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ASSESSMENT OF SOIL FERTILITY STATUS USING SOIL NUTRIENT INDEX(SNI) OF DIFFERENT VILLAGES OF MAJHGAWAN BLOCK OF SATNA DISTRICT ,MADHYA PRADESH, INDIA

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Keywords Soil fertility, Physico-chemical properties, Majhgawan block, GPS.

ABSTRACT

Soils provide important ecological services for the maintenance and survival of life. Soil health management is critical to maintaining biodiversity and ensuring sustainable agricultural production. Soil health is regulated by soil properties, namely physicochemical and biological properties. Modern agriculture relies heavily on chemical fertilizers. These are inevitable threats to agriculture. Nonetheless, they remain an important tool for global food security. As sustainable agriculture becomes a global goal, the ill effects of chemical fertilizers cannot be ignored. Fertilizers play a vital role in increasing crop yields and soil fertility. There are many kinds of chemical fertilizers, such as nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer. The use of fertilizers not only increases crop yields, but also alters the physicochemical and biological properties of the soil.

The random sampling technique was used to gather thirty soil Samples from fifteen different villages from majhgawan Block (Jhari,Majhgawan,Semra,Malmau,Hinauta,Bandhi,Berahna,Kawar,Machked,Chadai,chetehra,khutha,Birsinghpur,Marwa,Singhpur) Using GPS and bring them to the laboratory for soil physico-chemical properties analysis using standard methods. The collected soil samples were dried ,Sieved and analyzed for different parameters of fertility viz., bulk density, particle density, porosity percentage, water holding capacity, soil pH, electrical conductivity, organic carbon,available nitrogen, available phosphorus, available potassium, exchangeable calcium, exchangeable magnesium and sulfur. The findings indicated that the soils of studied areas were alkaline in nature, free from salinity hazards, rich in organic carbon, high in phosphorus, potassium, exchangeable calcium and magnesium, low in available nitrogen and medium in sulfur content. The findings of this research could help in crop nutrient management, fertilizer recommendation and decision-making for increasing agricultural output and farmer profitability.

1. INTRODUCTION

Growing sufficient quantities of the various crops needed to feed an ever-increasing population is a challenge faced by many countries - particularly, developing and under-developed countries. The availability of fertile land, suitable climatic conditions, and good agricultural practices; combined with a variety of inputs such as high yielding seeds, fertilizers, pest control agents, irrigation etc., play vital roles in this respect. This study aims to give an introduction to chemical impact of fertilizers on soil, one of the most important external inputs in food production.

The agricultural practices around the world are dependent upon extensive use of fertilizers and pesticides. These chemical formulations are being added to improve crop quality and meet the global food demand. Fertilizers and pesticides are also considered as critical farmland tools for food security. On the other hand, the inorganic fertilizers and pesticides have many undesirable aspects which cannot be overlooked. They have properties to remain in soil and environment for a long time and affect various biotic and abiotic factors. They have adverse effects on soil, microflora, other organisms, environment, and human health. These undesirable properties of fertilizers and pesticides have led to the search of another option, i.e., sustainable agriculture, which is attracting the farmers and gaining the attention. In this system, the use of harsh chemicals is avoided and other methods such as organic farming, biofertilizers, composting, and use of bio control agents etc. are adopted and that is sustainable agriculture. Keeping all these aspects in view, this study aims at discussing various impacts of fertilizers and pesticides on soil structure, composition and environment along with the various alternatives to inorganic fertilizers and pesticides, so that preventive measures can be taken to conserve the nature.

2. MATERIAL AND METHODS

2.1 Study area description

This study was conducted at one of the major Block of Satna District- Majhgawan where the Agriculture is main occupations of people.

Climate, Environment and Weather data, climate change reports. A brief summary of available data for Majhgawan is given below:

Category	Resolution	Period
Precipitation – h	Half Hourly / 0.1 deg (11 kms) grid	2001 – 2024
Precipitation – l	Daily / 0.25 deg (28 kms) grid	1901 – 2024
Temperature – h	Monthly / 0.5 deg (55 kms) grid	1901 – 2023
Temperature – l	Daily / 1 deg (111 kms) grid	1951 – 2024

(Table 1- Climate, Environment and Weather data, climate change reports)

Almost entire Satna district lies on the Vindhyan plateau, which extends from the Kaimur hill range in the south to the edge of the Ganga valley in the north. It is traversed by three prominent hill ranges from south-south west to north-north east and is occupied by a higher plateau in the south-western part of the district known as “ Parasmania Pahar” which is part of Bhander series. Maximum elevation of the district is 704 m above mean sea level, which is recorded near “Papra Reserve Forest” on Kaimur hill range on southern part of the district. The southern and northern fringes of the district lie low in the respective valleys of the Son and the Yamuna rivers. The soils are depending upon lithology of the area. Excepting small northen and southern part, Satna district is mainly underlain by sedimentary rocks of Vindhyan super group. In plateau area of the district which is occupied by shales with quartzites, Lime stones, conglomerates and sand stones is covered by “Red and Yellow Soils” and taxonomically it is designated as “Haplustults”. Upland area of the district

representing hill ranges is occupied by “Skeletal or Gravelly soils” and it is classified as “Lithic Entisols” from soil taxonomy point of view. Northern part of the area which is extension of Gangatic Plains is covered by “Alluvial Soil” and soil type is “Ustochrepts”. Southern part of the district in son valley area is underlain by “Alluvial soils” which is thin and gravelly fertile soil.

(Figure 1- Study area description, Soil Sampling Site)

3. Collection of soil samples:

Soil samples were collected from selected agricultural areas from different fifteen farm lands and non-agricultural lands. From each of the farm lands, composite soil samples were collected along with one sample from non-agricultural land. The soil samples were collected at 0-15 cm depth, air dried, ground and sieved through 2 mm sieve and stored in polythene bags until analysis. The physico-chemical parameters analyses was carried out as per standard methodology of Arun Kumar Saha (2008), GKVK manual (1999) and methods of analysis for soils, plants and waters (Chapman and Pratt, 1961).

(Figure 2- Tools Used for Soil Sample Collection)

(Figure 3- Preparation of soil samples)

(Figure 4- Preparation of soil samples)

(Figure 5- Preparation of soil samples, Labeling of soil samples)

Figure 5- Prepared Soil Samples for lab Test)

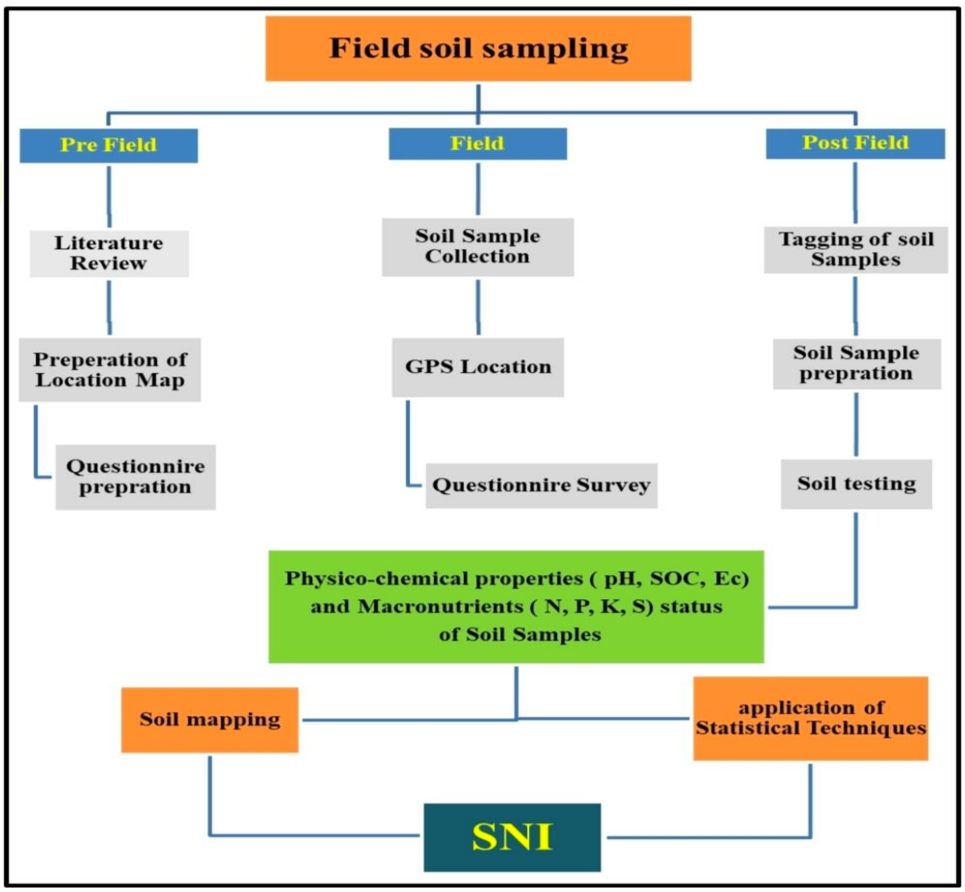

Figure 6- Methodological flowchart for the present study)

Collection of Soil Samples

A proper sampling process depends on the objective and methodology of the study. In this context, our goal was to assess the spatial distribution of soil parameters in the study area (Gabriel et al., 2021). The present research has

been performed based on primary data. The site selection, collection of block maps, literature review, and questionnaire preparation are completed before going to the field. The sampling sites were selected very carefully with the help of the grid method; the study area map was divided into 4 x 4 square kilometers grids, and the samples were collected from each grid of the study area (Cleide et al., 2011). For this study, soil samples were obtained at depths ranging from 0 to 15 centimeters. A grid wise soil sample was collected with the help of an auger. After that, the soil was mixed in a plastic tray to remove the external materials, such as stones, pebbles, gravel, etc. (Embrapa et al., 2009).

Soil Samples Analysis

Then, the soil samples were divided into 4 equal portions. Out of these, two diagonal portions were reserved,and the remaining two portions were removed. This process was repeated repeatedly until the samples were reduced to the weight of 500 gm. Finally, the soil samples were leveled through numbering and tagging. After the field survey, the collected soil samples were dried at room temperature for two weeks and passed through a 2 mm sieve and lastly, the sieved soil samples were stored in a laboratory for further chemical and mechanical analysis (Chaubey et al., 2021). Finally, the samples were analyzed for pH by the Khune's colorimetric method, and major macronutrients like (N, P, and K) were tested through the kit box method,and SOC was tested through the Walkley and Black method(Black, 1965). All the soil samples were tested in the applied pedology laboratory of the University of North Bengal.Afterward, the interpolation method was used with the help of ARC GIS software and statistical techniques were used through Microsoft Excel.

Soil Nutrient Index (SNI)

Calculating the nutrient index of each nutrient is critical to analyse the soil fertility status in each location and interpreting fertility status based on that single result. It assesses the soil's capacity to deliver plant nutrients (Singh

et al., 2016). Parker and others First (1951) presented the soil nutrient index method was presented. It is calculated as -

$$S.N.I = \{(1 * N_L) + (2 * N_M) + (3 * N_H)\} / T_{NS}$$

Where,

N_L= Number of samples in low category;
N_M= Number of samples in medium category;
N_H = Number of samples in high category,
T_{NS}= Total number of samples.

The soil Nutrient Index was used to determine the fertility status of the soil. Based on the number of samples that were classified into the 3 categories of low, medium, and high, and were rated by a particular rating chart (Rama-murthy and Bajaj 1969).

Soil Nutrient Index (SNI)	Values	Description
LOW	<1.67	Less fertility status
MEDIUM	1.67-2.33	Medium fertility status
HIGH	>2.33	High fertility status

Table 2. Soil Nutrient Index Table by (Rama-murthy and Bajaj 1969).

Table 3. Methodology used for physico-chemical analysis of soil.

Sl.No.	Parameters	Method	Reference
Physical properties			
1	Bulk density	Volumetric Flask Method	Chapman & Pratt (1961)(g/cm3)
	Particle density	Volumetric Flask Method	Chapman & Pratt (1961)(g/cm3)
	Water holding	Gravimetric	Chapman & Pratt (1961)(g/cm3)
Chemicalproperties			
1	Soil pH	Glass electrode	Jackson (1973)pH meter
2	Electrical conductivity (dSm-1)	Electrical conducivity meter	Jackson (1973)

3	Organic carbon(%)	Wet oxidation	Walkley and Black method (1934)
Primary macronutrients			
1	Available nitrogen	Kjeldhal Distillation	ICAR(2017)
2	Available phosphorus	Olsen's method	Olsen et al. (1954)
3	Available potassium	Flame photometer	Schollenberger and Simon (1945)
Secondary nutrients			
1	Calcium	EDTA Titration	ICAR(2017)
2	Magnesium	EDTA Titration	ICAR(2017)

Statistical analysis

Correlation coefficients were taken into consideration to examine the link between various soil parameters and micronutrient levels in soils and plants.

$$R=\sqrt{\frac{sp(xy)}{ss(x), ss(y)}}$$

Where:

r = Correlation coefficient

SP (xy) = Sum product of x, y variables

SS (x) = Sum of square of x variable

SS (y) = Sum of square of y variable

RESULTS AND DISCUSSION

Results of chemical fertilizers residues and physico-chemical characteristics of soil samples of selected Villages of Majhgawan Block

Sr No	Name of Village	Test Site	Sample	PH	EC	OC	N	P	K	S	ZN	B	FE
1			S1	7.0	0.28	0.5	207	59	396	6	1.48	0.78	9.32
2	Jhari	T1	S2	7.4	0.11	0.7	240	53	410	12	1.62	0.64	8.64
3			S3	7.3	0.17	0.6	220	65	350	10	1.4	0.76	9.35
4			S1	7.6	0.13	0.3	143	54	382	8	2.03	0.62	9.22
5	Majhgawan	T2	S2	7.8	0.09	0.7	240	55	338	15	0.92	0.72	9.52
6			S3	7.7	0.11	0.60	210	60	335	12	1.05	0.62	9.65
7			S1	7.3	0.08	0.5	207	68	416	7	0.32	0.69	8.64
8	Semra	T3	S2	7.3	0.07	0.3	143	37	422	5	1.48	0.56	8.32
9			S3	7.3	0.09	0.4	210	55	420	10	1.25	0.55	8.25
10			S1	7.5	0.12	0.5	207	26	348	9	0.55	0.68	10.60
11	Malmau	T4	S2	7.7	0.07	0.7	240	38	381	16	0.98	0.92	9.52
12			S3	7.7	0.10	0.6	210	40	370	12	0.56	0.61	10.50
13			S1	7.4	0.08	0.7	240	53	336	14	1.12	0.84	7.32
14	Hinautha	T5	S2	7.3	0.09	1	315	50	353	18	1.85	0.64	6.84
15			S3	7.4	0.07	0.7	240	55	350	15	1.22	0.60	9.66
16			S1	7.7	0.08	0.7	240	32	486	13	1.64	0.76	9.48
17	Berahna	T6	S2	7.7	0.07	0.7	240	38	465	13	1.30	0.64	9.66
18			S3	7.6	0.08	0.7	245	40	486	12	1.35	0.72	7.32
19			S1	7.6	0.16	0.3	143	58	393	5	1.60	0.66	8.92
20	Bandhi	T7	S2	7.5	0.14	0.5	207	54	348	7	0.55	0.56	8.52
21			S3	7.5	0.12	0.4	210	55	350	10	1.65	0.64	7.68
22			S1	7.4	0.15	0.5	212	76	221	10	0.83	0.37	19.30
23	Kawar	T8	S2	6.9	0.17	0.5	202	83	232	9	0.41	0.65	10.90
24			S3	7.3	0.34	0.4	210	56	185	12	0.44	0.64	7.68
25			S1	7.4	0.29	0.6	152	26	112	7	0.41	0.37	9.73
26	Mahkhed	T9	S2	7.3	0.21	0.6	200	32	221	10	0.83	0.35	9.48
27			S3	7.4	0.19	0.4	210	38	232	12	0.41	0.45	9.66
28			S1	6.7	0.39	0.6	221	30	425	9	0.44	0.45	6.20
29	Sahpur	T10	S2	7.1	0.44	0.6	210	20	389	10	0.29	0.48	7.20
30			S3	7.4	0.30	0.6	221	25	450	12	0.45	0.41	4.30
31			S1	7.3	0.42	0.5	184	25	425	7	0.38	0.33	4.60
32	Naugawan	T11	S2	6.7	0.39	0.6	221	20	389	9	0.29	0.38	6.20
33			S3	7.1	0.44	0.6	210	29	294	10	0.45	0.41	7.70
34			S1	7.4	0.45	0.6	232	25	294	8	0.45	0.49	4.30
35	Chandai	T12	S2	7.3	0.41	0.6	243	30	389	10	0.41	0.45	4.60
36			S3	7.4	0.39	0.6	232	27	450	12	0.45	0.44	6.20
37			S1	7.3	0.42	0.5	184	32	289	7	0.38	0.33	4.60
38	Pindra	T13	S2	6.9	0.41	0.5	194	17	350	10	0.41	0.35	9.48
39			S3	7.1	0.38	0.5	210	25	398	9	0.45	0.43	9.66
40			S1	8.0	0.56	0.4	168	27	290	8	0.44	0.38	10.60
41	Pagarkhurd	T14	S2	6.5	0.65	0.4	168	13	220	10	0.43	0.49	4.50
42			S3	7.1	0.61	0.4	210	25	232	10	0.33	0.45	9.66
43			S1	6.5	0.23	0.5	216	18	452	10	0.48	0.51	20.12
44	Panghati	T15	S2	7.4	0.21	0.5	211	23	419	20	0.57	0.38	21.21
45			S3	6.9	0.29	0.5	216	17	389	8	0.59	0.56	11.90
	Mean			**7.30**	**0.25**	**0.52**	**210**	**39**	**350**	**10.3**	**0.94**	**0.54**	**9.30**

	SD			**0.23**	**0.16**	**0.09**	**23.53**	**16**	**80**	**2.23**	**0.48**	**0.13**	**3.03**

(Table 5 : Electrochemical properties and Macronutrients status in soil of Majhgawan Block ,calculated by Author based on Soil Testing Results)

No of sample analysed	Parameters	Range	Mean	Catergory
45				
	pH	6.9-7.7	7.30	Neutral
	EC	0.08-0.61	0.25	No Deleterious effect on Crop
	OC	0.37-0.75	0.52	Medium
	N	182-265	210	Low
	P	19-71	39	High
	K	188-475	350	High
	S	7.3-15.6	10.3	Medium
	ZN	0.37-1.56	0.94	Sufficient
	B	0.37-0.73	0.54	Sufficient
	FE	5.30-17.74	9.03	Sufficient

*(Table 6 : Status of Nutrient for Majhgawan Block)As per the calculation by Author)

Electrochemical Properties of Soil

Soil pH

The pH of the soil is a significant chemical property of soil because it regulates the supply of important plant nutrients (Gunamantha et al., 2021). It is also a crucial indicator that aids in assessing the chemical nature of the soil because the concentration of H+ in the soil is analysed to reveal the soil's acidity and alkalinity (Shalini et al., 2003). The pHvalue of the soil samples in the Majhgawan block varied from 6.9-7.7 with a mean value of 7.30. which has been showing in figure 6. The soil pH values are Neutral which is required for healthy soil.

Electrical Conductivity (EC)

Electrical Conductivity refers to the amount of soluble salt present in the soil. Electronic conductivity is a measure of soil salinity (Huang et al., 2016) Greater the EC value the salinity of the soil will be more and the lesser the EC value represent lesser the salinity, and vice versa. (Ravikumar, 2013). The EC value of the soil samples in the Maghgawan block ranged from 0.08-0.61 µS/cmwith a mean value of 0.25 µS/cm.. If the EC of the soils is less than 1.0 S/cm1then it will be considered normal EC of soils which is No Deleterious effect on Crop (Singh et al., 2018). Figure 6

Soil Organic Matter (SOC)

The amount of organic carbon meets the nitrogen requirement of plants and also improves the soil nutrients availability and water holding capacity which enhance the physicochemical and biological properties of soil (Kavitha & Sujatha, 2015). Regions with a moderately dry regime and higher temperatures have less organic carbon than those with more rainfall and lower temperature variations (Saheed et al., 2020). The estimated value of soil organic carbon of the Maghgawan block is

0.37 %-0.75% to 1.76% with a mean value of 0.52 %. As per parker's Soil nutrients index the organic carbon of the area falls under a medium organic carbon concentration.

Macronutrient status of soil

Nitrogen (N)

In the Majhgawan block, the available nitrogen content ranged from 182-265 kg/ha, with an average of 210 kg/ha.The amount of accessible nitrogen in the agricultural soils in the Majhgawan block is low to medium. Using organic fertilizer and nitrogen fertilizer for crops may result in a medium soil nitrogen level (Zou et al., 2018). The sustainable method of enriching the amount of nitrogen in the soil we should plant leguminous crops or add an adequate amount of organic fertilizers (Pandiaraj et al., 2017). Modern agricultural practices have a significant role in controlling soil N, whereas anthropogenic activities could influence the N cycle (Sharma et al., 2012). Another way of meeting the nitrogen level in the soil is to add various nitrogenous fertilizers (Digal et al., 2019).

Available Phosphorus (P)

The role of soil, rhizobia, and plant processes is important in P transformation in the surface soil (Shen et al., 2011). The available phosphorus of soils in Majhgawan Block ranges from19 kg/ha -71 kg/ha with a mean value of 39 kg/ha. According to SNI the area occupied by high phosphorus content of the study area (Pulakeshi et al., 2012). Phosphorus-based fertilizers, organic manure, and phosphorus-solubilizing bacteria should be added to soils to enrich the available Phosphorus (Patil et al. 2017 and Singh et al. 2018).

Available Potassium (K)

Potassium plays a vital role in plant growth and sustainable nutrient management (Havlin et al., 2016). Potassium exists within the soil solution as K+ or catalyzer (Singh et al., 2016). The potassium content of soils in Majhgawan Block ranged between 188 kg/ha -475 kg/ha with a mean value of 350 kg/ha. According to SNI the area occupied by high potassium content of the study area. Potassium plays a crucial role in plant growth and it also promotes the formation of enzymes which are essential for the growth of plants (Amtmann et al., 2008). Potassium also plays an important role in the disease resistance of plants (Das et al. 2015).

Available Sulfur (S)

Low and medium levels of sulphate in soil may result from inadequate sulphate fertilization and sulphate removal by crops (Barooah et al., 2020). The sulfur content of soils in Majhgawan Block ranged between 7.3 kg/ha -15.6 kg/ha kg/ha with a mean value of 10.3 kg/ha. According to SNI the area is under medium sulfur content, Sulfur depletion in soil could result from intensive cultivation without sulfur fertilization (Patra et al., 2012).

Soil nutrient index

The nutrient index value of less than 1.67 is rated as low, 1.67 to 2.33 is rated as medium and more than 2.33 is rated as high fertility status as suggested (Rama-murthy and Bajaj 1969). The Nitrogen, Phosphorus, Potassium, Sulphur index calculated value is given in the Table 7.

SR No	Availabe Nutrient	Nutrient Index Values	Category
1	Nitrogen	1.02	LOW
2	Phosphorus	2.84	HIGH
3	Potassium	2.67	HIGH
4	Sulphur	1.63	MEDIUM
5	Organic Carbon	1.72	MEDIUM

*(Table 7: Soil Nutrient Index for Majhgawan Block)As per the calculation by Author)

	PH	EC	OC	N	P	K	S	ZN	B	FE
PH	1									
EC	-0.57729	1								
OC	0.18483	-0.23128	1							
N	0.106264	-0.28853	0.91291	1						
P	0.37499	-0.61853	-0.02678	0.064132	1					
K	-0.01836	-0.26091	0.233674	0.41889	-0.15633	1				
S	0.18209	-0.36018	0.79318	0.751543	-0.01409	0.127207	1			
ZN	0.519465	-0.72752	0.202561	0.138186	0.74534	-0.2307	0.190417	1		
B	0.650929	-0.78607	0.315693	0.428023	0.597668	0.337572	0.405362	0.588059	1	
FE	-0.19981	-0.29888	-0.18742	-0.08582	0.059012	-0.1021	0.31277	0.197128	0.130203	1

*(Table 8: Correlation Matrix between physical & Chemical properties of soil for Majhgawan Block)As per the calculation by Author)

The correlation between the available macronutrients and the physicochemical properties of soil is shown in Table number 8. The pH value of the soil is a significantly negative correlation with Ec (-0.57). EC is negatively non-significant relationship with P (-0.61), Zn (-0.72), and B (-0.78). The soil organic carbon content (SOC) is strongly positive correlation with N (0.98),S (0.79) and low positive correlation with K (0.23) Zn(0.20) B(0.31), on the other hand

negatively non-significant relationship with Fe (-0.18), The available Nitrogen content (N) is a strongly positive correlation with S (0.75) and a positively negligible correlation with P (0.41), and B (0.42) respectively.

CONCLUSION

Soil testing is a low-cost method of estimating the soil fertility and capacity of soils to support crop growth. Growers can take judicial decisions to minimize risk and maximize profitability. From the above results, it was concluded that the soils of Majhgawan Block were Neutral in nature and not Hazardous for crops. Using the soil nutrient index of the study region, it was observed that the soils of the Majhgawan block were low in available nitrogen, medium in sulfur and high in potassium. Phosphorus and organic carbon status were found to be medium to high in the soils of the studied area. Deficient nutrients can be supplemented to prevent crops from suffering from deficiencies and to optimize the efficiency of other nutrients. Integrated nutrient management holds the key to sustainable soil fertility management.

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