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DISTRIBUTION AND INDEXATION OF PLANT AVAILABLE NUTRIENTS IN BATHINDA DISTRICT OF SOUTH - WEST PUNJAB , INDIA

B. K. Yadav[1], A.S. Sidhu[2] and Deepak Kumar[3]

ABSTRACT

The block wise soil fertility was study for provision of guidelines to farmers and researchers for better crop production. The study was conducted in soil and water testing laboratory, PAU regional station, Bathinda, Punjab during 2012-2016. Results showed that, the soils were neutral to alkaline in reaction. About 85.0% samples had EC values within the normal range (< 0.8 dSm^{-1}) while 15% samples had EC > 0.8 dSm^{-1}. Maur blocks showed 18.8 % samples above salinity hazard followed by Bathinda (15.7 %) and Sangat (15.3%). Majority of samples ranged between low to medium organic carbon. The SOC ranged from 0.02 to 1.15%, 0.02 to 1.17%, 0.02 to 1.19%, 0.03 to 1.07%, 0.03 to 1.37% and 0.08 to 1.37% in Bathinda, Sangat, Talwandi-Sabo, Maur, Nathana and Rapura-Phul blocks, respectively. In general, available P ranged from low to medium, but high values of available P were also found in some part. The maximum average P was found in Nathana block (16.77 kg ha^{-1}) followed by Bathinda (16.53 kg ha^{-1}) and Maur (16.36 kg ha^{-1}). Potassium content of these soils are generally medium to high and only about 10% soil samples showed K deficiency. The Nutrient index revealed that the soils were low in available N, low to medium in available P and medium to high in available K content. The study also revealed that there was wide variation in soil fertility status of soils developed on various land forms in Bathinda district, but, by and large, the soils were low in available N, low to medium in available P and medium to high in available K content. The deficient nutrients had to be restored through chemical fertilizers and/or organic manures to maintain soil health. For efficient and sustainable crop production in these soils, a farming system that is both soil enriching and restoring needs to be developed.

(Key words: Soil pH, soil EC, organic carbon, available phosphorus, available potassium, soil fertility, nutrient index)

INTRODUCTION

In developing nations like India, where population is continuously increasing and land person ratio is rapidly declining; the only means to fulfil the needs of agricultural produce is through increased productivity without thrashing to environment and sustainability. A system is sustainable when it improves or at least maintains the quality of soil, water, plant and atmosphere. A soil looses a considerable amount of nutrients every year depending upon the cropping pattern, leaching and erosion. If cropping is continued over a period of time without nutrients being restored to the soil, its fertility will be reduced and crop yields will decline. The increasing population has forced farmers to make use of high doses of chemical fertilizers. The imbalance nutrient and incorrect amounts of chemical fertilizer use is a serious threat to sustainable agricultural production system. The success in soil management to maintain the soil quality depends on an understanding of how the soil responds to agricultural practices over time. In Punjab, majority of the farmers are following three or more crops rotation per year and are using large quantity of fertilizers, insecticides, pesticides in order to harvest maximum gross returns without taking into consideration the soil fertility status. Manan *et al.* (2016) reported that Punjab farmers applied more quantity of di-ammonium phosphate (DAP) than the recommendations, which lowered the net returns. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximising crop yields. Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes (Goovaerts,1998). It also helps in applying different nutrients in balanced ratio so as to get maximum efficiency of the applied fertilizers and profitable crop production (Motsara, 2002). In soil test measure some fraction of total supply of nutrients in the soil indicate its available nutrient level. The higher soil test values mean higher level of nutrients and thus, the lower will be the need for fertilization and vise-versa. The soil test data usually are summarized for a respective block and district and on an all India level. Such

1. Asstt. Soil Chemist, PAU, Regional Station, Bathinda-151001, Punjab, India
2. Sr. Scientist (Irrigation), PAU, Regional Station, Bathinda-151001, Punjab, India
3. Sr. Res. Fellow, PAU, Regional Station, Bathinda-151001, Punjab, India

soil fertility summaries are useful to administrators and planner in deciding the kind and amount of fertilizer most suitable in each area or district and determining the policy of fertilizer, distribution and consumption in different regions. The data also are of use to fertilizer association, fertilizer industries and extension workers in promoting their respective programme and to research workers, particularly from the point of view of changes in fertility levels, conditioned by different fertilizer use or by different soil and crop management practices. However, information regarding the effect of various cropping sequences followed by the farmers on the soil fertility status was lacking for Bathinda district, Punjab. The main objective of the study was to compile information on soil fertility and soil salinity/ sodicity status of district Bathinda, Punjab, India on the basis of soil samples analyzed during the last five years 2012-2016.

MATERIALS AND METHODS

Study area and its climate

The Bathinda district covers an area of 336725 ha, and it is situated in the southern part of Punjab in the Malwa region of North-West India. The district is lying between 74º38' to 75º46' E longitudes and 29º33' to 30º36' N latitude and 211 m high from the mean sea level. The climate of the area is characterized by a large seasonal variation as well as fluctuations both in monthly rainfall and temperature. The district falls in the semi arid region of Punjab having annual average rainfall of 523 mm. The total rainfall varies between 263.2 mm for 2012 to 619.0 mm for 2016 in the district. The maximum and minimum temperature varies between 42ºC and 4.8ºC, respectively. The district is surrounded by Mansa and Sangrur districts in the East, Muktasar and Faridkot districts in the northwest and on the north east Moga is located. Fatehabad and Sirsa (Haryana) districts are situated on the south of Bathinda district.

Processing and soil analysis

The study was conducted in Soil and Water Testing Laboratory, PAU, Regional Station, Bathinda, Punjab during 2012-2016. All the collected samples (2506) were air dried in shade, crushed gently with pestle and mortar, and then sieved through 2.0 mm sieve to obtain a uniform soil sample before analysed for different basic soil chemical properties and available nutrients. The pH of soil was determined in 1: 2, soil: water suspension at room temperature with single electrode pH meter (Richards, 1954). Conductivity Bridge was used to measure the electrical conductivity of 1: 2, soil: water suspension after overnight equilibration (Richards, 1954). Organic carbon was determined according to the Wet Digestion Method as described by Walkley and Black (1934). Available phosphorus was extracted by 0.5M $NaHCO_3$ solution buffer at pH 8.5 (Olsen *et al.*, 1954) and phosphorus was determined by ascorbic acid method (Watanabe and Olsen, 1965). The available K was extracted by neutral normal ammonium acetate and was determined by using flame photometer, as described by Richards (1954). The soil samples were categorized for various classes of soil parameters as per criteria (Arora, 2002) given in table 1. The data were subjected to statistical analysis using MS Excel 2007 package. Nutrient Index in order to compare the levels of soil fertility of one area with those of another, it is necessary to obtain a single value for each nutrient. Here the nutrient Index (NI) was calculated by following formula suggested by Parker *et al.* (1951).

Nutrient Index (NI) = ((Nl × 1) + (Nm × 2) + (Nh × 3))/ Nt,

Where Nt =Total number of samples analyzed in a given area.

Nl = Number of samples falling in low category of given nutrient.

Nm = Number of samples falling in medium category of given nutrient.

Nh= Number of samples falling in high category of given nutrient.

Nutrient index value below 1.5, in between 1.5 to 2.5 and above 2.5 has been considered as low, medium and high, respectively (Motsara, 2002).

RESULTS AND DISCUSSION

Soil reaction (pH)

The study on soil reaction (pH) presented in table 2 revealed that the soils were neutral to alkaline in reaction and pH ranged from 6.8 to 10.0 in Bathinda Sangat and Nathana block, 6.9 to 9.9 in Talwandi-Sabo block, 5.20 to10.0 in Maur block, and 7.5 to 9.4 in Rampura- Phul block with an average mean value from 8.4 to 8.5 during the study year. The data presented in Fig. 1 further revealed that 47.4 to 54.6 % samples during 2012 (excluding Rampura-Phul Block), 7.5 to 32.1 % during 2013, 7.7 to 17.6 % during 2014, 11.3 to 28.2 % during 2015 and 8.7 to 38.9 % during 2016 were alkaline to highly alkaline in reaction. The data regarding pH of the soils presented in table 2 revealed that the soils were neutral to alkaline in reaction. These high values might be due to presence of soluble and exchangeable sodium along with HCO_3^- ions, which precipitates calcium and magnesium carbonates during evaporation. Alkalinity problem in soils is due to the indigenous calcareous parent material with typical low organic matter content (Brady and Weil, 2007).When the average values are taken into consideration, the area looks free from salinity/sodicity menace. Verma *et al.* (2005) reported that soil pH varied from 8.16 to 9.62 in Mansa district of Punjab. Whereas, Singh *et al.* (2016) reported that pH value of soils in Kapurthala district of Punjab varied from 6.79 to 9.87. Sorte *et al.* (2016) analysed soils of Narkhed tahsil, Nagpur district of Maharashtra and reported that soils were neutral to moderately alkaline in reaction. It is observed that the soil alkalinity improved in all the blocks due to awareness of farmers and adopted practices for control the soil salinity/ sodicity. The major crop rotation followed by farmers was cotton/rice–wheat crop rotation so the farmers of these villages were educated for regular soil testing. After soil testing there were sufficient time between harvesting of wheat and transplanting of rice, therefore green manuring followed by gypsum application on the basis of soil test report was recommended in the rice growing blocks to enhance the crop productivity and sustain the soil health.

Electrical conductivity (EC)

The data (Table 2) showed the distribution of electrical conductivity in different blocks of Bathinda during the study year 2012-2016. The electrical conductivity varied from 0.04 to 5.70 dSm^{-1} with an average mean value of 0.57 dSm^{-1} in Bathinda block, from 0.03 to 5.70 dSm^{-1} with an average mean value of 0.61 dSm^{-1} in Sangat block, from 0.01 to 2.47 dSm^{-1} with an average mean value of 0.54 dSm^{-1} in Talwandi-Sabo block, from 0.12 to 5.53 dSm^{-1} with an average mean value of 0.65 dSm^{-1} in Maur block, from 0.12 to 4.50 dSm^{-1} with an average mean value of 0.52 dSm^{-1} in Nathana block and 0.03 to 3.80 dSm^{-1} with an average mean value of 0.47 dSm^{-1} in Rampura-Phul block. The average mean values indicated that salinity was not at all a problem in all blocks of the district and was in the order of the order Maur > Sangat > Bathinda > Talwandi-Sabo > Nathana >Rampura-Phul. Data (Fig. 1) indicated that the no soil samples were found above salinity hazard in Maur block during 2012, Rampura-Phul block during 2013 and 2014. On an average Maur block showed maximum (18.8 %) soil samples above salinity hazard followed by Bathinda (15.7 %) and Sangat block (15.3 %), however, Rampura-Phul blocks showed minimum (5.9 %) soil samples below salinity hazard followed by Nathana (11.4 %) and Talwandi-Sabo block (11.9 %) irrespective of the year. The average mean values of electrical conductivity (EC) indicated that salinity was not at all a problem in all blocks of the district and was in the order of Maur > Sangat > Bathinda > Talwandi-Sabo > Nathana >Rampura-Phul. Verma *et al.* (2005) found the range of EC from 0.07 to 0.77 with mean value of 0.32 dSm^{-1} in soils of arid tract of Punjab, India. The lower values of electrical conductivity in these soils may be attributed to more macro pores, as majority of the soil samples in the area are light textured, resulting in free drainage conditions. To overcome to salinity hazard in salt affected areas the farmers were advised to grow salt tolerant crops and use of organic manures in order to get higher crop yield under such situation.

Organic carbon (OC)

Organic matter plays a vital role in agricultural soil, which supplies plant nutrient, improve the soil structure, improve water retention and infiltration, feeds soil micro flora and fauna, and the retention and cycling of applied fertilizer (Johnston, 2007). Nitrogen requirements are usually recommended by the Soil Testing Laboratories, based on the estimation of nitrogen released by the soil organic matter contents (Cooke, 1982). The SOM contents (Table 3) ranged from 0.02 to 1.15%, 0.02 to 1.17%, 0.02 to 1.19%, 0.03 to 1.07%, 0.03 to 1.37% and 0.08 to 1.37% with average mean value of 0.44%, 0.39%, 0.41%, 0.44%, 0.44% and 0.48% in blocks Bathinda, Sangat, Talwandi-Sabo, Maur, Nathana and Rapura-Phul, respectively. The soils of the each block were low in organic carbon content, when the average values are taken in to consideration. The distribution of soil samples with respect to organic carbon content (Fig. 2) indicates that majority of soil samples ranged between low to medium. The block wise perusal of the data indicates that about 15% soil samples from Bathinda block had high organic carbon. In Sangat and Talwandi-Sabo block about 7% and 4% soil samples fall in high organic carbon range. Whereas, about 18%, 19% and 11% soil samples from Maur, Rampura-Phul and Nathana blocks had high organic carbon respectively. The soils of the each block were low in organic carbon content, when the average values are taken into consideration. Verma *et al.* (2005) reported that the soils of Mansa district of Punjab were low in organic carbon content. Singh *et al.* (2016) also reported that the soils of Kapurthala district of Punjab were low to medium in organic carbon content. The decline in SOM might be due to crops grown without or very meagre addition of plant and animal manners, due to burning of paddy and wheat straw residues in paddy-wheat cropping sequence. The high temperature prevailing in the area is also responsible for the rapid burning of organic matter, thus resulting in low to medium organic carbon content of these soils. Since organic matter contents are an indicator of available nitrogen status of soils, thus the soils of the area were also dominantly low in respect of their available nitrogen. Therefore, the farmers who have low OC content in soils were encouraged to use organic manures such as green manure and farmyard manure etc. so that the optimum crop productivity can be maintained for a longer period.

Available phosphorus (P)

The P range within the district is quite large which might be due to variation in soil properties viz., pH, organic matter content and various soil management and agronomic practices. The value of available phosphorus content varied from 2.5 to 95.0 kg ha^{-1} with an average mean value of 16.53 kg ha^{-1} in Bathinda block, 2.5 to 62.5 kg ha^{-1} with an average mean value of 14.43 kg ha^{-1} in Sangat block, 2.5 to 72.5 kg ha^{-1} with an average mean value of 15.30 kg ha^{-1} in Talwandi-Sabo block, 3.0 to 43.8 kg ha^{-1} with an average mean value of 14.13 kg ha^{-1} in Maur block, 2.5 to 70.8 kg ha^{-1} with an average mean value of 16.36 kg ha^{-1} in Nathana block and 5.0 to 72.5 kg ha^{-1} with an average mean value of 16.77 kg ha^{-1} in Rampura-Phul block. Considering the soil test rating for available phosphorus (Table 2) majority of the soils in the Bathinda district fell under low status. In general, available P ranged from low to medium, but high values of available P were also found in some part of the district (Fig. 2 & 3). About 78-95% soil samples tested ranged as low and 5-18% samples tested ranged as medium for available P content in Bathinda block. The data indicated that in Sangat block 78-99% samples were low and 1-20% samples were medium in available P content. 85- 96 % and 3-15% samples were found in low and medium category respectively, in Talwandi-Sabo block. The Maur, Rampura-Phul and Nathana blocks comprised 80-100%, 28-100% and 0-100% samples in low category, whereas 7-20%, 0-71% and 0-92% samples were found in medium category respectively. Considering the soil test rating for available phosphorus (Table 1) majority of the soils in the Bathinda district fell under low status. In general, available P ranged from low to medium, but high values of available P were also found in some part of the district (Fig. 2 & 3). These results were in conformity with the findings of Verma *et al.* (2005), who reported that available P content in soils of Mansa district of Punjab varied from 1.8 to 59.6 kg ha^{-1} with a mean value of 18.46 kg ha^{-1}. Similar results were also reported by Pathak (2010) and Singh *et al.* (2016), who concluded that available phosphorus ranged from medium to high category in India and Kapurthala district of Punjab, respectively. The reasons for poor available phosphorus is that farmers do not apply phosphatic fertilizers to crops according to recommendations and only nitrogenous fertilizers are applied due to price hike of phosphatic fertilizers. However, low to medium range of soil available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture, various soil management and agronomic practices (Verma *et al.,* 2005).

Available potassium (K)

The available potassium content of these soils is generally medium to high. The average K (Table 3) ranged from 281.9 to 405.0 kg ha^{-1} with a mean value of 337.14 kg ha^{-1} in Bathinda block, 234.0 to 412.5 kg ha^{-1} with a mean value of 313.08 kg ha^{-1} in Sangat block, 252.5 to 393.9 kg ha^{-1} with a mean value of 321.06 kg ha^{-1} in Talwandi-Sabo block, 221.0 to 335.3 kg ha^{-1} with a mean value of 281.1 kg ha^{-1} in Maur block, 232.8 to 347.1 kg ha^{-1} with a mean value of 274.0 kg ha^{-1} in Nathana block and 192.2 to 310.1 kg ha^{-1} with a mean value of 273.7 kg ha^{-1} in Rampura-Phul block. The frequency distribution data (Fig. 2 & 3) indicated that maximum 14%, 7%, 6%, 3%, 9%, 21% and 10% soil samples showed K deficiency in Bathinda, Sangat, Talwandi-Sabo, Maur, Rampura-Phul and Nathana block, respectively. The available potassium content of these soils is generally medium to high. Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium rich minerals like Illite and Feldspars (Sharma *et al.,* 2008). The K content had invariably been reported as adequate in Punjab soils except eroded or light textured soils (Bajwa, 1990). Moreover, as the ground waters of Bathinda district have considerable amount of dissolved potassium, irrigation with such waters also results in higher amounts of available K in these soils (Patel *et al.,* 2000). The result was in line with finding of Sorte *et al.* (2016), who reported that soils of Narkhed tahsil of Nagpur district were moderately high to very high in available K status. Verma *et al.* (2005) reported the available K content in Mansa district of Punjab was generally medium to high, and ranged from 67.2 to 851.2 kg ha^{-1} with mean value of 291.15 kg ha^{-1}.

Nutrient Index (NI)

The nutrient index, which indicates the overall fertility status of an area, was calculated (Parker *et al*., 1951) and data are presented in Fig. 4. It shows that available N was practically medium in Bathinda, Rampura-Phul and Nathana blocks during 2012. Maur block showed medium nitrogen during 2013, whereas during 2014 Bathinda and Maur blocks showed medium nitrogen. Only Nathana block showed medium nitrogen during 2015 and except Sangat block, all blocks showed medium nitrogen during 2016. Index for available P for all the blocks of district was low during 2012-2016, however, only Nathana block showed medium P (2.1) in the year 2012. The nutrient index for available K in the district is medium to high. The Bathinda, Sangat, Talwandi-Sabo and Maur blocks possess high nutrient index (2.7) in terms of potassium for 2012, whereas, all the blocks had medium values for potassium nutrient index during the study year. The observed differences in the nutrient index in different blocks were probably due to difference in the cropping sequence being followed by the farmers.

The parameters such as pH, EC, OC, available phosphorus and available potassium were undertaken for study. The study revealed that there was wide variation in soil fertility status of soils developed on various land forms in Bathinda district, but, by and large, the soils were low in available N, low to medium in available P and medium to high in available K content. The deficient nutrients had to be restored through chemical fertilizers and/or organic manures to maintain soil health. For efficient and sustainable crop production in these soils, a farming system that is both soil enriching and restoring needs to be developed.

Table 1. The criteria used to categorize the soil samples for various classes of soil parameters

Soil parameters	Rating		
pH (1:2)	Normal	Alkaline	Highly alkaline
	6.5-8.7	8.8-9.3	>9.3
EC (dSm^{-1}) (1:2)	Normal	Saline	
	<0.8	>0.8	
	Fertility rating of major nutrients		
	Low	Medium	High
Organic carbon (%)	<0.5	0.5-0.75	>0.75
Phosphorus (P_2O_5) (kg ha^{-1})	<22	22-55	>55
Potassium (K_2O) (kg ha^{-1})	<110	110 – 280	>280

Table 2. Distribution of soil reaction (pH) and electrical conductivity (EC) in different blocks for year 2012-2016

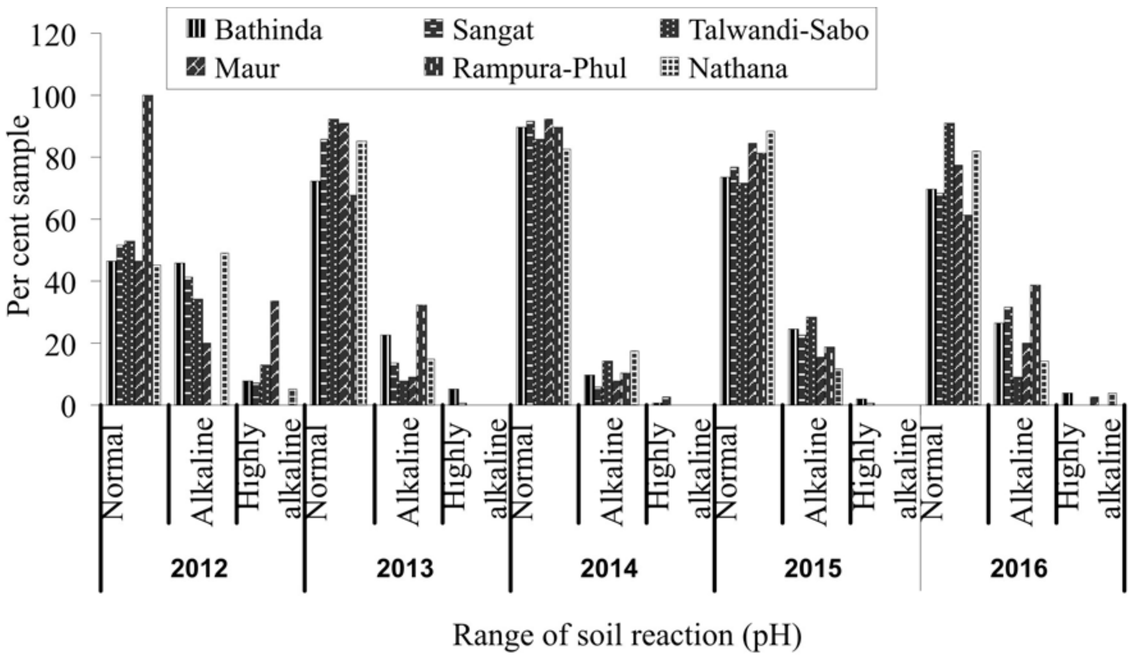
Soil parameter		Soil reaction (pH)		Electrical Conductivity (EC)	
Block	Year	Range	Mean ± SEm*	Range	Mean ± SEm*
Bathinda	2012 (340)	6.80 -10.00	8.77 ± 0.023	0.10 - 4.20	0.46 ± 0.020
	2013 (208)	7.07 - 9.66	8.53 ± 0.031	0.09 - 3.47	0.58 ± 0.032
	2014 (147)	6.80 - 9.50	8.24 ± 0.066	0.04 - 4.00	0.54 ± 0.044
	2015 (179)	7.24 - 9.72	8.52 ± 0.030	0.14 - 5.70	0.57 ± 0.045
	2016 (206)	6.60 - 9.61	8.50 ± 0.034	0.12 - 5.26	0.70 ± 0.045
Sangat	2012 (85)	7.00 -10.00	8.66 ± 0.063	0.03 - 5.70	0.65 ± 0.038
	2013 (126)	7.18 - 9.50	8.44 ± 0.028	0.08 - 3.15	0.49 ± 0.047
	2014 (83)	6.80 - 9.80	8.21 ± 0.049	0.16 - 1.40	0.44 ± 0.024
	2015 (150)	7.53 - 9.40	8.51 ± 0.028	0.10 - 2.80	0.58 ± 0.040
	2016 (114)	7.43 - 9.34	8.54 ± 0.036	0.17 - 3.80	0.88 ± 0.042
Talwandi - Sabo	2012 (76)	6.90 - 9.93	8.74 ±0.062	0.01 - 2.10	0.53 ± 0.040
	2013 (53)	7.04 - 9.23	8.14 ±0.070	0.14 - 2.47	0.52 ± 0.058
	2014 (72)	6.90 - 9.24	8.27 ±0.051	0.12 - 2.02	0.55 ± 0.047
	2015 (71)	7.24 - 9.28	8.58 ±0.043	0.13 - 2.00	0.54 ± 0.038
	2016 (103)	7.23 - 9.05	8.33 ±0.034	0.13 - 1.88	0.55 ± 0.030
Maur	2012 (15)	8.00 -10.00	8.91 ± 0.153	0.12 - 0.80	0.44 ± 0.056
	2013 (22)	5.20 - 8.90	8.22 ± 0.153	0.18 - 3.02	0.81 ± 0.053
	2014 (13)	7.90 - 9.10	8.37 ± 0.092	0.14 - 1.92	0.71 ± 0.057
	2015 (51)	7.61 - 9.27	8.49 ± 0.047	0.16 - 1.47	0.48 ± 0.041
	2016 (35)	8.08 - 9.37	8.53 ± 0.056	0.19 - 5.35	0.82 ± 0.015
Nathana	2012 (55)	7.30 - 9.64	8.68 ± 0.065	0.14 - 1.40	0.48 ± 0.040
	2013 (27)	7.91 - 9.06	8.38 ± 0.062	0.15 - 1.32	0.49 ± 0.054
	2014 (17)	7.65 - 8.94	8.30 ± 0.010	0.18 - 0.89	0.42 ± 0.045
	2015 (97)	6.80 - 9.02	8.19 ± 0.053	0.12 - 2.70	0.50 ± 0.047
	2016 (78)	6.69 - 9.97	8.42 ± 0.057	0.14 - 4.50	0.70 ± 0.044
Rampura-Phul	2012 (15)	8.09 - 8.70	8.43 ± 0.043	0.03 - 0.98	0.51 ± 0.043
	2013 (17)	8.10 - 9.39	8.63 ± 0.072	0.12 - 0.80	0.41 ± 0.027
	2014 (16)	7.53 - 9.05	8.29 ± 0.084	0.22 - 0.82	0.47 ± 0.036
	2015 (18)	8.06 - 9.05	8.44 ± 0.070	0.27 - 1.07	0.43 ± 0.050
	2016 (17)	8.00 - 9.22	8.63 ± 0.052	0.18 - 3.80	0.53 ± 0.045

Values in parentheses indicate the number of soil samples analysed;
*SEm = Standard error of the mean

Table 3. Distribution of organic carbon, phosphorus and potassium in different blocks for year 2012-2016

Soil parameter		Organic carbon (%)		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
Block	Year	Range	Mean ± SEm*	Range	Mean ± SEm*	Range	Mean ± SEm*
Bathinda	2012(340)	0.02-1.15	0.44 ± 0.014	2.5-72.5	14.35 ± 0.48	25.0 - 1117.5	405.0 ± 9.7
	2013(208)	0.03-0.97	0.40 ± 0.013	2.5-57.5	11.23 ± 0.51	107.5 - 950.5	281.9 ± 10.2
	2014(147)	0.02-0.99	0.46 ± 0.017	3.0-58.8	17.23 ± 0.69	93.8 - 980.0	384.6 ± 12.7
	2015(179)	0.02-0.93	0.43 ± 0.015	3.0-62.5	18.65 ± 0.70	147.5 - 1080.0	322.6 ± 11.7
	2016(206)	0.03-0.99	0.45 ± 0.017	2.5-95.0	21.18 ± 0.61	45.0 - 803.8	291.6 ± 12.3
Sangat	2012(85)	0.02-1.02	0.42 ± 0.023	2.5-35.0	12.43 ± 0.78	160.0 - 817.5	412.5 ± 15.2
	2013(126)	0.02-1.17	0.34 ± 0.019	2.5-56.3	11.93 ± 0.69	145.0 - 650.0	234.0 ± 12.1
	2014(83)	0.02-0.98	0.39 ± 0.022	3.0-58.8	18.15 ± 0.65	105.0 - 950.0	328.6 ± 17.2
	2015(150)	0.02-0.87	0.40 ± 0.015	6.0-62.5	14.53 ± 0.69	77.5 - 867.5	244.6 ± 12.4
	2016(114)	0.03-1.13	0.41 ± 0.018	5.3-48.3	15.13 ± 0.66	137.5 - 727.5	345.7 ± 16.5
Talwandi-Sabo	2012(76)	0.03-0.84	0.39 ± 0.018	2.8-55.0	14.08 ± 0.90	75.0 - 895.0	393.9 ± 14.9
	2013(53)	0.08-1.02	0.41 ± 0.026	2.8-55.0	11.20 ± 0.68	87.5 - 850.0	252.5 ± 10.2
	2014(72)	0.03-1.19	0.42 ± 0.022	2.5-45.0	14.73 ± 0.57	80.0 - 861.3	319.8 ± 14.6
	2015(71)	0.08-0.80	0.37 ± 0.021	4.5-72.5	17.70 ± 0.81	57.5 - 943.8	343.0 ± 15.4
	2016(103)	0.02-0.80	0.44 ± 0.018	2.5-70.0	18.80 ± 0.76	42.5 - 747.5	296.1 ± 15.0
Maur	2012(15)	0.08-0.87	0.31 ± 0.025	4.5-26.3	13.88 ± 0.58	155.0 - 487.5	335.3 ± 12.3
	2013(22)	0.11-0.92	0.45 ± 0.034	3.8-18.8	10.35 ± 0.76	160.0 - 430.0	221.0 ± 12.9
	2014(13)	0.03-0.93	0.57 ± 0.046	9.3-22.0	14.23 ± 0.69	112.5 - 812.5	319.0 ± 14.3
	2015(51)	0.08-0.82	0.39 ± 0.025	4.5-36.8	14.68 ± 0.65	145.0 - 512.5	253.9 ± 11.8
	2016(35)	0.08-1.07	0.46 ± 0.038	3.0-43.8	17.53 ± 0.51	45.0 - 610.0	276.3 ± 11.7
Nathana	2012 (55)	0.15-1.04	0.47 ± 0.020	2.5-35.0	12.85 ± 0.10	155.0 - 750.0	347.1 ± 12.1
	2013 (27)	0.09-0.90	0.47 ± 0.029	4.5-35.0	19.80 ± 0.58	147.5 - 767.5	232.8 ± 10.1
	2014 (17)	0.11-0.68	0.35 ± 0.018	4.5-18.8	12.05 ± 0.55	135.8 - 690.0	254.1 ± 12.2
	2015 (97)	0.06-0.95	0.47 ± 0.016	4.5-70.8	18.63 ± 0.70	150.0 - 800.0	294.2 ± 10.4
	2016 (78)	0.03-1.37	0.46 ± 0.026	3.8-55.5	18.48 ± 0.65	85.0- 755.0	243.2 ± 11.7
Rampura-Phul	2012(15)	0.28-1.02	0.62 ± 0.022	5.0-72.5	23.05 ± 0.51	222.5 - 442.5	303.4 ± 12.8
	2013(17)	0.10-0.95	0.41 ± 0.023	5.0-20.0	11.43 ± 0.74	137.5 - 950.0	310.1 ± 12.5
	2014(16)	0.09-0.85	0.32 ± 0.027	6.3-20.0	12.90 ± 0.69	100.0 - 442.5	192.2 ± 10.7
	2015(18)	0.08-0.75	0.48 ± 0.020	10.0-35.0	17.95 ± 0.72	150.0 - 942.5	303.5 ± 13.7
	2016(17)	0.15-1.37	0.55 ± 0.024	5.0-50.0	18.50 ± 0.59	145.0 - 762.5	259.3 ± 12.8

Values in parentheses indicate the number of soil samples analysed;
*SEm = Standard error of the mean



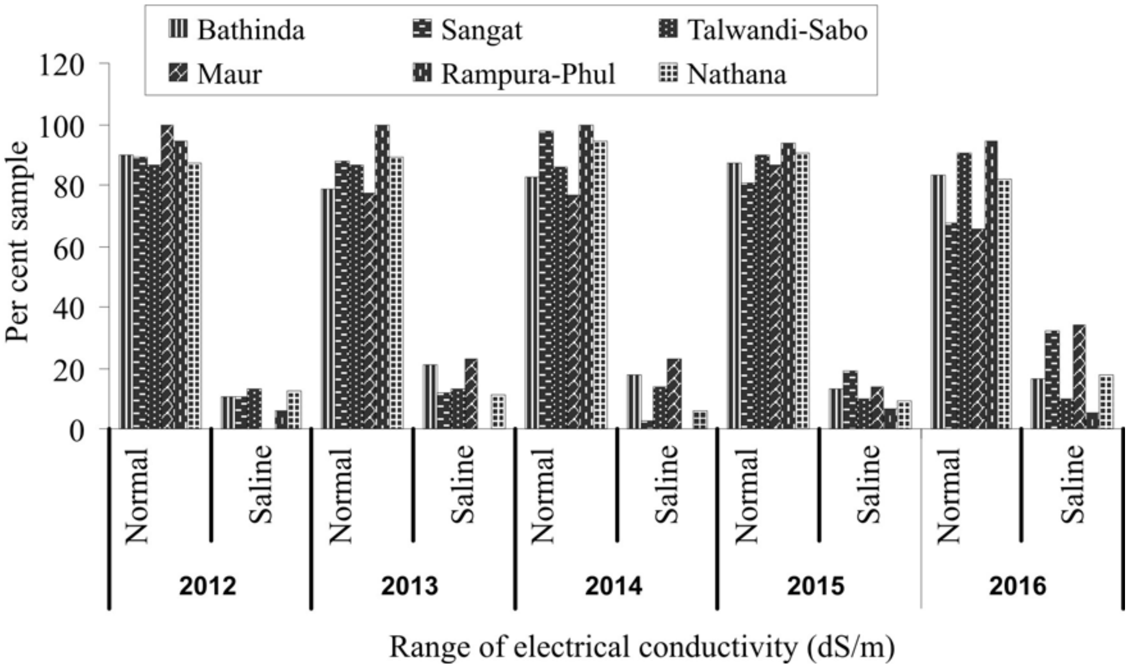


Fig. 1. Per cent distribution of soil reaction (pH) and electrical conductivity (EC) of soils in different blocks for year 2012-2016

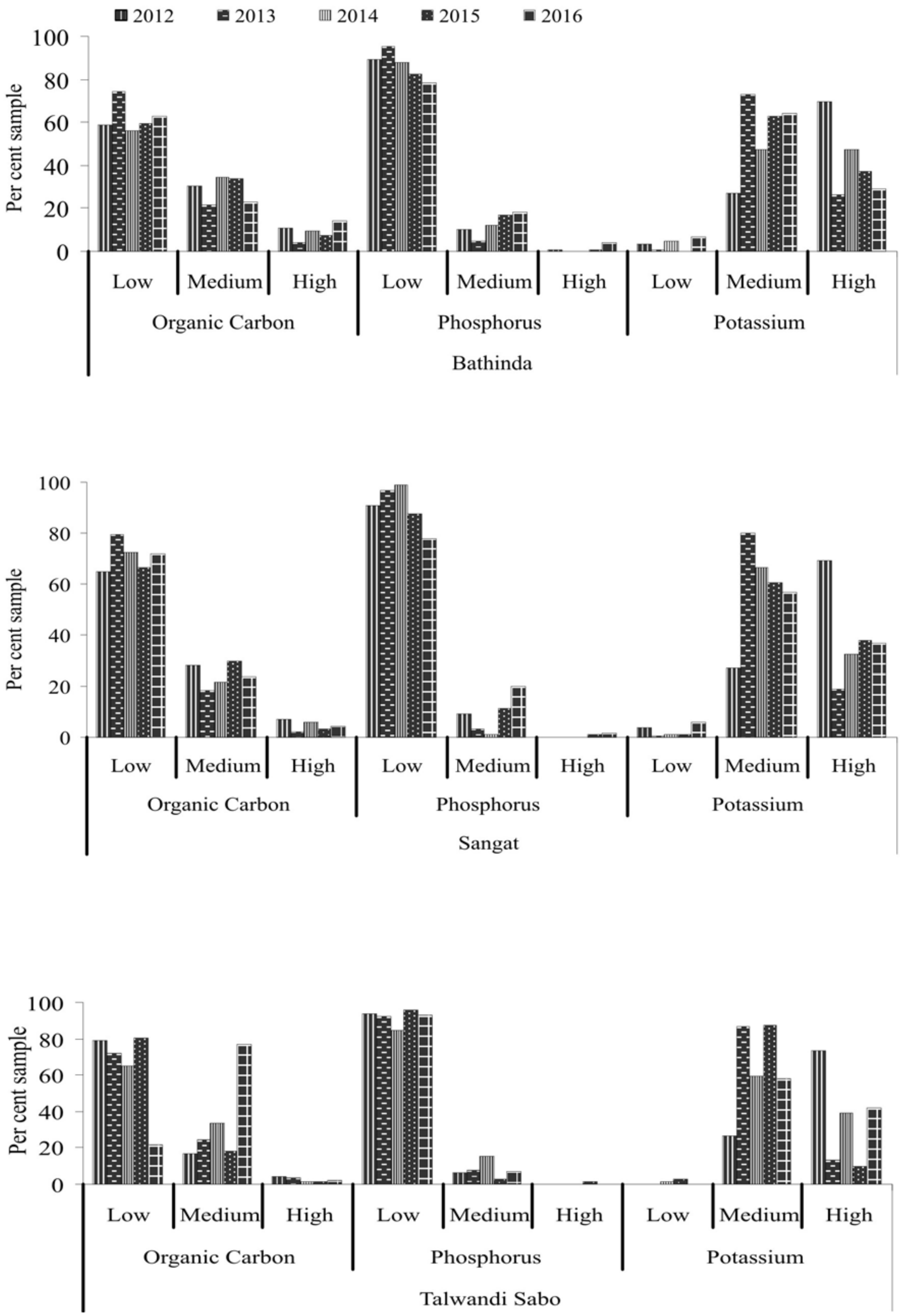


Fig. 2. Per cent distribution of soil available nutrients of Bathinda, Sangat and Talwandi-Sabo blocks for year 2012-2016

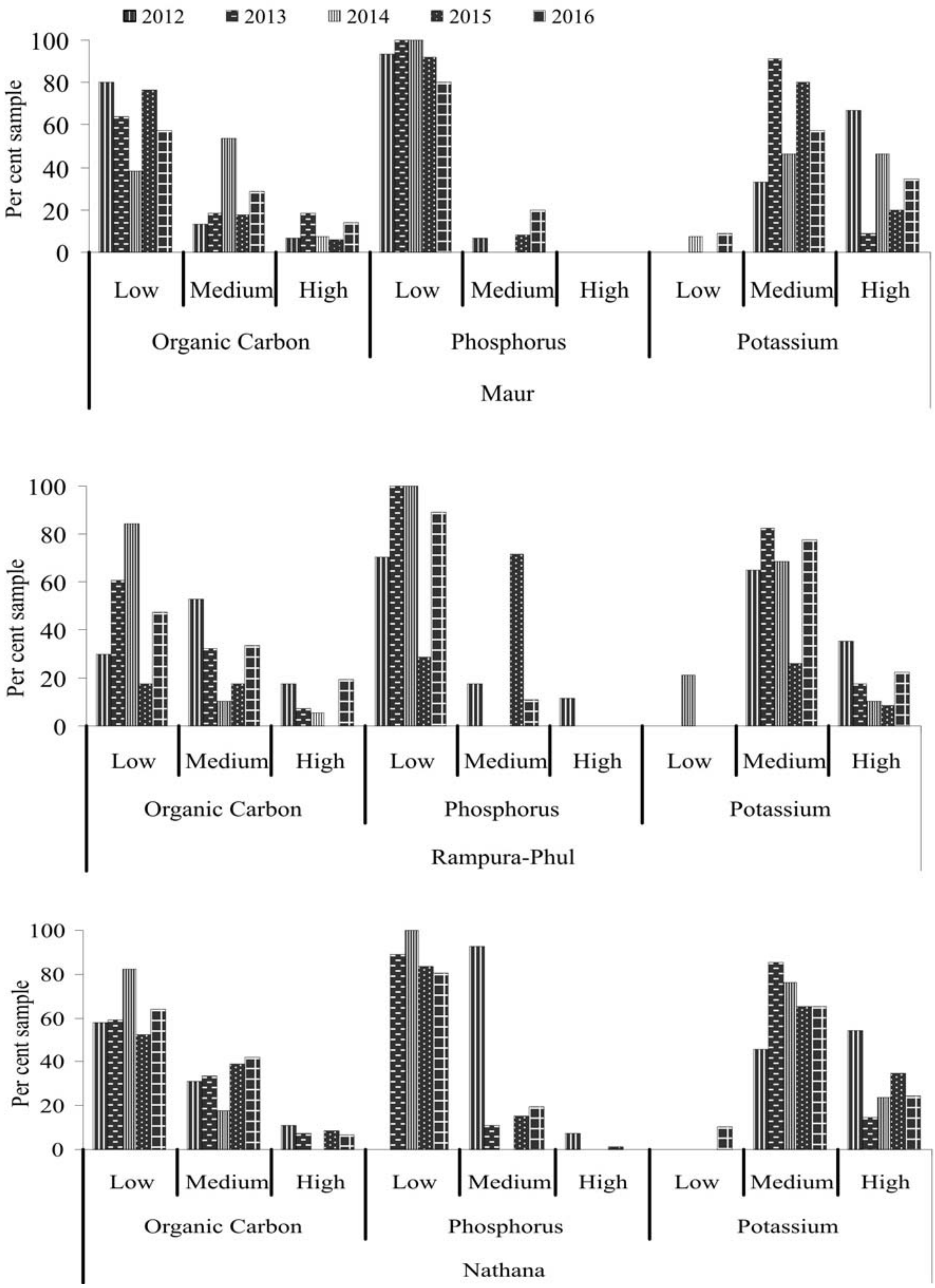


Fig. 3. Per cent distribution of soil available nutrients of Maur, Rampura-Phul and Nathana blocks for year 2012-2016

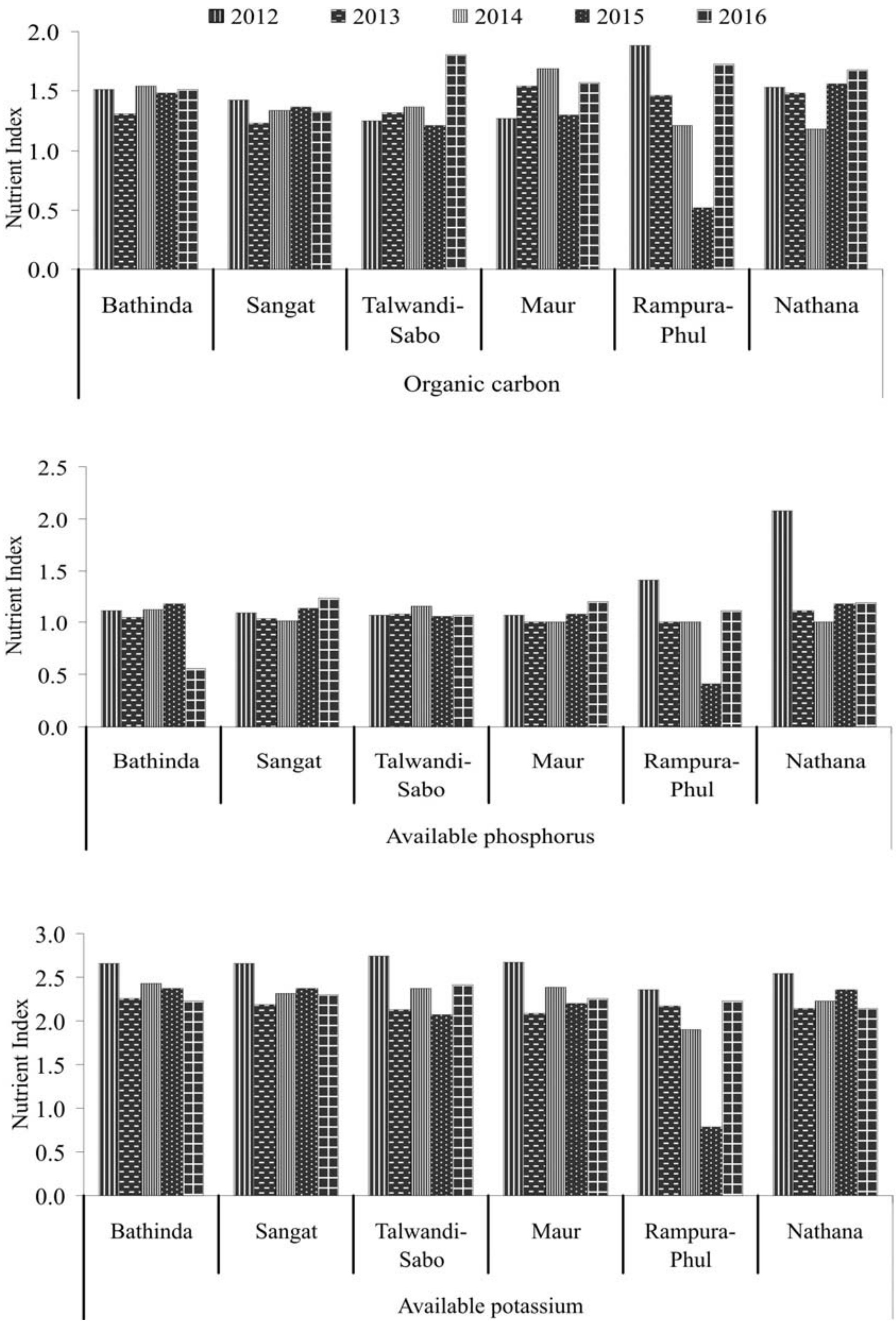


Fig. 4. Soil fertility index of nutrients in different blocks during the year 2012-2016

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