24 to 6.20, 4.02 to 6.18 and 5.10 to 6.83, respectively. These values showed extremely acidic to neutral, but most of the soils are moderately acidic (53%) to strongly acidic (36%) in nature. Similar results were also found in soils of Pamgarh block of Janjgir-Champa district by Shukla [12]. All the soil samples were found to be normal (EC < 1.0 dSm^{-1}) concerning plant growth. The normal EC may be ascribed to leaching of soluble salts to lower horizons. Average organic carbon content under study area of Birbhum district was in the range of 0.18 to 0.81% with a mean value of 0.60%. The highest organic carbon content was obtained in soils of Purba Ramchandrapur Mouza of Mayureswar block (Table 1) whereas, the lowest value was recorded in soils of Jaljaliya Mouza of Bolpur block (Table 3), it may due to high sand content in soils of this block, it is in agreement with findings of Singh et al. [13].

N content in soils of Mayureswar, Nalhati-1, Bolpur, Md Bazaar and Rajnagar blocks of Birbhum district ranged from 279.31-397.95 kg ha^{-1}, 262.59-398.91 kg ha^{-1}, 220.77-399.96 kg ha^{-1}, 128.79-332.83 kg ha^{-1} and 145.51-295.64 kg ha^{-1} with the mean values 356.58 kg ha^{-1},

Table 1. Physico-chemical characteristics of the soils of Mayureswar block of Birbhum district of West Bengal

Mouza name	Sample no.	pH	EC (dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Textural class
Talwan	S_1	4.86	0.02	0.54	319.94	33.20	110.60	21.81	SCL
	S_2	5.74	0.03	0.81	396.39	38.70	139.25	14.36	SCL
	S_3	5.71	0.02	0.72	371.30	33.67	129.46	10.11	SCL
	S_4	5.15	0.04	0.62	348.01	32.18	124.60	10.64	SCL
Purba	S_5	4.85	0.02	0.54	346.21	32.38	106.41	7.98	SCL
Ramchandrapur	S_6	5.63	0.02	0.73	379.67	31.50	128.08	12.77	SCL
	S_7	5.94	0.04	0.81	397.95	37.80	147.71	16.49	SCL
	S_8	5.80	0.03	0.73	393.26	33.31	130.52	12.77	SCL
Samachar	S_9	5.62	0.03	0.72	279.31	30.30	130.12	10.64	SCL
	S_{10}	5.65	0.03	0.64	346.21	30.42	124.19	11.17	SCL
	S_{11}	6.01	0.03	0.78	396.39	34.06	139.79	17.02	SCL
	S_{12}	5.60	0.03	0.62	354.58	32.08	103.62	12.77	SCL
Pashimgamini	S_{13}	5.61	0.04	0.66	341.86	32.40	111.78	8.51	SCL
	S_{14}	5.71	0.03	0.62	345.49	32.78	107.39	10.11	SCL
	S_{15}	5.74	0.03	0.63	362.94	29.60	111.28	11.70	SCL
	S_{16}	5.73	0.05	0.80	396.39	29.31	137.12	14.36	SCL
Bahina	S_{17}	5.68	0.02	0.63	354.58	31.03	116.21	11.17	SCL
	S_{18}	4.92	0.02	0.53	321.13	25.67	109.13	9.04	SCL
	S_{19}	5.63	0.02	0.72	371.30	22.65	122.88	11.70	SCL
	S_{20}	5.66	0.03	0.55	344.67	23.25	117.09	14.36	SL
	SEm(±)	0.06	0.01	0.01	14.15	0.28	1.08	0.31	
	CD (5%)	0.16	0.01	0.02	40.45	0.79	3.10	0.88	
	Minimum	4.85	0.02	0.53	279.31	22.65	103.62	7.98	
	Maximum	6.01	0.05	0.81	397.95	38.70	147.71	21.81	
	Average	5.55	0.03	0.67	356.58	31.26	122.66	12.70	

SCL=Sandy clay loam, SL=Sandy loam

Table 2. Physico-chemical characteristics of the soils of Nalhati-1 block of Birbhum district of West Bengal

Mouza name	Sample no.	pH	EC(dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Textural class
Paikpara	S_1	6.35	0.02	0.54	371.30	30.22	223.37	19.15	SCL
	S_2	6.71	0.07	0.75	396.39	29.90	287.12	22.32	SCL
	S_3	6.54	0.02	0.74	388.03	29.34	283.99	21.28	SCL
	S_4	6.37	0.01	0.68	346.21	29.11	260.24	22.12	SCL
Barsor	S_5	6.07	0.04	0.62	321.13	25.07	253.73	19.11	SCL
	S_6	6.21	0.02	0.56	316.45	24.40	260.42	19.68	SCL
	S_7	5.77	0.02	0.42	291.50	27.13	213.96	17.02	SCL
	S_8	5.42	0.03	0.58	296.04	27.27	225.33	17.56	SCL
Govindpur	S_9	5.19	0.05	0.45	262.59	23.18	230.59	17.02	SL
	S_{10}	5.84	0.05	0.55	262.59	22.85	253.73	17.56	SL
	S_{11}	6.24	0.02	0.54	296.04	27.14	240.86	18.62	SL
	S_{12}	6.06	0.02	0.63	321.13	21.72	261.27	21.28	SCL
Kushipur	S_{13}	6.54	0.02	0.68	324.99	22.90	235.47	21.68	SL
	S_{14}	6.04	0.01	0.60	311.38	22.98	253.52	18.09	SL
	S_{15}	6.35	0.04	0.65	321.13	28.07	261.14	20.75	SCL
	S_{16}	5.64	0.02	0.69	337.96	25.05	268.13	20.75	SL
Gopgram	S_{17}	6.06	0.03	0.74	344.18	28.05	238.65	20.75	SCL
	S_{18}	7.04	0.01	0.75	398.91	28.14	266.52	21.28	SCL
	S_{19}	6.68	0.02	0.74	396.39	30.97	275.23	21.28	SCL
	S_{20}	5.85	0.02	0.55	262.59	25.12	270.13	17.56	SCL
	SEm(±)	0.05	0.01	0.01	16.07	0.22	1.73	0.33	
	CD (5%)	0.14	0.01	0.02	45.94	0.62	4.94	0.94	
	Minimum	5.19	0.01	0.42	262.59	21.72	213.96	17.02	
	Maximum	7.04	0.07	0.75	398.91	30.97	287.12	22.32	
	Average	6.15	0.03	0.63	328.56	26.42	254.32	19.74	

SCL=Sandy clay loam, SL=Sandy loam

Table 3. Physico-chemical characteristics of the soils of Bolpur block of Birbhum district of West Bengal

Mouza Name	Sample No.	pH	EC (dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Textural class
Bidyadharpur	S_1	4.70	0.02	0.42	292.71	19.67	154.32	19.15	SCL
	S_2	4.99	0.02	0.32	321.13	21.99	188.34	17.56	SCL
	S_3	5.28	0.02	0.55	346.21	22.56	127.27	10.64	SCL
	S_4	5.42	0.02	0.44	342.88	21.03	119.19	10.57	SCL
Keshabpur	S_5	5.32	0.02	0.34	314.52	20.56	189.30	19.47	SCL
	S_6	5.57	0.02	0.41	371.30	25.51	121.54	17.56	SCL
	S_7	5.49	0.06	0.57	364.60	23.85	181.94	19.25	SCL
	S_8	5.72	0.05	0.64	371.30	27.37	106.81	21.00	SCL
Dukshin	S_9	5.65	0.07	0.60	364.54	27.10	118.33	20.75	SL
Gopinathpur	S_{10}	5.89	0.01	0.71	394.45	28.44	121.33	21.28	SL
	S_{11}	5.74	0.02	0.34	376.41	26.55	130.29	21.38	SL
	S_{12}	6.20	0.04	0.59	399.96	29.26	123.08	22.34	SCL
Jaljaliya	S_{13}	4.92	0.04	0.44	270.95	19.12	97.10	19.25	SL
	S_{14}	4.24	0.04	0.48	262.59	20.03	117.98	16.39	SL
	S_{15}	4.28	0.03	0.18	220.77	16.77	97.94	15.00	SCL
	S_{16}	4.28	0.02	0.18	229.14	18.37	95.60	19.59	SL
Adityapur	S_{17}	4.29	0.03	0.54	262.59	18.72	110.13	13.21	SCL
	S_{18}	4.60	0.02	0.48	229.14	18.09	113.74	16.77	SCL
	S_{19}	4.80	0.05	0.51	270.95	16.06	108.03	15.02	SCL
	S_{20}	4.92	0.03	0.45	259.29	18.79	95.26	12.68	SCL
	SEm(±)	0.03	0.01	0.01	22.34	0.34	0.52	0.38	
	CD (5%)	0.08	0.02	0.02	63.85	0.97	1.49	1.09	
	Minimum	4.24	0.01	0.18	220.77	16.06	95.26	10.57	
	Maximum	6.20	0.07	0.71	399.96	29.26	189.30	22.34	
	Average	5.13	0.03	0.46	313.01	22.05	127.37	17.35	

SCL=Sandy clay loam, SL=Sandy loam

Table 4. Physico-chemical characteristics of the soils of Md Bazar block of Birbhum district of West Bengal

Mouza name	Sample No.	pH	EC (dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Textural class
Fullaipur	S_1	4.79	0.02	0.73	296.04	19.04	124.84	14.36	SCL
	S_2	4.83	0.02	0.54	229.14	15.92	107.63	19.47	SCL
	S_3	6.18	0.04	0.75	332.83	21.28	136.09	22.34	SCL
	S_4	4.74	0.01	0.61	237.50	16.74	108.43	21.28	SCL
Kasthatari	S_5	4.69	0.05	0.61	262.52	15.48	125.19	21.81	SCL
	S_6	4.80	0.02	0.61	270.95	17.39	115.74	21.28	SCL
	S_7	4.52	0.02	0.51	170.60	14.30	118.12	14.58	SCL
	S_8	4.77	0.06	0.64	229.14	12.84	115.93	19.68	SCL
Tanshuli	S_9	4.74	0.05	0.66	262.59	14.64	118.57	18.62	SCL
	S_{10}	4.76	0.04	0.73	292.75	11.25	129.36	19.77	SCL
	S_{11}	4.70	0.01	0.68	287.68	11.63	120.46	15.43	SCL
	S_{12}	6.14	0.02	0.73	321.13	22.27	132.66	22.34	SCL
Khayarakuri	S_{13}	4.02	0.02	0.41	128.79	11.04	100.42	13.30	SL
	S_{14}	4.73	0.01	0.68	195.69	14.76	118.96	18.73	SL
	S_{15}	4.87	0.02	0.72	292.70	20.93	102.38	21.13	SCL
	S_{16}	4.78	0.02	0.69	262.59	15.95	105.01	19.34	SCL
Maladanga	S_{17}	5.94	0.02	0.72	296.01	20.08	129.87	17.79	SCL
	S_{18}	5.02	0.03	0.72	296.00	16.92	109.50	20.72	SCL
	S_{19}	5.06	0.02	0.63	245.86	16.27	109.00	18.64	SCL
	S_{20}	5.56	0.04	0.66	270.95	15.50	113.36	21.39	SCL
	SEm(±)	0.02	0.01	0.01	19.86	0.27	1.22	0.43	
	CD (5%)	0.05	0.02	0.02	56.78	0.77	3.50	1.24	
	Minimum	4.02	0.01	0.41	128.79	11.04	100.42	13.30	
	Maximum	6.18	0.06	0.75	332.83	22.27	136.09	22.34	
	Average	4.99	0.03	0.64	256.50	16.25	117.18	18.99	

Table 5. Physico-chemical characteristics of the soils of Rajnagar block of Birbhum district of West Bengal

Mouza name	Sample no.	pH	EC (dSm^{-1})	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Textural class
Jhikra	S_1	5.23	0.05	0.50	195.69	20.82	240.34	12.41	SCL
	S_2	5.79	0.07	0.74	237.50	21.81	178.80	16.32	SCL
	S_3	5.72	0.02	0.69	245.86	13.20	179.96	15.43	SCL
	S_4	5.30	0.02	0.75	294.64	19.94	171.90	21.79	SCL
Kastogara	S_5	5.14	0.07	0.43	145.51	11.55	140.31	10.30	SCL
	S_6	5.73	0.05	0.60	195.69	13.61	179.69	15.96	SCL
	S_7	5.66	0.03	0.66	170.60	13.08	180.36	15.19	SCL
	S_8	5.68	0.05	0.56	229.14	23.44	154.70	14.15	SCL
Ganeshpur	S_9	6.83	0.02	0.75	295.64	22.01	246.62	21.38	SCL
	S_{10}	5.10	0.09	0.50	145.51	10.61	248.76	10.64	SCL
	S_{11}	5.56	0.01	0.63	204.05	14.46	220.83	21.92	SCL
	S_{12}	5.36	0.04	0.74	220.77	14.92	228.38	19.31	SCL
Laujore	S_{13}	5.73	0.02	0.63	187.32	13.08	218.75	18.62	SCL
	S_{14}	5.78	0.05	0.63	170.60	12.28	182.38	15.43	SCL
	S_{15}	5.75	0.06	0.63	212.41	14.55	179.69	19.67	SCL
	S_{16}	6.16	0.06	0.73	262.59	17.96	241.96	19.14	SCL
Padampur	S_{17}	5.82	0.08	0.75	267.94	17.54	160.41	15.02	SCL
	S_{18}	5.77	0.03	0.57	245.86	16.68	210.60	19.88	SCL
	S_{19}	5.86	0.08	0.72	245.86	16.16	219.76	20.06	SCL
	S_{20}	5.77	0.02	0.54	195.69	17.15	150.35	15.69	SL
	SEm(±)	0.05	0.01	0.01	16.78	0.22	1.39	0.50	
	CD (5%)	0.15	0.02	0.02	47.95	0.64	3.97	1.44	
	Minimum	5.10	0.01	0.43	145.51	10.61	140.31	10.30	
	Maximum	6.83	0.09	0.75	295.64	23.44	248.76	21.92	
	Average	5.71	0.04	0.63	218.64	16.31	196.12	16.81	

328.56 kg ha^{-1}, 313.01 kg ha^{-1}, 256.50 kg ha^{-1} and 218.64 kg ha^{-1}, respectively.

All the soils of Mayureswar block (Table 1) were under the medium category in available N content. 85% soils of Nalhati-1 block (Table 2) were under medium category with rest 15% under low category concerning the available N content. In Bolpur block available N content was low (40%) to medium (60%). However, in Md Bazaar 60% of samples were under low category and rest 40% were under medium in available N content. In Rajnagar block 90% soils were found to be under low category and remaining 10% soils under the medium category of available nitrogen content in the soil. Highest N content was observed in soils of Dukshin Gopinathpur Mouza of Bolpur block (399.96 kg ha^{-1}), whereas the lowest value was observed in Khayarakuri Mouza of Md. Bazar block (128.79 kg ha^{-1}). It is quite obvious that efficiency of applied N is very low because N is lost through various mechanisms, like NH_3 volatilization, denitrification, chemical and microbial N-fixation, leaching and runoff [14].

The overall available P of the study area ranged from average 16.41 to 28.92 kg ha^{-1} with a mean value of 22.45 kg ha^{-1}. Available P status of five blocks *viz*., Mayureswar, Nalhati-1, Bolpur, Md Bazaar and Rajnagar varied from 22.65 to 38.70 kg ha^{-1}, 21.72 to 30.97 kg ha^{-1}, 16.06 to 29.26 kg ha^{-1}, 11.04 to 22.27 kg ha^{-1} and 10.61 to 23.44 kg ha^{-1} with mean values 31.26 kg ha^{-1}, 26.42 kg ha^{-1}, 22.05 kg ha^{-1}, 16.25 kg ha^{-1} and 16.31 kg ha^{-1}, respectively in soils of Birbhum district. 85% soils of Mayureswar block was under the low category in available P content with 15% falling under medium category and all the soil samples of the remaining four blocks were under the low category. The lowest value of available phosphorus content was observed in soils of Ganeshpur mouza of Rajnagar block (10.61 kg ha^{-1}) and the highest value (38.70 kg ha^{-1}) was observed in soils of Talwan mouza of Mayureswar block. Available phosphorus content of soils is mostly affected by past fertilization, pH, organic matter content, texture various soil management and agronomic practices [15].

The available K content in soils under the study area ranged from 130.71 to 201.79 kg ha^{-1} with an average value of 163.53 kg ha^{-1}. The values ranged from 103.62 to 147.71 kg ha^{-1}, 213.96 to 287.12, 95.26 to 189.30 kg ha^{-1}, 100.42 to 136.09 kg ha^{-1} and 140.31 to 248.76 kg ha^{-1} with average values 122.66, 254.32, 127.37, 117.18 and 196.12 kg ha^{-1}, respectively in blocks of Mayureswar, Nalhati, Bolpur, Md Bazar and Rajnagar respectively of Birbhum district.

The available K content of the soils of Mayureswar and Bolpur blocks were low (35%) to medium (75%). 85% soils of Nalhati-1 block was under medium category and the remaining 15% samples were under high category concerning available K content in the soil. In Md Bazaar block (Table 4) available K content was low (40%) to medium (60%). All the soils of Rajnagar block (Table 5) were medium in available potassium. The highest mean value (254.32 kg ha^{-1}) of available K was recorded in Nalhati-1 block and lowest (117.18 kg ha^{-1}) in Md. Bazar block of Birbhum district. These results confirmed the finding as reported by Shukla (2011) in the Alfisols orders of Pamgarh block in Janjgir-Champa district (C.G.) [16].

The available S content in study area soil varied from 7.98 to 21.81 kg ha^{-1}, 17.02 to 22.32 kg ha^{-1}, 10.57 to 22.34 kg ha^{-1}, 13.30 to 22.34 kg ha^{-1} and 10.30 to 21.92 kg ha^{-1} with mean values 12.70 kg ha^{-1}, 19.74 kg ha^{-1}, 17.35 kg ha^{-1}, 18.99 kg ha^{-1} and 16.81 kg ha^{-1} in the blocks of Mayureswar, Nalhati-1, Bolpur, Md Bazar and Rajnagar blocks, respectively. The lowest value (7.98 kg ha^{-1}) of available S content was observed in the soils of Purba Ramchandrapur mouza of Mayureswar block and the highest value (22.34 kg ha^{-1}) was recorded in soils of Dukshin Gopinathpur mouza of Bolpur block and Fullaipur and Tanshuli mouza of Md Bazaar block. The results showed that the available sulphur content was low in soils of study area of Birbhum district. A similar result was also reported by Ghosh et al. [17].

4. SUMMARY AND CONCLUSION

It can be concluded from the results under study that the lateritic soils of five blocks *viz*., Mayureswar, Nalahti-1, Bolpur, Md Bazar and Rajnagar of Birbhum district of West Bengal was characterized under acidic in soil reaction having EC values less than 1 dS m^{-1} which comes under safe limit for all growing crops. The organic carbon level was low to medium. The soils of the area were low to medium in available N and P content was under medium in 97% of soils and remaining 3% was found to be under low category. Available K status of the whole soil samples was low to medium and available sulphur content in all the soil samples was found to be low. Hence, the soils of the study area

need proper attention for balanced fertilization so that optimum level of crop production can be achieved. The soils of the study area need regular monitoring of soil health for better crop production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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