www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(10): 1613-1621

www.thepharmajournal.com
Received: 01-07-2023
Accepted: 04-09-2023

Aradhana Barooah
Associate Professor, Department of NRM Soil Science, College of Horticulture & FSR, Nalbari, Assam Agricultural University, Jorhat, Assam, India

Aradhana Phukan
Assistant Professor, Department of Basic Science Plant Breeding & Genetics, College of Horticulture & FSR, Nalbari, Assam Agricultural University, Jorhat, Assam, India

Rekhashree Kalita
Assistant Professor, Department of Agronomy, Biswanath Chariali College of Agriculture Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Aradhana Barooah
Associate Professor, Department of NRM Soil Science, College of Horticulture & FSR, Nalbari, Assam Agricultural University, Jorhat, Assam, India

Assessment of soil fertility status under different cropping sequences in Dibrugarh district, Assam, India

Aradhana Barooah, Aradhana Phukan and Rekhashree Kalita

Abstract
A study was conducted to assess the fertility status of soils under different cropping sequences in seven different villages of Dibrugarh district, Assam, India. Seven villages *viz.*, Jhanjimukh, Bhogamur, Melengial, 1 No. Kachari Pathar, Gozpuria, Chetia Gaon and Luramukh Bokolial, having three cropping sequences were selected. A total of 350 numbers of surface soil samples (0-15 cm depth), comprising of 50 composite soil samples from each site were collected using auger, after harvesting of Rabi crops during 2019-20. The collected soil samples were processed and analyzed for different soil parameter like soil pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium using standard analytical methods. Nutrient index value was calculated for each parameter for soil fertility rating as low, medium and high. Results revealed that pH of all the samples of study area was in the acidic range and majority of the samples (41%) lie in the strongly acidic range (5.1 to 5.5). Electrical conductivity of all the samples were found normal (< 1.0 ds m^{-1}). The organic carbon content of the study area varies from low to medium. Majority of the soil samples of all the villages except Jhanjimukh contain low status of organic carbon. Available nitrogen content was low to medium, 49% of the samples found in the low range (< 272 kg ha^{-1}) and 44% samples were in the medium (272-544 kg ha^{-1}) range. Available phosphorus and potassium content of the soils varied from low to high. More than 60% samples of the study area had medium available phosphorus (66% samples) and available potassium (62%). Based on nutrient indices, highest organic carbon and available nitrogen was observed in soil under vegetable based cropping sequence. On the other hand, higher available phosphorus was found in soils under potato based cropping sequence and higher available potassium was under paddy-rapeseed cropping sequence. Available nitrogen and electrical conductivity showed a positive correlation with cropping intensity might be due to application of inorganic fertilizer and plant biomass incorporation. On the other hand, pH, electrical conductivity, available phosphorus and available potassium exhibited a decreasing trend with cropping intensity.

Keywords: Cropping sequence, pH, organic carbon, nitrogen, phosphorus, potassium

Introduction
Soil fertility is the inherent capacity of a soil to supply essential nutrients for proper growth, development and enhancement of crop yield (Tisdale *et al.*, 1993) [1]. Various physical, chemical and biological properties of soil affect soil fertility which directly influences agricultural production (Rakesh *et al.*, 2012) [2]. The sustainable agricultural production as well as global food security may be hampered by soil fertility depletion. Soil fertility, a dynamic property of soil, may deteriorate due to increased anthropogenic activities, enhanced land fragmentation, deforestation, adverse climatic condition, overgrazing, nutrient mining due to continuous and intensive cropping without proper nutrient supplement and improper management practices. Excessive and disproportionate use of only chemical fertilizers and intensive cropping system may also be a major cause of soil pollution and fertility deterioration (Singh *et al.*, 2023; Bisht and Chauhan, 2020) [3, 4]. Fertile top soil erosion through run off and nutrient loss may cause reduction in soil fertility (Guimaraes *et al.*, 2021) [5] and decreases organic matter content of soil (Nathan *et al.*, 2022) [6]. Climatic pattern, land use, cropping sequence and farming system (Yang *et al.*, 2020; Rabbie *et al.*, 2014) [7, 8] may affect the seasonal changes of different soil fertility parameters *viz.*, soil organic carbon, major nutrients (nitrogen and phosphorus), total exchangeable cations, percentage base saturation, carbon nitrogen ratio etc. (Mirza and Patil, 2020; Omer *et al.*, 2018) [9, 10]. Different unscientific land use system and land management may drastically reduce soil fertility due to nutrient loss (Willy *et al.*, 2019; Kharal *et al.*, 2018) [11, 12]. The fertility status of soil differs under different agro-ecosystems also (Kavitha and Sujatha, 2015) [13].

Crop productivity of a particular area is influenced by the availability of soil macro and micro nutrients which determine the fertility of the soil (Bharati *et al.*, 2017) [14]. Soil fertility evaluation of a particular area has important significance for planning of sustainable agricultural production (Prasad and Shivay, 2020) [15] because soil fertility is the major limiting factor for production. Productivity as well as fertility of soil can be enhanced by soil test based fertility management (Singh *et al.*, 2018) [16]. According to Singh *et al.*, (2021) [17] sustainable yield enhancement and nutrient use efficiency as well as fertility of soil can be improved by soil test crop response nutrient management. Nutrient index methods and fertility indicators can be used to assess the fertility status of soil. Many workers have evaluated the soil fertility status of soil in different locations of the world as well as under different cropping sequences by using nutrient index approach (Tarar *et al.*, 2023; Hota *et al.*, 2022; Sachan and Krishna, 2021) [18, 19, 20].

In the north eastern state of Assam, India, majority of the population (about 90%) relies on agriculture for their livelihood (Upadhyai and Nayak, 2017) [21]. Tea and rice are the two dominant crops grown in the district. Though majority of the farmers of the district cultivate only mono cropping of rice but some farmers grow rapeseed, vegetables, potato or other *rabi* crops followed by rice. To increase agricultural production crop rotation is essential but intensive farming may deteriorate ecological balance and soil fertility (Fargione *et al.*, 2018) [22]. Giri *et al.*, (2022) [23] made an experiment in the soil of western terai of Nepal under rice wheat cropping system and found that soil health was very poor. The present study sites of Dibrugarh district, Assam is having no detailed information of soil fertility status. Nutrient management in the crop field without knowing the fertility status of soil may deteriorate the soil health as well as crop productivity (Lalrinfela *et al.,* 2016) [24]. Therefor the present study was undertaken to assess the fertility status of soils under different cropping sequences followed in seven different villages of Dibrugarh district, Assam, India using fertility rating and nutrient index to determine the variability among different soil parameters. The study will help for future planning of proper nutrient management in different cropping sequences for sustainable crop production by maintaining soil health.

Materials and Methods

Dibrugarh district is located in the upper Brahmaputra Valley Zone and Eastern Himalayan Region in eastern part of the state Assam, India. Soil samples were collected from seven different villages *viz.*, Jhanjimukh, Bhogamur, Melengial, 1 No. Kachari Pathar, Gozpuria, Chetia Gaon, Luramukh Bokolial of Dibrugarh district, India. Details of selection of the study sites or villages were done based on cropping sequences *viz.*, rice-rapeseed, vegetable based and potato based (Table 1). The study sites are having humid and warm climate, annual average precipitation is 2781 mm with 135 rainy days. Temperature in winter ranges from 11 °C to 23.2 °C and summer temperature varies 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 350 numbers of surface soil samples (0-15 cm depth) were collected from the seven villages (35 numbers of samples from each village) in the year 2019-20, at the end of cropping cycle and composite soil samples were prepared. The collected soil samples were air dried at room temperature, ground and passed through 2 mm sieve and analysed for different soil parameters *viz.*, soil pH, electrical conductivity (EC), organic carbon, available nitrogen, available phosphorus and available potassium 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 the calibrated glass electrode pH meter and Systronics Digital Electrical Conductivity meter respectively (Jackson, 1973) [25]. Titrimetric method or wet digestion method of Walkley and Black (1934) [26] was used to determine organic carbon content of the soil samples. Available nitrogen and available phosphorus content of the study site soil samples were assessed using alkaline potassium permanganate method (Sharawat and Burford, 1982; Subbiah and Asija, 1956) [27, 28] and Bray's I method (Bray and Kurtz, 1945) [29], respectively. Determination of available potassium was done by flame photometer using neutral normal ammonium acetate as an extractant (Hanway and Heidel, 1952) [30].

Table 1: Sampling location and cropping sequences of selected sites

Sl. No.	Village name	GPS location	Cropping sequence (percent samples)		
			Paddy-Rapeseed	Paddy-Winter vegetable	Paddy-Potato
1	Jhanjimukh	27° 16' 23" N 94° 49' 07" E	15	20	15
2	Bhogamur	27° 16' 23" N 94° 50' 22" E	19	19	12
3	Melengial	27° 26' 45" N 95° 01' 14" E	18	17	15
4	1 No. Kachari Pathar	27° 19' 26" N 95° 18' 12" E	16	19	15
5	Gozpuria	27° 12' 16" N 94° 52' 10" E	18	18	14
6	Chetia Gaon	27° 26' 45" N 95° 01' 14" E	15	19	16
7	Luramukh Bokolial	27° 30' 19" N 95° 09' 00" E	14	18	18

Nutrient availability index determination

Specific rating chart is used (Table 2) to evaluate the fertility status like soil pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium of the study area.

Table 2: Nutrient Index range and remarks

Nutrient index	Range	Remarks
I	Below 1.67	Low
II	1.67-2.33	Medium
III	Above 2.33	High

To obtain a single value for each of the soil, to compare and assess the fertility level of soil of one area with the other, the nutrient index approach introduced by Parker *et al.*, (1951) [31] and modified by Pathak (2010) [32], Kumar *et al.*, (2013) [33], Ravikumar and Shoemaker (2013) [34] as below is followed:

NIV = (NL x 1 + NM x 2 + NH x 3) / NT

Where, NIV = Nutrient index value, NL = Number of samples in low category, NM = number of samples in medium category, NH = Number of samples in high category, NT = Total number of soil samples.

Results and Discussion

Soil pH

The acidity or alkalinity of a soil can be indicated by the pH of the soil. Soil pH plays a major role in various chemical reactions in release of available nutrients affecting plant growth and so pH is known as the master variable in soil chemistry (Penn and Camberto, 2019) [35]. Soil pH influences nutrient availability and fertility status of soil by changing the form of the nutrients. The present study reveals that the pH of the soils of the study sites (Table 3) vary from extremely acidic to slightly acidic range (4.12-6.33). According to the results, majority of the soil samples of Jhanjimukh (48%), Melengial (48%), 1 No. Kachari Pathar (36%) and Gozpuria (56%) are under strongly acidic range, whereas most of the samples of Chetia Gaon (62%) ans Luramukh Bokolial (50%) lies in the very strongly acidic in reaction. On the other hand, 40% of the samples of Bhogamur lies in the medium acidic range with a mean value of 5.41. High rainfall in the study area may leach out the basic cations from the soil surface resulting in acidity. The average soil pH of old alluvial flood plains with annual average rainfall > 2000 mm was reported as 5.0 by Chakravarty *et al.*, (1987) [36]. The pH of tea garden belts of Assam soil was reported as acidic throughout the growing season (Gogoi *et al.*, 2016; Baruah *et al.*, 2013) [37, 38]. Soil acidity may be increased due to long term application of chemical fertilizer leading to depletion or excessive deposition of some plant nutrients (Nath, 2013) [39]. Decomposition of soil organic matter by micro organisms releases organic acids like -COOH and -OH group may also be a cause of soil acidity (Lalrinfela *et al.*, 2016) [24].

Table 3: Soil acidity class of different study sites

	Extremely acidic (<4.5)	Very strongly acidic (4.5-5.0)	Strongly acidic (5.1-5.59)	Medium acidic (5.6-6.0)	Slightly acidic (6.1-6.59)	Neutral (6.6-7.59)	Mean ± SD	Range
Jhanjimukh								
Percent samples	0	16	48	32	2	0		
Range	-	4.87-5.09	5.11-5.55	5.60 -6.09	6.10	-	5.45±0.35	4.87-6.1
Bhogamur								
Percent samples	4	18	38	40	0	0		
Range	4.12-4.41	4.76-5.09	5.12-5.55	5.61-6.09	-	-	5.41±0.42	4.12-6.09
Melengial								
Percent samples	4	46	48	2	0	0		
Range	4.32-4.42	4.51-5.09	5.10-5.54	5.65	-	-	5.10±0.27	4.32-5.65
1 No. Kachari Pathar								
Percent samples	8	18	36	32	6	0		
Range	4.33-4.54	4.65-5.07	5.23-5.59	5.64-6.03	6.10-6.33	-	5.43±0.48	4.33-6.33
Gozpuria								
Percent samples	2	22	56	20	0	0		
Range	4.42	4.51-5.09	5.11-5.57	5.65-6.09	-	-	5.32±0.39	4.42-6.09
Chetia Gaon								
Percent samples	0	62	28	10	0	0		
Range	-	4.56-5.09	5.11-5.54	5.61-5.87	-	-	5.06±0.31	4.56-5.87
Luramukh Bokolial								
Percent samples	4	50	28	16	2	0		
Range	4.34-4.44	4.55-5.09	5.15-5.45	5.65-5.98	6.11	-	5.11±0.44	4.34-6.11
Study site total samples								
Percent samples	3	33	41	22	1			
Range	4.12-4.54	4.51-5.09	5.10-5.59	5.60-6.09	6.10-6.33	-	5.27±0.39	4.12-6.33

Electrical conductivity

Electrical conductivity of soil indicates the soluble salts present in the soil and various factors like cropping sequence, irrigation, land use, application of fertilizers, manures and composts etc. affect it (Singh *et al*., 2016) [40]. Higher value of electrical conductivity due to excessive amount of dissolved salt in soil solution disrupts the normal nutrient uptake process and adversely affect crop productivity (Rahman *et al.*, 2010) [41]. The electrical conductivity of the study area was found in the normal range (< 1.0 dsm^{-1}) (Table 4) based on the limit given by Muhr *et al.*, (1965) [42]. Inherent factors like soil minerals, climate, soil texture, and leaching of soluble salts due to excessive rainfall might be the cause of low electrical conductivity of the study area (Barooah *et al.*, 2020; Singh and Mishra, 2012) [43, 44]. The mean electrical conductivity of the study site varies from 0.05 to 0.09 dsm^{-1} with a range of 0.01 to 0.41 dsm^{-1}. The variation in electrical conductivity of the study site soils might be due to inherent drainage system of soils in different villages of Dibrugarh district.

Table 4: EC values of soils of different villages

Sl. No	Percent samples within the range			Mean ± SD	Range
	< 1 ds m^{-1} (Normal)	1-2 ds m^{-1} (Medium)	>2 ds m^{-1} (High)		
Jhanjimukh	100	-	-	0.05±0.02	0.01-0.09
Bhagamur	100	-	-	0.06±0.07	0.02-0.41
Melengial	100	-	-	0.06±0.03	0.02-0.21
1 No. Kachari Pathar	100	-	-	0.08±0.04	0.03-0.16
Gozpuria	100	-	-	0.07±0.03	0.01-0.13
Chetia Gaon	100	-	-	0.06±0.04	0.02-0.24
Luramukh Bokolial	100	-	-	0.09±0.04	0.05-0.19
Range and average Mean ± SD				0.07±0.04	0.01-0.41

Organic carbon

Soil organic matter is an important index of soil quality and best integrator of inherent soil productivity (Gurmu, 2019) [45]. Soil organic matter acts as a reservoir of plant nutrients and form the foundation of healthy and productive soil. Besides supplying nutrients soil organic matter also improves soil physical characteristics like improves soil structure, increases water infiltration, soil moisture retention and increases the activity and growth of soil flora and fauna which in turn enhances retention and cycling of applied fertilizer (Johnston, 2007) [46]. The organic carbon content of the study area varies from 0.23 to 0.86% (Table 5). The mean value was high (0.59%) in Melengial and low (0.50%) in Bhogamur village. From the result it was observed that except Jhanjimukh (52% of the samples in medium range), the organic matter content in majority of the soils of Bhogamur (58% of the samples), Melengial (48% of the samples), 1 No. Kachari Pathar (54% of the samples), Gozpuria (52% of the samples), Chetia Gaon (50% of the samples) and Luramukh Bokolial (50% of the samples) falls in the low category (< 0.5%) which might be due to burning of paddy straw residues and continuous and intensive cultivation leading to crop removal of soil organic carbon (Campbell *et al.*, 1991) [47]. Again soil carbon Humification and accumulation is greatly influenced by soil pH and mineralogy (Djukick *et al.*, 2010) [48]. The farmers of these villages should be suggested to apply adequate amount of organic manures like vermicompost, farmyard manure etc. and green manure for sustainable crop productivity for a longer period.

Table 5: Organic carbon (%) content of soils of different villages

Sl. No	Percent samples within the range			Mean ± SD	Range
	< 0.5 (Low)	0.5-0.75 (Medium)	> 0.75 (High)		
Jhanjimukh	38	52	10	0.55±0.14	0.23-0.80
Bhogamur	58	38	4	0.50±0.13	0.28-0.79
Melengial	48	42	10	0.59±0.14	0.33-0.84
1 No. Kachari Pathar	54	36	10	0.52±0.11	0.32-0.80
Gozpuria	52	42	6	0.53±0.13	0.31-0.79
Chetia Gaon	50	48	2	0.56±0.14	0.32-0.86
Luramukh Bokolial	50	40	10	0.55±0.14	0.30-0.79
Range and average Mean ± SD				0.55±0.13	0.23-0.86

Available nitrogen

Nitrogen is an important plant nutrient as it forms the fundamental building block of proteins, nucleic acids and other cell organelles. Availability of nitrogen is essential for crop growth and is an important indicator of soil fertility (Liu *et al.*, 2023) [49]. Soil type, crop rotation, management practices like tillage, stubble retention and fertilizer application *etc.*, affects different microbial activity involved in nitrogen fixation, mineralization, availability and losses of nitrogen from soil. Available nitrogen content in the study area ranges from 176.98 to 576.90 kg ha^{-1} (Table 6) with an average value of 325.10 kg ha^{-1}. According to the rating suggested by Baruah and Barthakur (1997) [50], majority of the samples (49%) found in the low (< 272 kg ha^{-1}) range followed by 44% of the samples in the medium (272-544 kg ha^{-1}) range and only 7% of the samples lie in the high (> 544 kg ha^{-1}) range (Fig 1). Low organic matter content and loss of nitrogen from the soil due to stubble burning may be a cause of low nitrogen status of the study site soils. Land uses under different cropping system (Uzoho *et al.*, 2014) [51], soil management, application of FYM and fertilizer to previous crop (Asok Kumar, 2000) [52], agronomic practices (Zou *et al.*, 2018) [53], anthropogenic activity (Sharma *et al.*, 2012) [54] may be some factors for variation of soil nitrogen.

Table 6: Available Nitrogen (kg ha^{-1}) content of soils of different villages

Sl. No	Percent samples falling within the range			Mean ± SD	Range
	< 272 (Low)	272-544 (Medium)	> 544 (High)		
Jhanjimukh	50	44	6	316.80±101.16	180.97-547.98
Bhagamur	52	44	4	322.75±105.62	201.08-550.98
Melengial	44	44	12	343.89±111.49	198.09-547.98
1 No. Kachari Pathar	46	44	10	332.61±113.81	189.87-554.09
Gozpuria	52	42	6	324.17±115.43	176.98-567.98
Chetia Gaon	54	42	4	314.39±101.11	197.87-576.90
Luramukh Bokolial	50	44	6	321.09±100.63	200.34-547.98
Range and average Mean ± SD				325.10±107.04	176.98-576.90

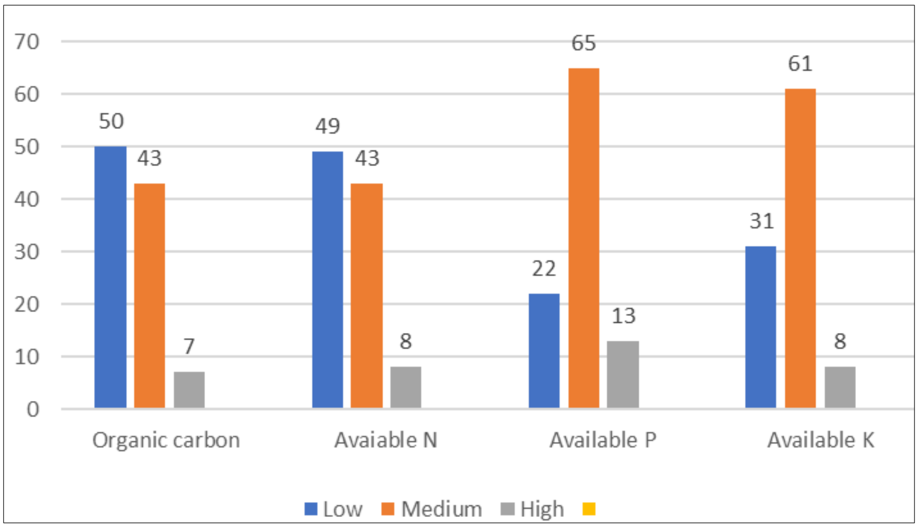

Fig 1: Percentage of organic carbon, available N, available P and available K status of study site soils on the basis of different category

Available Phosphorus

Phosphorus, being a part of several key structural compounds and as a catalyst in many biochemical reactions, plays an important role in plant growth. Phosphorus is called as "Master key to agriculture" because, besides nitrogen, phosphorus deficiency is considered as the cause of low crop productivity (Singh *et al.*, 2016) [40]. The genetic aspects of plant, soil-plant-fertilizer-environment relationship governs the phosphorus dynamics in a system (Lizcano-Toledo *et al.*, 2021) [55]. The phosphorus content of the study site soil (Table 7) varies from 9.90 to 60.12 kg ha^{-1} with a mean value of 35.07 kg ha^{-1}. Based on the limits given by Baruah and Barthakur (1997) [50], 22% of the samples were found in low (< 22.5 kg ha^{-1}), 66% samples lie in medium (22.5 to 56.0 kg ha^{-1}) and only 7% samples were found in high (> 56 kg ha^{-1}) category. Similar trend of available phosphorus in Assam soil was also reported by Barooah *et al.*, (2020) [56]. Basumatary *et al.*, (2014) [57] made an experiment on fertility status of Upper Brahmaputra Valley soils of Assam and reported that available phosphorus status in Jorhat, Sivasagar and Golaghat district ranged between 14.81 to 39.49, 10.54 to 34.21 and 14.28 to 36.38 kg ha^{-1}, respectively. In acid soil, there is a tendency towards low phosphorus level over time due to reduction in solubility of soil inorganic phosphorus through fixation and formation of insoluble Al and Fe precipitates (Johan *et al.*, 2021; Dutta *et al.*, 2008) [58, 59].

Table 7: Available Phosphorus (kg/ha) content of soils of different villages

Sl. No	Percent samples within the range			Mean ± SD	Range
	< 22.5 (Low)	22.5-56 (Medium)	> 56 (High)		
Jhanjimukh	22	66	12	33.80±12.80	11.96-60.12
Bhagamur	26	50	14	35.56±13.75	12.98-59.97
Melengial	26	66	8	34.91±13.50	9.90-58.98
1 No. Kachari Pathar	20	68	12	35.38±13.09	12.22-59.93
Gozpuria	22	66	12	35.07±12.97	10.56-59.00
Chetia Gaon	14	74	12	35.20±13.72	15.98-59.50
Luramukh Bokolial	22	62	16	35.58±13.70	14.87-58.93
Range and average Mean ± SD				35.07±13.48	9.90-60.12

Available potassium

Potassium is one of the important major nutrients required by crops. In soil solution potassium is mostly present in the ionic form *i.e.* K^+ and it acts as a catalyst in various physiological processes in plants (Singh *et al.*, 2016) [40]. Potassium imparts pests, diseases and stress resistance capacity to plants and also controls opening and closing of stomata and thereby regulates cell osmotic pressure and cation and anion balance in plant cell (Hu *et al.*, 2016) [60]. According to Molepo *et al.*, (2014) [61], exchangeable K, texture and soil mineralogical properties affect soil fertility and acts as a measure of creating stable agricultural environment. The content of available potassium in the soils of the present study area varies from 44.09 to 348.98 kg ha^{-1} with an average value of 186.00 kg ha^{-1}. According to Baruah and Barthakur (1997) [50], most of the sail samples (62%) found under medium (136 to 337.5 kg ha^{-1}) range followed by 31% of the samples in low (< 136 kg ha^{-1}) and 7% samples in the high (> 337.5 kg ha^{-1}) range (Fig.1). Majority of the soil samples of all the villages were found in medium range (Table 8). Low and medium level of potassium in Assam soil was earlier reported by many workers (Ramamurthy *et al.*, 2017; Motsari, 2002; Hasan and Tiwari, 2002) [62, 63, 64]. Unproportionate use of NPK fertilizers, comparatively less addition of potassic fertilizer and intensive cropping might be the probable cause of K deficiency in soils and crops (Naidu *et al.*, 2011) [65]. Kaolinitic type of clay mineralogy also affects the medium and low level of potassium content of soil (Pulakeshi *et al.*, 2012) [66].

Table 8: Available Potassium (kg ha^{-1}) content of soils of different villages

Sl. No	Percent samples within the range			Mean ± SD	Range
	< 136 (Low)	136-337.5 (Medium)	> 337.5 (High)		
Jhanjimukh	36	56	8	192.80±90.32	44.09-341.25
Bhagamur	28	64	8	188.49±80.96	65.98-348.98
Melengial	32	62	6	181.59±72.55	65.92-341.22
1 No. Kachari Pathar	38	56	6	181.65±81.86	55.87-343.09
Gozpuria	30	62	8	184.35±74.56	76.98-342.09
Chetia Gaon	22	68	10	193.84±79.35	86.81-341.11
Luramukh Bokolial	34	60	6	179.29±69.79	87.00-338.98
Range and average Mean ± SD				186.00±78.48	44.09-348.98

Nutrient index value (NIV) is a measure of nutrient supplying capacity of soils to the plants (Sachan and Krishna, 2021; Singh *et al*., 2016) [20, 40]. The fertility status of the study area calculated for low, medium and high ratings as shown in Table 10. The fertility status was low if the index value of the soils was less than 1.67, when the value was between 1.67 to 2.33, then the status of soil was medium and if the nutrient index value of the soils was more than 2.33 then the value was high. It was revealed that, organic carbon and available nitrogen content varied from low to medium range in the study area. Only Jhanjimukh village had medium organic carbon and Melengial had medium available nitrogen status of soil. All the villages of the study area had medium range of available phosphorus and potassium. The differences in NIV in the soils of different villages might be due to differences in cropping sequence followed by the farmers.

Table 10: Nutrient index values of soils of different villages

	Organic carbon (%)	Available Nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Jhanjimukh	1.72	1.56	1.90	1.72
Bhagamur	1.60	1.52	1.88	1.80
Melengial	1.68	1.68	1.86	1.74
1 No. Kachari Pathar	1.68	1.64	1.92	1.68
Gozpuria	1.56	1.54	1.90	1.78
Chetia Gaon	1.54	1.50	1.92	1.88
Luramukh Bokolial	1.60	1.56	1.92	1.72

Effect of cropping sequences in soil fertility:

In vegetable based cropping sequence, farmers generally apply higher amount of nutrients as fertilizers and after harvesting of the crop, in situ incorporation of plant biomass in the soil enhances organic carbon and available nitrogen content of soil and only 34% and 30% of the soils were low in organic carbon and available nitrogen content respectively (Table 11). On the other hand, in potato based cropping sequence, organic carbon and available nitrogen content of the soil was low (65% for organic carbon and 59% for available nitrogen) probably due to higher uptake of nitrogen by the crop. In paddy rapeseed cropping sequence, in majority of the soils organic carbon and available nitrogen content was low (57% for organic carbon and 63% for available nitrogen) might be due to burning of paddy straw and complete uprooting of rapeseed crop at the time of harvest. Highest available phosphorus content was found in the soils of potato based cropping sequence and highest available potassium was found in the soils of rice rapeseed cropping sequence and lowest available potassium content was observed in the soils of vegetable based cropping sequence. Highest NIV for organic carbon and available nitrogen was found under vegetable based cropping sequence, for available phosphorus it was potato based cropping sequence and highest NIV for available potassium was found in rice based cropping sequence (Table 12).

Table 11: Effect of cropping sequences on fertility status

Cropping sequence	Organic Carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	Low	Medum	High	Low	Medum	High	Low	Medum	High	Low	Medum	High
Paddy rapeseed	57	38	5	63	32	5	27	61	12	22	65	13
Vegetable based	34	52	14	30	59	11	23	67	10	40	55	5
Potato based	65	34	1	59	37	4	19	65	16	28	65	7

Table 12: Nutrient index values of the cropping sequence

Cropping sequence	Organic Carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Paddy-rapeseed	1.48	1.56	1.85	1.85
Vegetable based	1.81	1.80	1.87	1.64
Potato based	1.35	1.44	1.97	1.80

Correlation of cropping sequence with soil physico-chemical properties

The correlation of cropping sequence in the study sites of Dibrugarh district, Assam, India with the physico-chemical properties of soils are shown in Table 13. Available nitrogen and electrical conductivity showed a positive correlation with cropping intensity might be due to in situ incorporation of plant biomass, specially in vegetable based cropping sequence. On the other hand, pH, organic carbon, available phosphorus and available potassium exhibited a negative trend with cropping intensity. A significantly positive correlation was observed between organic carbon and available phosphorus might be due to mineralization of organic matter enhances availability of phosphorus in soil. Similar result was reported by Bhavsar *et al.*, 2018. A significant negative correlation was found between available nitrogen and available potassium content of the soil.

Table 13: Corelation of cropping intensity with physico-chemical properties of soils

	CI	pH	Electrical conductivity	Organic carbon	Available N	Available P	Available K
CI	1	-8.5572**	0.9774	-0.1889	0.9977*	-0.2119	-0.9944
pH		1	-0.2116	0.98219	0.0671	0.9773	-0.1058
Electrical conductivity			1	-0.3925	-0.1226	-0.4139	-0.9495
Organic carbon				1	0.9609	0.9997**	0.0839
Available N					1	-0.1459	-0.9993**
Available P						1	0.1073
Available K							1
** Correlation is significant at 0.01 level							
* Correlation is significant at 0.05 level							

Conclusion

Different fertility parameters of soil *viz.*, pH, electrical conductivity, organic carbon, available nitrogen, available phosphorus and available potassium were analysed for seven different villages of Dibrugarh district, Assam, India. The study showed that pH of all the soils were acidic and electrical conductivity was in normal range. Soils with high organic carbon and available nitrogen was found in vegetable based cropping sequence might be due to addition of higher fertilizer and in situ incorporation of vegetable stubbles. Again comparatively higher available phosphorus was found in the soils under potato based cropping sequence and higher potassium was observed in paddy rapeseed cropping sequence. Assessment of different soil parameters in different villages of the study area only gave a basic idea of fertility status of the soil. So, in order to enhance the soil fertility as well as crop productivity application of different organic nutrients, judicious application of inorganic fertilizer and adoption of proper cropping sequence including leguminous crop is essential.

Acknowledgement

I express my sincere gratitude to the Senior Scientist & Head, Krishi Vigyan Kendra, Dibrugarh, Assam for providing necessary support and other basic infrastructure for this study.

References

1. Tisdale SL, Nelson WL, Beaton JD. Soil Fertility and Fertilizers. 5th Edition. Macmillan Publishing Co. Inc. New York and Colloir Macmillan Publishers, London, 1993.
2. Rakesh K, Rakesh KUS, Brijesh Y. Vertical distribution of physico-chemical properties under under different topo-sequence in soils of Jharkhand. Journal of Agricultural Physics 2012; 12(1):63-69.
3. Singh SK, Tagung T, Kashiwar SR, Kumar A, Tiwari S, Singh SK *et al*. Assessment of soil fertility status in Paroo and Saraiyan blocks of Muzaffarpur district of Bihar using GPS and GIS. International Journal of Plant and Soil Science 2023; 35(17):89-101.
4. Bisht N, Chauhan PS. Excessive and disproportionate use of chemicals cause soil contamination and nutritional stress. 2020; Open-Access Peer reviewed chapter DOI: 10.5772/intechopen.94593
5. Guimaraes DV, Silva MLN, Beniaich A, Pio R, Gonzaga MIS, Avanzi JC *et al.*, Dynamics and losses of soil organic matter and nutrients by water erosion in cover crop management systems in olive groves, in tropical regions. Soil and Tillage Research. 2021;209:104863.
6. Nathan OO, Monicah MM, Jayne MN, Isaya S, George N, Daniel MN. Nutrient and organic carbon loss by erosion, and their economic and environmental implications in the drylands of Kenya. Environmental Challenges. 2022;7(22):100519.
7. Yang T, Siddiqui KHM, Liu K. Cropping systems in agriculture and their impact on soil health-A review. Global Ecology and Conservation. 2020;23:e01118.
8. Rabbie SMF, Roy BR, Miah MM, Amin MS, Khandakar T. Spatial variability of physical soil quality index of an agricultural field. Applied Environment and Soil Science; 2014. Article ID 379012.
9. Mirza AN, Patil SS. Assessment of seasonal variation in physicochemical characteristics of the soil at Gautala Reserve Forest (M. s.), India. Current World Environment. 2020;15(2):289-303.
10. Omer M, Idowu OJ, Ulery AL, VanLeeuwen D, Guldan SJ. Seasonal changes of soil quality indicators in selected arid cropping systems. Agriculture. 2018;8(8):124
11. Willy DK, Muyanga M, Mbuvi J, Jayne T. The effect of land use change on soil fertility parameters in densely populated areas of Kenya. Geoderma. 2019;343:245-262.
12. Kharal S, Khanal BR, Pandey D. Assessment of soil fertility under different land use systems in Dhading district of Nepal. Soil Systems, 2018, 2(57). Doi. 10.3390/soilsystems2040057
13. Kavitha C, Sujatha MP. Evaluation of soil fertility status in various agro ecosystems of Thrissur distrct, Kerala, India. International Journal of Agricultural Croop Science. 2015;8(3):328-338.
14. Bharati VS, Dotaniya ML, Shukla SP, Yadav VK. Managing soil fertility through microbes: prospects, challenges and future strategies. Agro-Environmental Sustainability (Singh JS, Seneviratne G, eds.), Springer; c2017. p. 81-111. DOI: 10.1007/978-3-319-49724-2_5.
15. Prasad R, Shivay YS. Agronomic biofortification of plant foods with minerals, vitamins and metabolites with chemical fertilizers and liming. Journal of Plant Nutrition. 2020;43(10):1534-1554.
16. Singh SP, Singh S, Kumar A, Kumar R. Soil fertility evaluation for macronutrients using Parkers Nutrient

Index approach in some soils of Varanasi district of Eastern Uttar Pradesh, India. International Journal of Pure and Applied Bioscience. 2018;6(5):542-548.
17. Singh VK, Gautam P, Nanda G, Dhaliwal SS, Pramanick B, Meena SS *et al*., Soil test based fertilizer application improves productivity, profitability and nutrient use efficiency of rice (*Oryza sativa* L.) under direct seeded condition. Agronomy. 2021;11(9):1756.
18. Tarar MK, Tedia K, Shrivastava RR, Khalkho D, Sengar AS, Dadsena R. Assessment of soil fertility status of research farm, Indira Gandhi Krishi Viswavidyalay, Raipur, Chattishgarh. International Journal of Current Microbiology and Applied Sciences 2023; 12(1):29-35.
19. Hota R, Thomas T, Swaroop N, Singh AK. Assessment of fertility status of soil in major cropping systems from different blocks of Ganjam district, Odisha. The Pharma Innovation Journal. 2022;;11(5):1450-1458.
20. Sachan HK, Krishna D. Assessment of soil fertility status using nutrient index approach in Cassava farms of Rewa Province, Fiji. Indian Journal of Agricultural Research. 2021. DOI: 10.18805/JAReAF-680.
21. Upadhyai K, Nayak BD. Problem and prospects of agricultural development in Upper Assam: A case study of Sadiya block of Tinsukia district. International Journal of Scientific Research Management. 2017;(e-7):6248-6256. Doi.10.18535/ijsrm/v5i7.57.
22. Fargione JE, Bassett S, Boucher T, Bridgham SD, Conant RT, Cook-Patton SC. Natural climate solutions for the United States. Science Advances. 2018;4(11):eaat1869.
23. Giri PR, Bhatt P, Pande KR. Fertility assessment in different depth of soil in rice-wheat cropping system of Western Terai of Nepal. International Journal for Research in Applied Science and Engineering Technology, 2022, 10(III). https://doi.org/10.22214/ijraset.2022.40669.
24. Lalrinfela T, Talukdar MC, Medhi BK, Thakuria RK. Macronutrient status and their spatial variability in soils of Meleng watershed of Jorhat district Assam-a GIS approach. International Journal of Advance Research. 2016;4(10):905-911.
25. Jackson ML. In: Soil chemical anlysis, Prentice Hall of India Pvt. Ltd., New Delhi; c1973. p. 498.
26. Walkley A, Black IA. Estimation of soil organic carbon by chromic acid titration method. Soil Science. 1934;37:29-38.
27. Sharawat KL, Burford JR. Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. Soil Science. 1982;133:53-57.
28. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Science. 1956;25:259-260.
29. Bray, RH, Kurtz LT. Determination of total, organic and available forms of phosphorus in soils. Soil Science. 1945;59:39-45.
30. Hanway JJ, Heidel H. Soil analysis methods as used in Lowa State College, Soil Testing Laboratory, Lowa State College Bulletin. 1952;57:1-131.
31. Parker FW, Nelson WL, Winters E, Miles JE. The broad interpretation and application of soil test summaries. Agronomy Journal. 1951;43(3):103-112.
32. Pathak H. Trend of fertility status of Indian soils. Current Advances in Agricultural Science. 2010;2(1):10-12.
33. Kumar P, Kumar A, Dyani BP, Kumar P, Shahi UP, Singh SP *et al.* Soil fertility status in some soils of Muzaffarnagar District of Uttar Pradesh, India, along with Ganga canal command area. African Journal of Agricultural Research. 2013;8(14):1209-1217.
34. Ravikumar P, Somashekar KR. Evaluation of nutrient index using organic C, available P and available K concentrations as a measure of soil fertility in Varahi River Basin, India. Proceedings of International Academic Ecological Environmental Science. 2013;3(4):330-343.
35. Penn CJ, Camberto JJ. A critical review on soil chemical processes that control how soil pH affects phosphorus availability to plants. Agriculture. 2019;9:120-138.
36. Chakravarty DN, Tiwari SN, Barthakur BC. Assam soils and their fertility management. Research Bulletin 8, Directorate of Research, Assam Agricultural University, Jorhat-6, Assam; c1987.
37. Gogoi S, Mishra G, Deka AK. Soil nutrient dynamics in tea agroforestry ecosystem of Golaghat district of Assam, India. Agriculture Science Digest. 2016;36(3):185-190.
38. Baruah BK, Das B, Medhi C, Misra AK. Fertility status of soil in the tea garden belts of Golaghat District, Assam, India. Journal of Chemistry, 2013, 2013. Artle ID 983297.
39. Nath TN. The macronutrients status of long term tea cultivated soils in Dibrugarh and Sivasagar districts of Assam, India. Environment, 2013, 2(5). May, 2013. ISSN No. 2277-8179.
40. Singh G, Sharma M, Manan J, Singh G. Assessment of soil fertility status under different cropping sequences in district Kapurthala. Journal of Krishi Vigyan 2016;5(1):1-9.
41. Rahman O, Ahmad B, Afzal S. Soil fertility and salinity status of Attock district. Journal of Agricultural Research. 2010;48(4):505-516.
42. Muhr GR, Datta NP, Dever F, Lecy VK, Donahue RR. In: Soil Testing India, USAID, New Delhi, 1965, 120.
43. Barooah A, Bhattacharyya HK, Chetri KB. Soil fertility evaluation of Dibrugarh district, India using nutrient index approach. Academia Journal of Agricultural Research. 2020;8(2):059-071.
44. Singh RP, Mishra SK. Available macronutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (U.P.) in relation to soil characteristics. Indian Journal of Scientific Research. 2012;3(1):11-21.
45. Gurmu G. Soil organic matter and its role in soil health and crop productivity improvement. Academic Research Journal of Agricultural Science and Research. 2019;7(7):475-483.
46. Johnston AE. Soil organic matter, effects on soil and crop. Soil use and management. 2007;2(3):97-105.
47. Campbell CA, Bowren KE, Schnitzer M, Zentner RP, Townley-Smith L. Effect of crop rotation and fertilization on soil organic matter some biochemical properties of a thick black Chernozem. Canadian Journal of Soil Science. 1991;71L:377-387.
48. Djukick I, Zehetner F, Tatzber M, Gerzabek MH. Soil organic matter stocks and characteristics along an Alpine elevation gradient. Journal of Plant Nutrition and Soil Science. 2010;173:30-38.
49. Liu J, Cai H, Chen S, Pi J, Zhao L. A review on soil nitrogen sensing technologies: Challenges, Progress and Prospectives. Agriculture 2023; 13(4):743 https://doi.org/10.3390/agriculture13040743

50. Baruah TC, Barthakur HP. A textbook on soil analysis. Vikash Publishing House PVT. LTD. 576. Masjid Road, Jangpura, New Delhi 110014; c1997.
51. Uzoho BU, Ekpe II, Ahukaemere CM, Ndukwu BN, Okoli NH, Osisi FA. Nitrogen status of soils of selected land uses of two cropping systems in the humid tropical rainforest, Southeastern Nigeria. Advances in Life Science and Technology. 2014;25:24-33.
52. Asok KS. Studies on soil aggregation in Vertisols of North Karnataka. M.Sc. (Agri) Thesis. Univ. Agric. Sci. Dharwad (India); c2000.
53. Zou C, Pearce RC, Grove JH, Li Y, Hu X, Chen J. *et al*. Relationship of agronomic practices on soil nitrogen dynamics. Open access peer-reviewed chapter. November 5th; c2018.
54. Sharma KL, Mandal B, Venkateswaralu. Soil quality and productivity improvement under Rainfed conditions- Indian perspectives. Chapter 8 in Resource Management for Sustainable Agriculture. In Teech; c2012. p. 203-237. http://cativecommons.org/licenses/by/3.0 (DOI: 10.5772/45870).
55. Lizcano-Toledo R, Reyes-Martin MP, Celi L, Fernandez-Ondono E. Phosphorus dynamics in the soil-plant-environment relationship in cropping systems: A review. Applied Sciences. 2021;11:11133.
56. Barooah A, Bhattacharyya HK, Chetri KB. Assessment of soil fertility of some villages of Lahowal Block, Dibrugarh, India. International Journal of Current Microbiology and Applied Sciences. 2020;9(8):1438-1450.
57. Basumatary A, Baruah R, Medhi BK. Spatial variability of fertility status of soils of upper Brahmaputra valley zones of Assam. Asian Journal of Soil Science. 2014;9(1):142-148.
58. Johan PD, Ahmed OH, Omar L, Hasbullah NA. Phosphorus transformation in soils following co-application of charcoal and wood ash. Agronomy 2021; 11(10), 2010; https://doi.org/10.3390/agronomy11102010
59. Dutta J, Bhuyan B, Misra AK. Chemical estimation of soil fertility status in and around the tea gardens of Gohpur sub-division, Assam. International Journal of Chemical Studies. 2008;6(2):1099-1105.
60. Hu W, Zhao W, Yang J, Oosterhuis DM, Loka DA, Zhou Z. Relationship between potassium fertilization and nitrogen metabolism in leaf subtending the cotton (*Gossypium hirsutum* L.) boll during the boll development stage. Plant Physiological Biochemistry. 2016;101:113-123.
61. Molepo KJ, Ekosse GE, Ngole VM. The role of potassium in the fertility status of soils: A case study of University of Limpopo Experimental Farm, South Africa. Research Journal of Biotechnology. 2014;9(8):78-89.
62. Ramamurthy V, Naidu LGK, Chary GR, Mamatha D, Singh SK. Potassium status of Indian soils: Need for rethinking in research, recommendation and policy. International Journal of Current Microbiology and Applied Sciences. 2017;6(12):1529-1540.
63. Motsari MR. Available NPK status of Indian soils as depicted by soil fertility maps. Fertilizer News. 2002;47(8):15-21.
64. Hasan R, Tiwari KN. Available potassium status of soils of India. Fertilizer Knowledge. No. 1; c2002.
65. Naidu LGK, Ramamurthy V, Sidhu GS, Sarkar D. Emerging deficiency of potassium in soils and crops of India. Karnataka Journal of Agricultural Sciences 2011;24(1):12-19.
66. Pulakeshi HBP, Patil PL, Dasog GS, Radder BM, Mansur CP. Mapping nutrient status by geographic information system (GIS) in Montagani village under northern transition zone of Karnataka. Karnataka Journal of Agricultural Sciences. 2012;25(3):232-235.
67. Bhavsar MS, Ghagare RB, Shinde SN. Study of different phosphorus fractions and their relationship with soil properties in Agricultural Botany Research Farm, Nagpur, India. International Journal of Current Microbiology and Applied Science. 2018;7(1):1130-1137.