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Availability of Macronutrients & Sulphur and their Relationship with Physico-chemical Properties in Lateritic Soils of Birbhum District, West Bengal

Mamta Sahu, Mohammed Nisab C. P and Suchhanda Mondal*

Dept. of Soil Science and Agricultural Chemistry, Palli Siksha Bhavana, Visva-Bharati, West Bengal (731 236), India

Corresponding Author

Suchhanda Mondal
e-mail: suchhandamondal@rediffmail.com

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Abstract

The present study was undertaken during 2017–18 at Palli Siksha Bhavana, Visva-Bharati, West Bengal, India to characterize the lateritic soils of Birbhum district, West Bengal, India to investigate the status of macronutrients and sulphur and its relationship with soil physico-chemical properties. Altogether 100 soil samples were collected from different mouzas of five different blocks (Mayureswar, Nalhati-1, Bolpur, Md Bazar and Rajnagar) of Birbhum district of West Bengal, India. Results of the study indicated that soils of different blocks of Birbhum district were sandy loam to sandy clay loam in texture with moderately to strong acidic in reaction.Electrical conductivity was within normal limits. Soils showed deficiency in organic carbon (OC) content. Most of the soil showed low to medium in available N content. Available K content showed medium category whereas soils under study was poor in available P and available sulphur. The pH of the collected soil samples showed significant and Positive correlation with available N (r= 0.48**), available P (r=0.473**), available K (r=0.643**) and available S (r=0.265**). Soil organic carbon showed significant and positive correlation with available N (r=0.326**) and available P (r=0.236**) whereas non-significant and positive correlation with available K and S. Significant and negative correlation was found between electrical conductivity and available N (r= -0.211**). Sand content showed negative correlation with all the macronutrients. Significant and positive correlation showed silt content with available P (r= 0.45**) and available K (r=0.468**). Clay content showed positive and significant correlation with available K (r=0.678**) while non-significant correlation with available sulphur.

Keywords: Lateritic soil, available sulphur, organic carbon, correlation

1. Introduction

Soil is the chief component of the environment and is considered the most valuable asset for providing the essential nutrients required for the growth and development of plants. Along with food production, it's critically important for the quality of the environment (Doran and Parkin, 1994).As the soil quality changes through any natural or artificial ways lead to the degradation of the agro-ecosystem (Mandal et al., 2020). Infelicitous use of chemical fertilizers and insufficient applications of organic matter caused severe fertility deterioration in our soils leading to the diminishing of soil health and crop productivity (Baruah et al., 2013). For this reason, the soil quality evaluation getting paramount importance for the conservation of our valuable resource. Primary macronutrients, i.e. nitrogen, phosphorus, and potassium play a vital role in enhancing the production and the quality of the produce. These nutrients are the building block of all proteins, including the enzymes, which control the biological processes. They have a crucial role in achieving the food sufficiency of India.Among the nutrients, nitrogen (N) is the fundamental nutrient that needs the most for crop production and its one of the key elements for the plants (White and Brown, 2010). Next to N, Phosphorus (P) plays an important role in plant development and productivity, as it is involved in cell division, enzyme activity, membrane structure maintenance, and the synthesis of high-energy molecules. (Malhotra et al., 2018). Potassium (K) is an essential plant macronutrient that is involved in a variety of physiological activities that are critical for plant nutrient and water uptake, nutrient transport, and growth, particularly in adverse situations. (Jiang et al., 2018). Potassium has many functions in plant nutrition and growth that influence both the yield and quality of the crop (Kow and Nabwami, 2015). Along with macronutrients sulphur also got great importance as it has a role in the synthesis of proteins, oils, vitamins and flavoured compounds in plants (Sakal et al., 1997). It's called as the fourth most important plant nutrient (Rathore et al., 2015). It is a constituent of three amino acids viz. meth(21% S), cysteine (26% S) and cystine (27% S), which are the building blocks of protein. Most of the plant sulphur is present in these amino

acids (Tandon and Messick, 2002) Sulphur deficiencies in India are widespread as the nutrient management strategy is limited to Nitrogen (N), phosphorus (P) and Potassium (K) (Tandon, 1991). Aside from that, sulphur deficiency developed as a result of increasing sulphur removal due to high production rates (Tandon, 2011).Soils of Bhirbhum districts are deficient in sulphur (Patra et al., 2012). The variation of available S status in soils of different series was due to variation in different soil properties, soil and crop management practice and fertilizer use (Hembram et al., 2012).The availability of nutrients in soil is influenced by the rhizosphere's pH, organic matter, adsorptive surfaces, and other physical, chemical, and biological factors (Jiang et al., 2009). Availability of primary nutrients at low pH, while for secondary nutrients requires high pH. Thus balance of such problem is possible only through proper management of soil pH (Dinesh Khadka et al., 2016). Soil characterization in relation to evaluating the fertility status of a region's soils is a crucial aspect of long-term agricultural production. Soil testing is essential for maintaining soil fertility since it offers the most reliable information on the availability of various plant nutrients.A systematic study has to be conducted to understand the status of macronutrients and sulphur and their relationship with physico-chemical properties in order to do the proper management strategies.

2. Materials and Methods

2.1. Details of study Area

The experiments were carried out at PalliSikshaBhavana, Visva–Bharati, West Bengal, India to characterize the lateritic soils of Birbhum district, West Bengal during 2017–18. The study area is situated in Birbhum district, West Bengal; India. The district is situated between 23° 32' 30'' and 24° 35' 0'' north latitude and 88° 1' 40'' and 87° 5' 25'' east longitude. Comprise of 5.12% of the total area of state. During summer, the temperature can shoot well above 40°C (104°F) and in winters it can drop to around 10°C (50°F). The main vegetation of the district is rice.

2.2. Soil sampling and analysis

Surface soil of the farmer's field 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 composite sample from farmer's fields were collected. The physical properties of soil viz Particle size analysis was carried out by Hydrometer method using sodium hexa-metaphosphate as a dispersing agent as described by Bouyoucos (1927). Soil pH and electrical conductivity (EC) of the soil samples in soil: water suspension (1:2.5) was measured using a glass electrode in a digital pH meter and electrical conductivity meter, respectively. Organic carbon was determined by wet digestion method of Walkley and Black (1934), available Nitrogen by Alkaline permanganate method, Available phosphorus was extracted with Bray No-1 solution as extractant (Bray, 1945) and the amount of P in the extract was estimated by chlorostannous reduced phosphomolybdate blue colour method using spectrophotometer at wave length of 660 nm. The available potassium (K) was determined in neutral normal ammonium acetate [1 N CH_3COONa] extract of soil using flame photometer. Available S determined by 0.15% $CaCl_2$ extractable method by William and Steinberg (1959). The correlation analysis of data was computed in relation to available macronutrients and sulphur content with different physico-chemical properties of the soils as suggested by Pearson (Gogtay and Thatte, 2017).

3. Results and Discussion

3.1. Physico-chemical properties of soil

Physico-chemical properties of soils under study (Table 1) revealed that soils belong to sandy loam to sandy clay loam in texture. 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 as reported by Sathyanarayana and Biswas (1970). The pH most of the soils was moderately acidic (53%) to strongly acidic (36%) in nature. Majority of the soil samples were medium to high in their organic matter status. Organic matter content varied from 0.18 to 0.81% with a mean value of 0.60%. The highest organic carbon (OC) content (0.81%) was obtained in soils of Mayureswar block whereas; lowest value (0.18%) was recorded in soils of Bolpur block. Lower values of organic matter content in these soils might be due to rapid decomposition of organic matter. These findings are in agreement with the results reported by Sharma et al. (2013).

Available nitrogen content of these soils showed low to medium. Highest N content was observed in soils of Bolpur block (399.96 kg ha^{-1}), whereas lowest value was observed in Md. Bazar block (128.79 kg ha^{-1}). The low N content in these soils might due to lack of application of organic manure. Similar results were observed by Verma et al. (2005). The overall available P of the study area was ranged from average 16.41 to 28.92 kg ha^{-1} with a mean value of 22.45 kg ha^{-1}. Most of the soils of under study showed low in available phosphorus. Low phosphorus content may due to high acidity in these areas as reported by earlier. Status of available potassium content in these soils ranged from 130.71 to 201.79 kg ha^{-1} with an average value of 163.53 kg ha^{-1}. Most of the soils of Nalhati-1 block were under medium category and remaining samples were under high category. Soils of Md Bazaar block showed low to medium category while all the soils of Rajnagar block were medium in available potassium. The data on status of available S content in the study area showed that most of the soils showed deficiency in available S (<10 kg S ha^{-1}). The lowest value (7.98 kg ha^{-1}) of available S content was observed in the soils of Mayureswar block and the highest value (22.34 kg ha^{-1}) was recorded in soils of Bolpur block and Md Bazaar block. Similar result was also reported by Ghosh et al. (2012).

Table 1: Physico-chemical characteristics of the soils of Birbhum district of West Bengal

Name of Block		pH	EC (dS m^{-1})	Organic C (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})	Textural Class
Mayureswar	Range	4.85-6.01	0.02-0.05	0.53-0.081	279.31-397.95	22.65-38.70	103.62-147.71	7.98-21.81	SCL
	Mean	5.55	0.03	0.67	356.58	31.26	122.66	12.70	
Nalhati-1	Range	5.19-7.04	0.01-0.07	0.42-0.75	262.59-398.91	21.72-30.97	213.96-287.12	17.02-22.32	SCL
	Mean	6.15	0.03	0.63	328.56	26.42	254.32	19.74	
Bolpur	Range	4.24-6.20	0.01-0.07	0.18-0.71	220.77-399.96	16.06-29.26	95.26-189.30	10.57-22.34	SL
	Mean	5.13	0.03	0.46	313.01	22.05	127.37	17.35	
Md Bazar	Range	4.02-6.18	0.01-0.06	0.41-0.75	128.79-332.83	11.04-22.27	100.42-136.09	13.30-22.34	SCL
	Mean	4.99	0.03	0.64	256.50	16.25	117.18	18.99	
Rajnagar	Range	5.10-6.83	0.01-0.09	0.43-0.75	145.51-295.64	10.61-23.44	140.31-248.76	10.30-21.92	SCL
	Mean	5.71	0.04	0.63	218.64	16.31	196.12	16.81	

SCL: Sandy clay loam, SL: Sandy loam

3.2. Correlation between physico-chemical properties and available macro and secondary nutrients

Data pertaining to the relationship between physico-chemical properties and available N, P, K and S in soils of Birbhum district (Table 2) revealed the soil pH ($r=0.487^{**}$) and organic carbon ($r=0.326^{**}$) was positively correlated with available nitrogen and comparable with the relationship reported by Somasundaramet al. (2013) and Kartikeyanet al. (2014). Available N showed negative and significant correlation with electrical conductivity($r=-0.211^{*}$). Available phosphorus had significantly positive correlation with organic carbon ($r=0.236^{**}$), soil pH($r= 0.473^{**}$) and silt content ($r=0.450^{**}$). The increased availability of P with increase in OC content was also reported by Singh and Mishra (2012). Availability of P decreased along with increasing pH, which might be due to complex formation of P with Fe and Al in acidic soils. Available Potassium significantly and positively correlated with pH ($r=0.643^{**}$), silt ($r= 0.468^{**}$) content and clay content($r=0.678^{**}$) whereas negatively with sand content ($r=-0.727^{**}$). The available S showed correlated significantly positively correlated with pH ($r=0.523^{*}$), non- significantly with organic carbon, sand content and clay content. These results corroborate the finding of Ramana et al. (2015)and Meena et al. (2006).

Table 2: Correlation in between macro and secondary nutrients with physico-chemical properties in soils of Birbhum district

Parameters	Available N	Available P	Available K	Available S
pH	0.487^{**}	0.473^{**}	0.643^{**}	0.265^{**}
EC	-0.211^{*}	-0.170	0.087	-0.082
OC	0.326^{**}	0.236^{**}	0.175	0.152
Sand	-0.125	-0.270^{**}	-0.727^{**}	0.021
Silt	0.279	0.450^{**}	0.468^{**}	-0.174
Clay	-0.072	-0.012	0.678^{**}	0.133

*: $p < 0.05$; **: $p < 0.01$

4. Conclusion

Soils under the study weresandy loam to sandy clay loam in texture with moderately to strong acidic in reaction.The organic carbon content and status of available phosphorus and sulphur were low. Availability of N and K categorized as low to medium and medium respectively. Macronutrients and available S showed positive correlation with soil reaction while organic carbon showed positive and significant correlation available N and P while non significant correlation showed with available K and S.

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