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Assessment of Soil Fertility of Some Villages of Lahowal Block, Dibrugarh, India

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A B S T R A C T

A study was conducted to evaluate the fertility status of soils of five different villages of Lahowal block of Dibrugarh district, Assam, India. A total of 100 numbers of surface soil samples (0-15 cm depth), comprising of 20 composite soil samples from each site, were collected. The collected soil samples were air dried, sieved and analyzed for different fertility parameters viz., soil pH, electrical conductivity, organic carbon, primary nutrients (available nitrogen, available phosphorus, available potassium), available sulphur and micronutrients (available zinc and boron) using standard analytical methods. Soil fertility rating as low, medium and high for each fertility parameter was done by calculating nutrient index value. Results revealed that pH of the all soils of study area was found in the acidic range and majority (51 %) of the samples lie in the very strongly acidic (4.5 to 5.0) range. Electrical conductivity was normal (<1.0 ds/m). Soil organic carbon was medium to high. Nutrient index value for available nitrogen and phosphorus was low to medium range. Available potassium content was low and sulphur and zinc content was found medium in all the samples but available boron was in low to medium index level.

Introduction

Soil fertility, being the complex and dynamic natural property, is the inherent capacity of soil to provide essential nutrients for crop growth and yield enhancement (Tisdale *et al.*, 1993). Soil fertility is the result of interaction among physical, chemical and biological properties of soil which is directly related to agricultural production (Rakesh *et al.*, 2012). Soil fertility depletion is a major concern worldwide because it affects the sustainable agricultural production system as well as food security (Tan *et al.*, 2005). Soil fertility deterioration mostly occurs due to increased population density, land use, adverse climatic conditions, over grazing, increased land fragmentation and deforestation *etc*. Continuous and intensive cropping without adequate use of nutrients and improper soil management practices may decline soil fertility. Soil erosion through run off and sediment is also an important cause of soil fertility deterioration (Sahoo *et al.*, 2015; Meena *et al.*, 2017; Bashagaluke *et al.*, 2018) and reduces soil organic matter. Imbalanced and inadequate use of chemical fertilizers, improper irrigation, crop residue removal and different cultural practices may also deplete soil fertility (Pathak, 2010; Medhe *et al.*, 2012). Seasonal variation of different soil fertility parameters like organic carbon, major nutrients *viz.*, nitrogen and phosphorus, total exchangeable cations, percentage base saturation *etc.*, (Roberts, 1987; Isichei and Muoghalu, 1992) may be affected by factors like climatic pattern, land use, cropping sequence and farming system (Rabbi *et al.*, 2014). Soil fertility varies both temporally and spatially and are influenced by both intrinsic and extrinsic factors (Cambardella and Karlen, 1999, Ondersteijn *et al.*, 2003). Soil fertility of different land use system and land treatment varies and requires soil and crop specific nutrient management for yield enhancement (Moran and Mausel, 2002; Singh and Jamir, 2017; Chandrakala *et al.*, 2018). The fertility of soil may vary among various agro-ecosystems too (Kavitha and Sujatha, 2015).

The availability of macro and micro nutrients in the soil determines the fertility level which in turn governs the crop productivity of that soil (Bharti *et al.*, 2017). The quality and productivity of any soil depends on the concentration of soil fertility parameters like organic C, N, P and K and their effect on physical, chemical and biological properties of soil (Cao *et al.*, 2011). For sustainable agricultural production, maintenance of soil fertility and soil health is crucial (Prasad and Power, 1997) as it is related with chemical reactions in soil, availability of essential nutrients, their depletion and replenishment in soil.

Evaluation of soil fertility is essential to provide nutrients for optimum crop growth (Nafiu*et al.*, 2012). Perhaps soil testing is the most commonly used method for soil fertility evaluation (Havlin*et al.*, 2010) for increasing agricultural production through fertility management (Goovaerts, 1998). In practical agriculture, soil test based nutrient management approach is important to diagnose and manage soil fertility (Wani, 2008). It also helps in judicious and efficient use of nutrients in local as well as regional level (Black, 1993; Sahrawat *et al.*, 2010). Soil testing reveals the current fertility status of the soil which provides information regarding nutrient availability in soils that forms the basis for the fertilizer recommendations for increasing crop yields and to maintain the optimum soil fertility (Singh *et al.*, 2018). Therefore, it is necessary to assess the fertility status of soil before crop planning for judicious use of required nutrients. Nutrient index method and fertility indicators can be used to evaluate the fertility status of the soil (Khadka *et al.*, 2016; Annepu*et al.*, 2017; Singh *et al.*, 2018). The soil fertility status under different cropping sequence can also be assessed by using nutrient index approach (Singh *et al.*, 2016).

In Assam state, India about 90% of population depends on agriculture for their livelihood (Upadhyai and Nayak, 2017). Lahowal block is located in the eastern side of Dibrugarh district, Assam state, India, and tea and rice are two major crops grown in the block. Tea, being a commercial perennial crop, requires large amount of nutrients and to increase crop yield farmers practice to use chemical fertilizers injudiciously which may cause serious soil as well as environmental degradation (Rahman and Zhang, 2018).

Application of fertilizers without considering the soil fertility status and crop requirement may adversely affect the soil health as well as crop production (Ray *et al.*, 2000). The present study site, Lahowal block of Dibrugarh district, Assam is lacking the detail information of fertility status. Since sustainable agricultural production needs use of essential plant nutrients in right quantity, in appropriate proportion and at right time following right method is a matter of concern (Jaga and Patel, 2012). Prior knowledge of soil fertility is essential to maintain soil health as well as for enhanced crop production. Accordingly, there is a need of assessing and monitoring different soil fertility parameters of Lahowal block of Dibrugarh district for adoption of proper management strategies to maintain sustainable agricultural production and soil health. Keeping this in view the present study attempts to evaluate the fertility status of five different villages of Lahowal block of Dibrugarh district, Assam, India using fertility ratings and nutrient index in order to determine the variability existing among different soil parameters.

Materials and Methods

Soil samples were collected from five different villages *viz.*, Rongpuria (27°41'63''N latitude to 95°04'39''E longitude), Ikoratoli (27°47'07''N latitude to 95°08'54''E longitude), Phutahula (27°38'11''N latitude to 95°04'24''E longitude), Bokul Majgaon (27°42'97''N latitude to 94°98'96''E longitude) and Alimur (27°23'79''N latitude to 94°30'85''E longitude) of Lahowal block of Dibrugarh district, India. The climate of the study sites is basically humid and warm with annual average precipitation of 2781 mm with 135 rainy days. Temperature in winter ranges from 11°C to 23.2°C and summer temperature lies from 23.7°C to 31°C. (Source: Inventory of Soil Resources of Dibrugarh District, Assam, using Remote Sensing and GIS Technique).A total of 100 numbers of surface soil samples (0-15 cm depth) were collected from the five villages (20 numbers of samples from each village) with the help of screw auger and composite soil samples were prepared. All the composite soil samples were air dried at room temperature, ground and passed through 2 mm sieve and analyzed for different soil parameters *viz.*, soil pH, electrical conductivity (EC), organic carbon, available nitrogen, available phosphorus, available potassium, available sulphur and micronutrients (available zinc and boron) by using standard analytical methods. Soil pH and electrical conductivity in 1:2.5 soil: water suspension of the processed samples were determined by potentiometric method using glass electrode pH meter and Systronics Digital Electrical Conductivity meter respectively (Jackson, 1973). Titrimetric determination or wet digestion method of Walkley and Black (1934) was used to determine organic carbon content of the composite soil samples.

The soil samples were analyzed for macronutrients like available nitrogen and phosphorus by alkaline potassium permanganate method (Subbiah and Asija, 1956; Sharawat and Burford, 1982) and Bray's I method (Bray and Kurtz, 1945),respectively. Available potassium was determined by flame photometer with neutral normal ammonium acetate as an extractant (Hanway and Heidel, 1952). Available Sulphur content of the soil samples were determined by turbidimetric method (Black, 1965). Micronutrients *viz.*, available zinc (DTPA extractable) was determined by using Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978) and hot water-soluble boron was determined by using UV-VIS Spectrophotometer (Wear, 1965). To assess the fertility status of the soil, Nutrient Index Value (NIV) approach introduced by Parker *et al* (1951) and modified by Pathak (2010), Kumar *et al* (2013), Ravikumar and Somashekar (2013) as below is followed:

$$NIV = (NL \times 1 + NM \times 2 + NH \times 3)/NT$$

Where, NL, NM and NH are per cent samples testing low, medium and high category, respectively and NT means total number of soil samples used for calculation.

Results and Discussion

Physico-chemical properties of soil

A total of hundred numbers of surface soil samples were analyzed and investigated. The results of pH, electrical conductivity (EC) and organic carbon (OC) are depicted in Table 1. From the table, it was observed that pH of the soils varied from 4.30 to 6.30 (mean 5.14), EC varies from 0.01 to 0.31 dsm^{-1} (mean 0.06 dsm^{-1}) and organic carbon ranged from 0.33 to 1.20% with 0.75% mean value. The study shows that pH of the soils in all the villages are in the acidic range (Table 1b) and majority (51 %) of the samples lies in the very strongly acidic range.

The acidity of the study area may be due to leaching loss of basic cations from the soil surface because of high rainfall of the study area. Average soil pH of old alluvial flood plains in Assam under high rainfall (> 2000 mm/year) area was found 5 by Chakravarty *et al.,* (1987). Similar result was also reported by Barooah *et al.,* (2020). Soils of Golaghat district of Assam were found acidic in reaction in all seasons with variation (Baruah *et al.,* 2013; Gogoi *et al.,* 2016). Assam soil is basically acidic in reaction. Increased acidity in Assam soil might be due to long term application of chemical fertilizers leading to depletion as well as deposition of some nutrients in soils of tea grown areas (Nath, 2013).

Decomposition of organic matter by microorganisms leading to release of organic acids like -COOH and -OH may be one of the causes of soil acidity (Lalrinfela *et al.,* 2016). Based on the limits given by Muhr *et al.,* (1965), the electrical conductivity of the study area was found in the normal range (< 1.0 dsm^{-1}). Electrical conductivity can be an important soil fertility index for site specific management as it is highly corelated to crop yield (Li *et al.,* 2008). Low electrical conductivity of the study area might be due to inherent factors like soil minerals, climate, soil texture and leaching of soluble salts due to excessive rainfall (>2700 mm/annum) (Roy and Landey, 1962; Singh and Mishra, 2012; Barooah *et al.,* 2020). Results (Figure 1) show that the organic carbon content was high (> 0.75%) in majority of the soils (52% samples), medium (0.5 to 0.75%) in 28% of the soils and low (< 0.5%) in remaining 20% of soils of the study area. Good vegetative growth as well as addition of organic matter into the soil may increase the organic matter content in the soil (Patil and Ananth Narayana, 1990).

Availability of organic matter like vegetative growth and litter and their slow decomposition may lead to high level of organic matter which enriches nutrient and water retention capacity of soil and create favourable physical, chemical and biological environment (Kavitha and Sujatha, 2015).

Available macro nutrients (N, P, K and S) of the soil

Available nitrogen content of the study area ranges from 131.75 to 551.98 kg/ha with an average value of 326.90 kg/ha (Table 3). On the basis of the rating suggested by Baruah and Barthakur (1997), majority of the samples (57%) found in medium (272 to 544 kg/ha) range and remaining 35% of the samples in low (< 272 kg/ha) and 8% in high (> 544 kg/ha) category (Fig. 1).

Similar result was also reported by Verma *et al.,* (2007) and Pandiaraj *et al.,* (2017). Recommended organic manure and nitrogen fertilizer application in crops may build medium range of available soil nitrogen. Soil management, application of FYM and fertilizer to previous crop may be related to variation in soil N content (Ashok Kumar, 2000). Soil N dynamics regulation is mostly controlled by various agronomic practices (Zou *et al.*, 2018) and anthropogenic activity may also alter N cycling (Sharma *et al.*, 2012). Available phosphorus content (Table 3) varied from 12.25 to 58.90 kg/ha (Ikoratoli) with a mean value of 29.05 kg/ha. Based on the limits suggested by Baruah and Barthakur (1997), 47% of the samples were found in low (< 22.5 kg/ha), 45% in medium (22.5 to 56 kg/ha) and 8% in high (> 56 kg/ha) category (Fig 1). Dutta *et al.*, (2008) reported that in acid soils, there is a tendency of low soil phosphorus over time.

The integrative effects of P transformation, availability and utilization caused by soil, rhizosphere and plant processes influence phosphorus dynamics in soil plant system (Shen *et al.*, 2011). The content of available potassium of the present study area (Table 3) varied from 70.98 to 345.50 kg/ha with the mean content of 161.05 kg/ha available potassium. According to Baruah and Barthakur (1997), most of the soil samples (68%) found under low (< 136 kg/ha) and remaining 23% samples under medium (136 to 337.5 kg/ha) and 9% samples under high (> 337.5 kg/ha) range (Fig 1). Low levels of potassium (Ghosh and Hasan, 1976) and medium range of potassium (Hasan and Tiwari, 2002; Motsari, 2002) in Assam soil was reported earlier. Acid sandy soils, waterlogged soils and saline soils predominantly contain low amount of potassium (Mengel and Kirkby, 2001). Medium and low available potassium content of soil also depends on Kaolinite type of clay mineralogy (Pulakeshi *et al.*, 2012).

The available sulphur status of the study area varied from 6.43 to 23.87 mg/kg (Rongpuria) with mean value of 14.33 mg/kg (Table 1). According to the category given by Hariram and Dwivedi (1994), 20% of the samples were found under deficient (< 10 mg/kg), 63% samples in the medium category and 17% samples in the sufficient range (Fig 1). Lack of sulphur fertilization and removal of sulphur by crops may lead to low and medium amount of sulphur in soil (Balangoudar, 1989). Intensive cropping without sulphur fertilization may lead to sulphur depletion in soil (Patra *et al.*, 2012).

Table.1 Range and mean values of physico-chemical properties of soil of the study area

Village	No of samples	pH		EC (dsm^{-1})		Org. C (%)	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Rongpuria	20	4.51-5.65	5.18 ± 0.29	0.01-0.31	0.09 ± 0.08	0.35-0.78	0.54 ± 0.12
Ikoratoli	20	4.67-5.43	5.06 ± 0.24	0.02-0.09	0.05 ± 0.02	0.49-1.12	0.85 ± 0.19
Phutahola	20	4.33-6.38	5.60 ± 0.65	0.03-0.13	0.05 ± 0.05	0.33-1.20	0.67 ± 0.28
BokulMajgaon	20	4.56-5.55	4.94 ± 0.24	0.02-0.09	0.05 ± 0.02	0.44-1.12	0.87± 0.22
Alimur	20	4.55-5.32	4.98 ± 0.23	0.02-0.13	0.05 ± 0.06	0.48-1.05	0.81 ± 0.18
Range and average Mean± SD		4.30-6.30	5.14 ± 0.42	0.01-0.31	0.06 ± 0.05	0.33-1.20	0.75 ± 0.54

Table.2 Soil acidity class of different villages of study site

	Extremely acidic (<4.5)	Very strongly acidic (4.5-5.0)	Strongly acidic (5.1-5.5)	Medium acidic (5.6-6.0)	Slightly acidic (6.10-6.59)	Neutral (6.60-7.39)
Rongpuria						
Percent samples falling	0	35	60	5	0	0
Range	-	4.51-5.04	5.11-5.55	5.65	-	-
Ikoratoli						
Percent samples falling	0	60	40	0	0	0
Range	-	4.67-5.09	5.12-5.43	-	-	-
Phutahula						
Percent samples falling	15	5	25	30	25	0
Range	4.33	4.51-4.66	5.21-5.54	5.74-6.09	6.10-6.38	-
BokulMajgaon						
Percent samples falling	0	75	25	0	0	0
Range	-	4.56-5.09	5.11-5.55	-	-	-
Alimur						
Percent samples falling	0	70	30	0	0	0
Range	-	4.55-5.09	5.12-5.32	-	-	-
Study site total samples						
Percent samples falling	1	51	36	7	5	0
Range	4.33	4.51-5.09	5.11-5.55	5.74-6.09	6.10-6.38	-

(Source: USDA, 1998)

Table.3 Range and mean values of macro nutrients (N, P, K and S) of soil of the study area

Village	No of samples	Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)		Available S (mg/kg)	
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Rongpuria	**20**	131.75-546.87	369.13 ±132.75	13.87-57.98	29.05±13.38	99.57-341.19	186.52 ± 90.6	6.99-23.87	15.99 ± 5.02
Ikoratoli	**20**	209.98-551.11	324.87 ± 96.55	12.25-58.90	27.80 ± 2.87	70.98 343.87	158.14 ± 5.74	8.50-23.50	16.73 ± 4.57
Phutahola	**20**	148.99-454.87	269.60 ± 85.65	14.30-57.75	29.35 ±12.48	88.97-345.5	140.81 ± 63.4	8.96-22.53	14.48 ± 3.83
BokulMajgaon	**20**	163.50-551.98	317.97 ± 117	15.54–57.45	31.71 ±15.08	88.76-339.8	147.9 ±67.64	7.88-18.7	12.01 ± 2.87
Alimur	**20**	200.54-546.98	352.95 ± 89.6	15.87-49.87	27.33 ±10.29	78.00-342.98	171.86 ±84.92	6.43-21.13	12.44± 4.38
Range and average Mean± SD		131.75-551.98	326.90 ±108.46	12.25-58.90	29.05 ±12.75	70.98-345.50	161.05 ±79.33	6.43-23.87	14.33± 4.52

Table.4 Range, mean value and per cent samples fall under deficient and sufficient of micro nutrients of soil of the study area

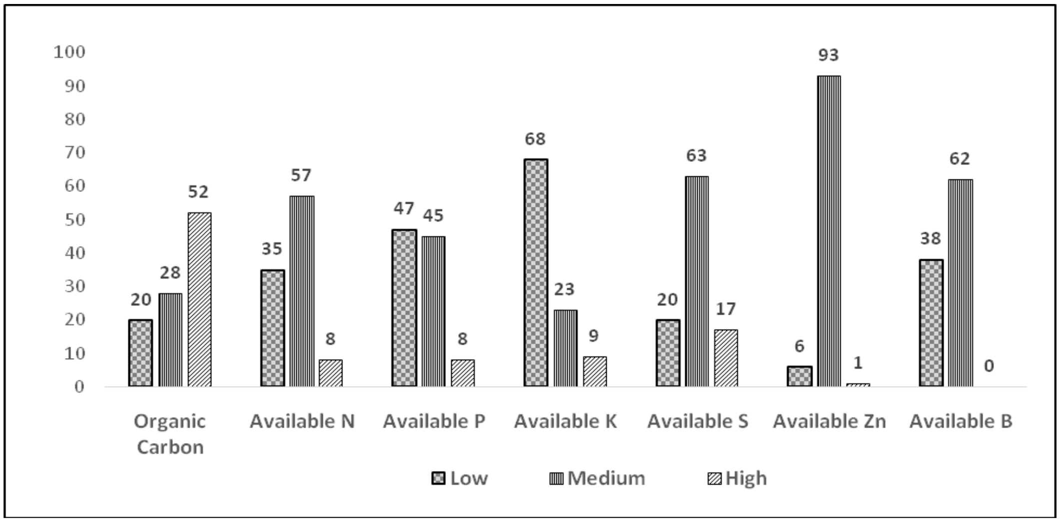
Village	No of samples	Available Zn (mg/kg)				Available B (mg/kg)			
		Range	Mean ± SD	Percent samples fall under		Range	Mean ± SD	Percent samples fall under	
				Deficient (< 0.6)	Sufficient (> 0.6)			Deficient (< 0.5)	Sufficient (> 0.5)
Rongpuria	20	0.25-1.22	0.73 ±0.24	20	80	0.29-0.70	0.51 ± 0.12	45	55
Ikoratoli	20	0.28-2.31	0.97 ± 0.38	5	95	0.44-0.71	0.56 ± 0.08	20	80
Phutahola	20	0.21-1.86	0.76 ± 0.44	65	35	0.32-0.55	0.49 ± 0.06	45	55
BokulMajgaon	20	0.35-1.21	0.86± 0.22	10	90	0.27-0.62	0.47 ± 0.11	55	45
Alimur	20	0.32-1.21	0.83 ±. 27	20	80	0.27-0.71	0.52 ± 0.09	25	75
Range and average Mean± SD		0.21-1.31	0.83 ± 0.33	18	82	0.27-0.71	0.51 ±. 1	38	62

Table.5 Soil fertility status of the study area

Village		OC (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Av. S (mg/kg)	Av. Zn (mg/kg)	Av. B (mg/kg)
Rongpuria	NIV	1.70	1.85	1.55	1.55	2.15	1.90	1.55
	FR	Medium	Medium	Low	Low	Medium	Medium	Low
Ikoratoli	NIV	2.75	1.80	1.50	1.45	2.40	2.00	1.80
	FR	High	Medium	Low	Low	Medium	Medium	Medium
Phutahula	NIV	1.95	1.45	1.80	1.25	2.20	1.85	1.55
	FR	Medium	Low	Medium	Low	Medium	Medium	Low
BokulMajgaon	NIV	2.65	1.65	1.70	1.30	1.75	2.00	1.45
	FR	High	Low	Medium	Low	Medium	Medium	Low
Alimur	NIV	2.55	1.90	1.50	1.50	1.85	2.00	1.75
	FR	High	Medium	Low	Low	Medium	Medium	Medium

Where NIV – Nutrient Index Value; FR – Fertility Rate; L – Low; M – Medium; H – High

Fig.1 Percentage of organic carbon, macronutrient (N, P, K & S) & micronutrient (Zn & B) status of study site soils on the basis of different category



Available micro nutrients (Zn and B) of the soil

Available zinc content of the study area ranges from 0.21 to 1.31 mg/kg with an average value of 0.83 mg/kg (Table 4). On the basis of the rating suggested by Baruah and Barthakur (1997), most of the samples (93%) found in medium (0.3 to 2.3 mg/kg) range and only 6% of the samples in low (< 0.3 mg/kg) and almost negligible amount of samples (1%) in high (> 2.3 mg/kg) category (Fig 1). It was also observed from Table 4, that 89% of the analyzed soil samples are sufficient (> 0.6 mg/kg) in available zinc content and only 11% samples lied under deficient (< 0.6 mg/kg) category. Distribution of zinc in any soil might be altered markedly by soil pH (Sims, 1986). Zinc sufficiency in the study area may be due to low pH of the soil. In the study sites, available boron content varied from 0.27 to 0.77 mg/kg with mean value of 0.51 mg/kg (Table 4).

According to the category given by Berger and Truog (1939), maximum number of soil samples (62%) of the study area remains in the sufficient range (> 0.5 mg/kg) and remaining 38% samples were found under deficient or low (< 0.5 mg/kg) category of available boron (Fig 1). Low and medium range of available boron in the study site might be due to soil acidity induced water solubility of boron and leaching below the root zone of plants (Chaitanya *et al.*, 2014) due to excessive rainfall of the area.

Soil nutrient indices of study sites

Nutrient index value is used to measure the nutrient supplying capacity of soils to plants (Singh *et al.*, 2016). The fertility status of the study area was calculated from low, medium and high ratings as cited in Table 5. If the index value of the soils was less than 1.67, the fertility status was low, when the value was between 1.67 and 2.33 then the status of soil was medium and if the index value of the soils was more than 2.33 then the value was high. In the study area, nutrient index analysis revealed that organic carbon status varied from medium to high.

Rongpuria and Phutahula villages had medium organic carbon whereas Ikoratoli, Bokul Majgaon and Alimur villages had high organic carbon. Available N was medium in Rongpuria, Ikoratoli and Alimur villages and low in Phutahula and Bokul Majgaon villages. Available P status varied from low to medium. Phutahula and BokulMajgaon had medium available P but Rongpuria, Ikoratoli and Alimur villages had low status of available P. Available K and available S was low in all the villages. Available Zn status was also medium in all the villages of the study area. Available B was low *i.e.*, deficient in Rongpuria, Phutahula and Bokul Majgaon villages except Ikoratoli and Alimur where medium status of available B was found.

In conclusion, it is observed from the study that soils of all the villages of the study area was acidic in reaction with normal electrical conductivity and soil organic carbon varied from medium to high range. Available nitrogen and phosphorus were found in low to medium category. On the contrary, available potassium was low and available sulphur was medium in all the soils of the study area. The availability of micronutrients *i.e.*, available Zinc was found in medium range and available Boron was in low to medium range. Therefore, regular and site specific nutrient management practices, application of balanced organic and inorganic nutrients, proper cropping system and adequate agronomic practices are essential to enhance the soil fertility as well as for sustainable crop production.

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