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Spatial variability of fertility status in soils of Dima Hasao district of Assam

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ABSTRACT

Two hundred fifty geo-referenced surfaces (0-15 cm) soil samples were collected andanalysed for macronutrientsand micronutrients to study fertility status in soils of Dima Hasao district of Assam and their relationship with some important soil properties. Soils of the district were found to be extremely acidic to slightly acidic in reaction with a low to high organic carbon content and low in cation exchange capacity.The soil of the district indicated that the available nitrogen, phosphorus and potassium status was observed to the tune of 14.0 %,7.2% and 67.2% under low and 86.0 %, 92.8 % and 32.8 %under medium categories, respectively. The overall percent deficient of exchangeable calcium, magnesium and available sulphur in soils was 25.6, 30.4 and 6.8 %, respectively. Based on critical limit,all soils were adequately supplied with DTPA-extractable Fe, Mn and Cu content. In respect of zinc and boron, soils exhibited 90.4 and 73 per cent under sufficient, while, 2.4 and 12 per cent were found deficient in DTPA -Zn and HWS-B,respectively.Soil pH and EC showed positive correlation with macro nutrients and negative correlation with micronutrients. The macro- and micronutrient showed significant positive relation with soil organic carbon and cation exchange capacity.

Key words: *Macronutrients, micronutrients, soil properties, nutrient index*

INTRODUCTION

Evaluation of fertility status of the soils of a region is an important aspect in context of sustainable agricultural production.Soil fertility is one of the important factors controlling yields of crops. Macro and micronutrients are important elements that control soil fertility and yield of crops. The variation in major and micronutrients supply in soil is a natural phenomenon and some of them may be sufficient where others deficient. The decline in soil fertility due to imbalance fertilizer use has been recognized as one of the most important factors limiting crop yield. Sound knowledge about soil fertility is very much relevant for identifying constraint in crop husbandry for attaining sustained productivity and facility agro-technology transfer programme. Information on status of macro-and micronutrients for different soil types, districts and region as well as for the country is highly essential to determine the nature and extent of their deficiencies/toxicities and to formulate strategies for their correction for enhancing crop production. For understanding the reasons of deficiency of available nutrients in soil, correlation of physic-chemical properties with available macro and micronutrients is needed. Therefore, to understand the inherent capacity of soil to supply thesenutrientsto plants, study on status of macro- and micronutrients and their interrelationship with soil characteristics is essential to achieve balance nutrition to overcome soil fertility and improve soil fertility on a sustainable basis. Analysis of fertility status of soils of Upper Brahmaputra Valley Zones of Assam indicated that soils exhibited deficiency in nitrogen, phosphorus, potassium, zinc and boron ranging from 6.0-16.0, 11.0-15.0,14.0-17.0, 23-34 and 17-49%, respectively (Basumatary *et al.*, 2014). However, information with respect to availability of macro-andmicronutrientsand soil characteristics of the present study area is lacking. Keeping these aspects in view,a comprehensive study was undertaken to know the fertility status in soils of Dima Hasaodistrict and an attempt was also made to correlate macro-and micronutrient content of the soils with soil properties.

MATERIALS AND METHODS

Study area

Dima Hasaodistrict lies between 24° 57′to 25° 43′north latitude and 92°32′to 93°28’ east longitude with its headquarters at Haflong. Dima Hasao has a total geographical area of 4888 square kilometers which makes it the third largest district in Assam. The district is

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predominantly hilly due to the prominence of the Borail Range and the Shillong Plateau. The climate of the district is characterized by coolness, generally high humidity nearly all the year round and abundant rainfall. The soil condition of the district is a heterogenous one. The soil of the district varies from non-lateritic soil to lateritic red soil ranging from sandy loam to clay loam in texture.

Collection of soil samples and analysis

Two hundred fifty (250) surface soil (0-15 cm) samples were collected at an interval of 2.5 km representing five blocks *viz*. Harangajao, Maibong, Mahur, Diyungbra and Sangbar. The collected soil samples were processed and analysed for pH, electrical conductivity (EC) and cation exchange capacity (CEC) and organiccarbon (OC) by standard methods (Jackson,1973). Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus (Bray and Kurtz, 1945), available potassium by flame photometric (Jackson, 1973) and available sulphur (Chesnin and Yien,1951). Available micronutrients (Fe, Cu, Zn and Mn) were extracted by DTPA and measured by atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Hot water extractable B concentration from soil extracts was determined by Azomethine-H colorimetric method (Wolf, 1974). The analytical results of each soil samples were categorized as low, medium and high categories based on the critical limits for macro and micro nutrients. The nutrient index and categorization of available nutrients as low (<1.67), medium (1.67-2.33) and high (>2.33) was calculated. Simple correlation coefficients were made to relate physicochemical properties of soils with macro- and micronutrient by adopting standard statistical procedures.

RESULTS AND DISCUSSION

Soil characteristics

The pH of the soils of the district were very strongly acidic to slightly acidic (pH 4.75-6.37)in reaction (Table 1). The highest mean value was recorded in Diyungbra block with a mean of 5.90 while the lowest mean value of 5.19 was recorded in Harangajao block.High exchangeable aluminium and hydrogen ions content under acidic condition might be the cause of lower pH value. Bhuyan*et al.* (2014) and Basumatary *et al.* (2019) also reported the acidic condition in in soils of Assam. The electrical conductivity of the studied soils was low (0.02-0.09 dSm^{-1}). This low value in all the land uses might due to loss of soluble salts from the soils under high rainfall condition.The organic carbon content of the soil ranged from 4.10-21.00g kg^{-1} with an overall mean of 10.30 g kg^{-1}. The lowest (4.10g kg^{-1}) organic carbon content was found in soils of Harangajao block while the highest value (21.00g kg^{-1}) was found in soils from Sangbar block.The differences in the amount of soil organic carbon might be due to the differences in biomass addition and differential rate of decomposition in the vicinity under different land uses, as the degradation of organic matter depends on nature of the plant materials and soil microbes.

Table 1: Chemical properties of soils of Dima Hasao district

Name of block	No of samples	pH	Electrical conductivity (dSm^{-1})	Organic carbon (g kg^{-1})	Cation exchange capacity [cmol (p+) kg^{-1}]
Harangajao	50	4.75-6.37 (5.19)	0.02-0.06 (0.03)	4.10-17.10 (7.80)	4.46-9.80 (6.42)
Maibong	50	5.10-6.36 (5.86)	0.03-0.09 (0.05)	6.60-15.30 (9.70)	5.10-8.36 (6.93)
Mahur	50	4.92-6.30 (5.67)	0.02-0.09 (0.05)	6.50-18.40 (11.00)	5.15-9.70 (7.00)
Diyungbra	50	5.04-6.30 (5.90)	0.04-0.09 (0.06)	7.80-18.30 (11.40)	5.16-9.80 (7.14)
Sangbar	50	4.85-6.30 (5.67)	0.04-0.08 (0.06)	7.80-21.00 (11.60)	6.10-10.25 (7.30)
Over all range/mean		4.75-6.37 (5.66)	4.75-6.37 (5.66)	4.10-21.00 (10.30)	4.46-10.25 (6.96)

Values in parentheses indicate the mean values

The cation exchange capacity (CEC) of the soils were invariably low [4.50 to 10.25 cmol (p^+) kg^{-1}] reflecting the dominance of low activity clay (Kaolinite) in these soils. Among the blocks, the highest mean value as recorded in soils of Sangbar block might be due to high content of organic carbon and cations. On the other hand, the lowest mean value of 6.42 was recorded in soils from Harangajao block and this might be due to lowest content of organic carbon and cations as compared to other blocks.

Macronutrient Status in soils

***Available* nitrogen:** Available nitrogen status in the soil ranged from 181.0-414.0kg ha^{-1} having a mean value of 321.2 kg ha^{-1}(Table 2). The highest mean value of 345.6kg ha^{-1} was observed in Diyungbra block while, the lowest mean value of 268.6 kg $ha^{-1}$was recorded in soils from Harangajao block.The variation of available nitrogen content in the soils might be due to different amount of organic carbon present in the soils which released different amounts of nitrogen into the soils.This was evident from significant positive correlation in between organic carbon (r= 0.948**) and cation exchange capacity(r=0.738**)with available nitrogen (Table4).Similar results were also observed by Sangtam*et al.* (2017) and Maqbool*et al.* (2017). Result (Table 2) indicated that about 14.0 per cent of soils of the district were categorized as low and 86.0 per cent of the soils were reported as medium. The overall nutrient index of the district was found as 1.86 and fertility rating was medium.

***Available phosphorus*:** Results (Table 2) that available phosphorus content in soil ranged from 15.2-56.0kg ha^{-1} with a mean of 43.6 kg ha^{-1}. Among the blocks, the highest mean value of 49.8 kg ha^{-1} was observed in Sangbar block. This higher value might be due to higher content of organic carbon present in soils. Significant positive correlation with organic carbon (r= 0.588**) also indicated that organic carbon is a major source of available P in soils. Further, pH and CEC also govern the availability of P (Table 4). These results are comparable with the findings of Bhuyan*et al.* (2014) and Maqbool *et al.* (2017). The soil of the district indicated that the available phosphorus status was observed to the tune of 7.2% and 92.8 % under low and medium categories, respectively (Table 2). Overall nutrient index value was 1.94and overall fertility rating was medium (Table 2).

***Available potassium*:** Status of available potassium in the soil varied from 41.3-157.1 kg ha^{-1} with a mean value of 122.8kg ha^{-1}(Table2). Among the blocks, maximum content was observed in Sangbar block which varied from 100.5-150.6 with a mean value of 137.8kg ha^{-1}. This higher content might be due to might be due to creation of favorable soil environment with presence of higher content of organic carbon as compare to other blocks. Correlation study also reported that available potassium showed a significant and positive correlation with pH, OC, and CEC (Table 4). Similar relation was also reported by Basumatary *et al.* (2014). The soil of the district exhibited that 67.2 per cent of the soils were categorized as low and 32.8 per cent of the soils were reported as medium (Table 2). The overall nutrient index of the district was found as 1.33and fertility rating was low (Table 2).

***Exchangeable calcium and magnesium*:** Exchangeable calcium and magnesium under study showed the range between 0.80 to 2.70cmol (p^+) $kg^{-1}$and 0.50 to-2.10cmol (p+) kg^{-1} with the mean value of 1.78cmol and 1.21(p+) kg^{-1}, respectively (Table 2). Among the blocks, soils from Diyungbra black recorded the highest mean value of exchangeable Ca [2.00cmol (p+) kg^{-1}] and Mg [1.39cmol (p^+) kg^{-1}]. This higher value might be due to high pH and organic carbon content in soil as compare to other soils. Correlation study (Table 4) also showed that both exchangeable Ca and Mg exhibited a significant and positive correlation with pH, OC, and CEC indicating that these properties played an important role in improvement of status of exchangeable Ca and Mg. Considering 1.50 and 1.00cmol (p+) kg^{-1} as critical limit for exchangeable Ca and Mg, it was observed that 25.6 and 30.4per cent of the soils exhibited as deficient of exchangeable Ca and Mg in soil (Table 2). The results are similar with the studies of Sathish *et al.* (2018) and Basumatary *et al.* (2019).

***Available sulphur*:** Available sulphur varied from 3.90 to 45.78 mg kg^{-1}having order of mean value of 20.54, 20.23, 19.72, 19.2 and 18.95 mg kg^{-1} in soils of Diyungbra, Sangbar, Mahur, Maibong and Harangajao blocks, respectively. This variation might be due to variation in content of organic carbon in soils. This was supported by a highly significant positive correlation of available sulphur with organic carbon (r=0.389**). The results resemble to the of Basumatary *et al.* (2010) in soils of Assam. About 6.8 per cent of the soils were found as deficient while 73.2per cent of the soils were reported as high.This indicates that soils have sufficient amount of available sulphur to meet demand of sulphur by crops.

Table 2: Primary and secondary nutrient status in soils of Dima Hasao district

Name of block	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Exch. Ca [cmol (p+) kg^{-1}]	Exch. Mg [cmol (p+) kg^{-1}]	Available S (mg kg^{-1})
Harangajao	181.0-414.0 (268.6)	15.2-56.0 (36. 6)	41.3-157.1 (109.6)	0.80-2.40 (1.48)	0.50-1.80 (1.06)	5.63-37.30 (18.95)
Maibong	239.0-413.0 (316.5)	16.9-47.2 (38.3)	82.4-131.8 (111.2)	1.10-2.30 (1.72)	0.60-1.60 (1.11)	6.40-34.58 (19.22)
Mahur	249.0-411.0 (335.3)	36.1-53.6 (44.6)	97.9-135.7 (120.4)	1.1-2.50 (1.78)	0.60-1.80 (1.18)	6.35-45.78 (19.72)
Diyungbra	275.0-412.0 (345.6)	32.4-55.8 (48.9)	87.9-154.2 (134.8)	1.20-2.70 (2.00)	0.55-2.10 (1.39)	9.80-39.23 (20.54)
Sangbar	274.0-412.0 (340.3)	24.7-55.5 (49.8)	100.5-150.6 (137.8)	0.80-2.60 (1.90)	0.60-1.90 (1.29)	3.90-42.53 (20.23)
Overall range/mean	181.0-414.0 (321.2)	15.2-56.0 (43.6)	41.3-157.1 (122.8)	0.80-2.70 (1.78)	0.50-2.10 (1.21)	3.90-45.78 (19.73)
Overall low (%)	14.0	7.2	67.2	25.6(deficient)	30.4(deficient)	6.8
Overall medium(%)	86.0	92.8	32.8	74.4(sufficient)	69.6(sufficient)	20.2
Overall high (%)	0.0	0.0	0.0			73.2
Overall Nutrient Index	1.86	1.93	1.33			2.66

Micronutrientsstatus in Soils

***DTPA- Zn*: The DTPA-Zn content ranged between 0.31-4.60mg kg^{-1}(Table 3). Maximum content was recorded in Harangajaoblock,which varied from 1.10 to 3.57mg kg^{-1} with a mean of 2.35mg kg^{-1}. while, the minimum was recorded in Maibong block which ranged from 0.31 to 4.59 mg kg^{-1} with a mean of 2.14 mg kg^{-1}.Based on the critical limit (0.6 mg kg^{-1}), 12 per cent soil samples were found to be deficient in DTPA-Znat Maibongblock,while, no deficiency was exhibited in other blocks and this might be due to higher content of organic carbon and CEC in soils(Table 1). The district recorded 80-96 % of the soils were under high category. The overall nutrient index of the district was found as 2.88 and fertility rating was high (Table 3). Correlation study indicated that the availability of Zn increased significantly with increase in organic carbon and CEC (Table 4). This positive correlation might be due to the formation of organic complexes between organic matter and zinc that protect it from leaching (Shah *et al.* ,2018).The available Zn was negatively correlated with soil pH (r=-0.100) which is in line with the earlier finding of Sidhu and Sharma (2010).

***DTPA-Fe*:** Result (Table 3) indicatedthat overall, Fe content of the district ranged from 20.8-294.5mg kg^{-1}with a mean value of 119.5mg kg^{-1}. The highest Fe content was found in Sangbar block which varied from 58.2-271.2mg kg^{-1}with mean value of 127.0 mg kg^{-1}. The higher concentration in this block might be due to the higher organic carbon content because it acts as chelating agent. Fe reacts with certain organic molecules to form organo metallic complexes as chelates and the soluble chelates can increase the availability of the micronutrient and protect it from precipitation reactions. These chelates may also be synthesized by plant roots and released to the surrounding soil or may be present in soil humus. This was sustained by a significant and positive correlation obtained between DTPA-Fe and OC (r = 0.188**). The increase in DTPA-Fe content with increase in soil organic carbon also reported by various workers (Behera and Shukla 2013; Basumatary *et al.* 2019).The overall nutrient index mean value of 3.00 indicated that soils were sufficiently high in iron content (Table 3).The sufficiency of DTPA-Fe may also be due to lower pH of the studied soils. This is sustained by the overall negative significant correlation obtained between DTPA-Fe and soil pH (r = -0.302**). The results are in conformity with Bhuyan *et al.* (2014). *DTPA -Cu*: The Cu content ranged from 0.50-5.40mg $kg^{-1}$with a mean value of 2.39(Table 3). Among the blocks, the highest average Cu was found in Harangajao block (2.64 mg kg^{-1}) and the lowest was recorded in Diyungbra block (2.20 mg kg^{-1}). Based on critical limit, all the soils were adequately supplied with Cu content (Table 3). The nutrient index of the district was reported as 3.00and fertility rating was high. The sufficiency of DTPA-Cu might be due to the higher organic carbon content and chelating effect. Basumatary *et al.* (2019) also reported no deficiency of Cu in Assam soils. Correlation studies (Table 4) revealed positive significant correlation obtained between DTPA-Cu and organic carboncontent. This might be due to the formation of soluble Cu-organic complexes on the clay surfaces.On the other hand, Cu was negatively correlated with pH (r=-0.211**) indicating increased availability of Cu at lower pH range. The increase in DTPA-Cu with decrease in pH and increase in organic carbon was also reported by Talukdar *et al.* (2009) and Sharma *et al.* (2013).

Table 3: Available micronutrients in soils of Dima Hasao district

Name of block	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})	HWS-B (mg kg^{-1})
Harangajao	1.10-3.57 (2.35)	47.2-219.3 (114.3)	0.80-4.47 (2.64)	17.9-135.1 (54.2)	0.11-2.30 (0.85)
Maibong	0.31-4.59 (2.14)	42.6-294.5 (116.0)	0.50-5.14 (2.34)	23.3-95.2 (59.6)	0.11-2.38 (0.95)
Mahur	1.17-3.60 (2.23)	43.3-280.5 (117.2)	0.60-5.40 (2.45)	20.3-93.1 (60.1)	0.62-2.33 (1.03)
Diyungbra	1.05-3.94 (2.26)	20.8-284.3 (123.1)	0.55-4.72 (2.20)	23.5-106.1 (59.8)	0.64-2.10 (1.04)
Sangbar	1.07-4.60 (2.29)	58.2-271.2 (127.0)	1.10-4.27 (2.32)	16.2-99.9 (67.5)	0.62-2.11 (1.17)
Overall range and mean	0.31-4.60 (2.25)	20.8-294.5 (119.5)	0.50-5.40 (2.39)	16.2-135.1 (60.2)	0.11-2.38 (1.01)
Overall low (%)	2.4	0.0	0.0	0.0	12.0
Overall medium (%)	7.2	0.0	0.0	0.0	15.0
Overall high (%)	90.4	100.0	100.0	100.0	73.0
Overall Nutrient Index	2.88	3.00	3.00	3.00	2.66

DTPA-Mn: Result (Table 3) revealed that DTPA-Mn content ranged between 16.3-135.1 mg kg^{-1} with a mean value of 60.2 mg kg^{-1}. Among the blocks, the highest and the lowest average Mn were found in soils from Sangbar block (67.5 mg kg^{-1}) and Harangajao block (54.2 mg kg^{-1}). Soils were found sufficiency in soils of all the blocks (Table 3). The overall nutrient index was found as 3.00 indicated that soils were sufficiently high (Table 3). Thissufficiency may also be due to the fact that decrease in soil pH increased the solubility of DTPA-Mn while increase in organic matter and the exchange capacity of the soil leading tomore retention of DTPA-Mn resulting in increased availability of DTPA-Mn.These findingswere supported by a negative significant correlation between DTPA-Mn and soil pH and a positive significant correlation between DTPA-Mn and soil OC and CEC (Table 4). Similar results were reported by Bhuyan*et al.* (2014) and Basumatary*et al.* (2014).

Table 4: Correlation coefficient (r) among soil properties and available nutrients

Parameters	pH	EC	OC	CEC
Available N	0.351**	0.076	0.948**	0.738**
Available P_2O_5	0.139*	0.050	0.588**	0.449**
Available K_2O	0.165**	0.080	0.546**	0.473**
Exchangeable Ca	0.469**	0.175	0.694**	0.575**
Exchangeable Mg	0.289**	0.085	0.563**	0.479**
Available S	0.017	0.004	0.389**	0.378**
DTPA-Zn	-0.157*	-0.207**	0.181**	0.389**
DTPA-Fe	-0.302**	-0.117	0.188**	0.197**
DTPA-Cu	-0.211**	-0.177**	0.297**	0.273**
DTPA-Mn	-0.228**	-0.007	0.156*	0.173**
HWS-B	-0.017	-0.060	0.393**	0.277**

*HWS-B***:** The status of HWS-B content was found in between0.11-2.40mg kg^{-1} with a mean value of 1.01 mg kg^{-1} (Table 3). The average B content was found highest in Sangbar block (1.17mg kg^{-1}) and the lowest in Harangajao block (0.85 mg kg^{-1}). Based on 0.5 mg kg^{-1} as critical limit soils from Harangajao and Maibong block exhibited 30% deficient in boron. Basumatary *et al.* (2014) also reported 49% deficiency of B in Golagh at district of Assam.This might be due to low content of organic carbon and leaching loss of B. The overall nutrient index of the district was found as 2.6 and overall fertility rating was high.Correlation studies (Table 4)indicated that HWS-B showed apositive significant correlation organic carbon (r=0.393**) and CEC(r=0.277**) content. This is in conformity with the findings of Choudhari (2015).

Based on findings of present study, it could be inferred that the soils of Dima Hasao district were medium in available nitrogen, and phosphorus and low in potassium. Among the micronutrinets, contents of DTPA extractable Fe, Cu and Mn were sufficient in all the blocks. Soils of the district exhibited 2.4 % deficient in zinc and 12 per cent deficient in HWS-B. Thus, judicious applications of boron and zinc fertilizer are necessary for sustaining crop productivity and soil health in the region. Among soil properties, organic carbon and CEC had a positive influence on the availability of macro- and micronutrients whereas pH had negative influence on the availability of these nutrients. This information can be useful in developing management practices for cultivated soils of Dima Hasao district.

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