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Assessment of Macronutrients and Physicochemical Parameters of Agricultural Soils in Nawanshahr-Hoshiarpur Districts of Punjab

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Both improving agricultural soil productivity and maintaining its quality are now the focal points of ongoing research in agriculture. The purpose of this research is to examine the soil's health, and in order to do so, a survey was carried out in which the physicochemical parameters and the macronutrients of agricultural soils from two districts in the state of Punjab (Hoshiarpur and Nawanshahr) were analyzed. Around 40 composite soil samples were taken from 0 to 15 cm depth and critically assessed. This study analyzed soil's colour, texture, pH, electrical conductivity and organic carbon physicochemical parameters. The soil sample's colour varied from light yellow to dark solid brown, and its texture was observed to be sandy loam, which was analyzed through the sedimentation process and feel method. The soil sample's pH was slightly alkaline, and the electrical conductivity showed the expected results. Organic carbon was found in the medium and surplus ranges in the studied fields. According to the results of the macro-element analysis, the soil samples lacked Potassium concentration while having excessive levels of Nitrogen and Phosphorous. These results were compared to the normal range of values for healthy soil, and the discrepancy was found to be statistically significant. This research points out that phosphorus and nitrogen-based fertilizer, likely to be urea and other synthetic fertilizers containing phosphorus, had been overused without considering the soil's health.

Keywords: Hoshiarpur and Nawanshahr district; Macro-elemental analysis; Physicochemical parameter; Soil health

1 Introduction

From a perspective of the future, food security is a rising challenge. The world's population might exceed 600 million by 2025, necessitating further efforts to improve crop yield[1]. Today's need is to engage sustainable practices as food production, and soil health goes hand in hand[2]. Plants take the nutrients from the soil, thus creating a deficiency of nutrients in the soil and to consummate this void, the soil needs artificial fertilizers. As solely organic fertilizers did not quench the nutrient thirst unless accompanied by synthetic fertilizers. The most effective way to replace nutrients is by using synthetic fertilizers. Even if it is the finest invention, if applied beyond what the soil requires, it may negatively impact physicochemical characteristics and the drainage system[3]. The decisive approach to using fertilizers is appreciated as one of the potential technical factors for sustained crop production[4]. One of the ecological indexes for measuring agricultural sustainability in developing countries is the amount of fertilizer or pesticides used per unit of cropped land[5]. Soil testing comes into play to harness the yield by using specific fertilizer that is truly required for the soil[6]. Soil testing is important as food security and production are directly related to soil fertility and physiochemical characteristics. It provides information about the nutrient accessibility of the soil that can help to accelerate crop productivity. India is the major producer of agricultural products and food grains which also assures that agriculture and its allied sectors will shares 20.19% of India's GDP in 2021, as per reports[7]. Punjab, well known as India’s breadbasket, is located in the northwest of India. It covers an area of 50,362sq km, and extends from 29.30° North to 32.32° North latitudes and 73.55° East to 76.50° East longitudes. According to the report[8], Punjab consumes about 9 % of the total fertilizers used in India, and this use is soaring on a per unit area basis as Punjab’s consumption is 76.93 kg/acre of gross cropped area versus India’s consumption of 35.6 kg/acre. The two main cereal crops *i.e.*, wheat and rice, are sown during the year. This monoculture of the crop cycle has a

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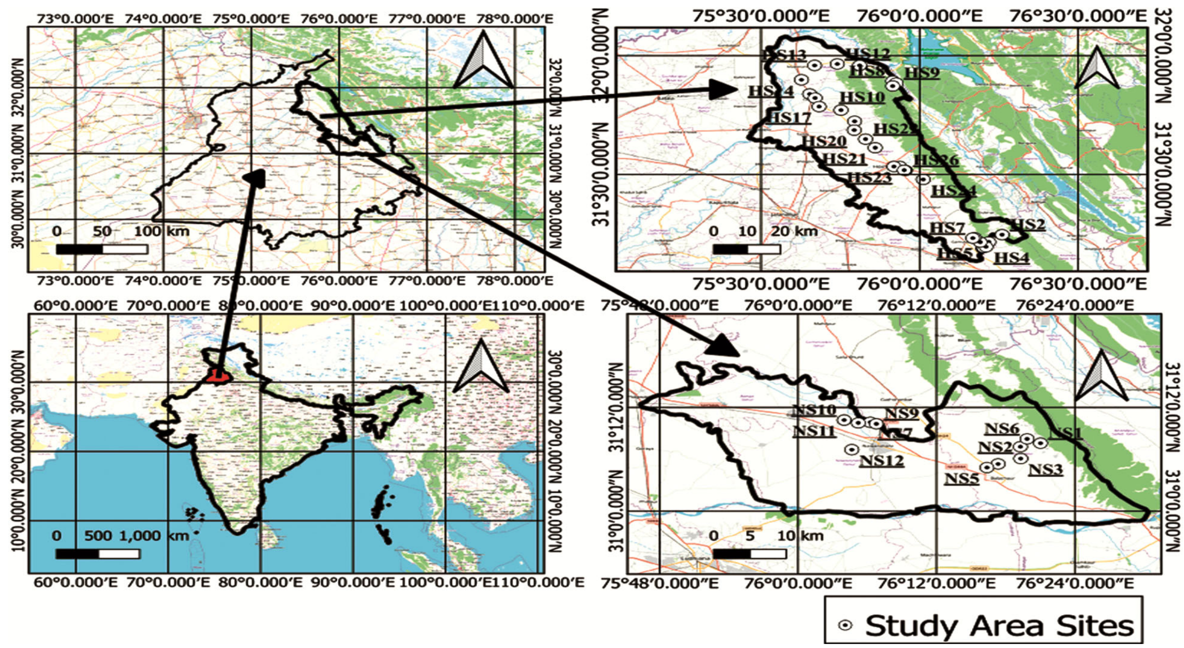

Fig. 1 — Study area map with sample locations

negative impact on soil nutrients, leading to nutrient mining and influencing other soil characteristics. To examine its influence, a survey was conducted in the districts of Hoshiarpur and Nawanshahr, Punjab, by collecting soil samples from several villages in the study region.

2 Description of the study area

The Hoshiarpur and Nawanshahr district lies in the north-east of Punjab between 31°0' North to 32°5' North latitudes to 75°30' East to 76°32' East, and Nawanshahr lies between 31°05' North to 31°15' North latitudes and 75°45' East to 76°30' East longitudes with the geographical area 3365 sq.km and 1267 sq.km, respectively. The average elevations from sea level are 296m and 257m, respectively. The Hoshiarpur district comprises four tehsils, Hoshiarpur, Dasuya, Garhshankar, Mukerian, and the Nawanshahr district comprises three tehsils, Nawanshahr, Balachaur, Banga. From both districts, 40 samples were collected from different villages to analyze the nutrient status and other physical and chemical parameters. The map, as shown in Fig. 1 shows the study area sites in Nawanshahr and Hoshiarpur districts.

3 Soil sampling technique and resources

The composite soil samples of 1kg at 0-15 cm depths were collected from agricultural fields of study area with a shovel, digging a V-shaped hole. Samples were then dried in proper sunlight, crushed by wooden mottle and passed through the sieve of

Fig. 2 — (a) Shows V shape hole for sample collection; (b) shows sample collection upto depth 15 cm; (c);(d) shows selection and drying of sample and (e) shows sieving of soil sample.

2mm. After this, the samples are sealed in airtight plastic bags. The various processes of sample collection are shown in Fig. 2. The sample sites were recorded with their location with the help of a

GPS device, and the crop cycle was noted. The location and crop cycle of various sampling sites of Hoshiarpur and Nawanshahr districts are given in Table 1 and 2, respectively.

4 Methodology

The processed composite soils were analyzed for physicochemical properties and macronutrients level by standard methods. The physical and chemical parameters are measured using different methods listed in Table 3.

4.1 Physicochemical parameters

The processes of analysis of physical and chemical parameters are described below.

Table 1 — Representing the sampling sites of the Hoshiarpur district with their crop cycle

Sample Code	Latitude	Longitude	Kharif crop	Rabi crop
Hs1	31°11'32.8"	76°12'06.2"	Sorghum	Wheat
Hs2	31°14'47.7"	76°15'36.9"	Bajra	Potato
Hs3	31°12'57.8"	76°13'05.6"	Maize	Wheat
Hs4	31°11'44.4"	76°12'33.7"	Rice	Wheat
Hs5	31°12'55.0"	76°11'28.8"	Maize	Peas
Hs6	31°14'01.7"	76°10'22.8"	Paddy	Wheat
Hs7	31°13'55.8"	76°10'04.4"	Paddy	Wheat
Hs8	31°53'35.7"	75°54'54.8"	Maize	Wheat
Hs9	31°53'05.5”	75°55'34.1"	Paddy	Potato
Hs10	31°52'20.0"	75°54'55.2"	Bajra	Berseem
Hs11	31°57'33.2”	75°48'39.7”	Marigold	Ginger
Hs12	31°57'54.3”	75°44'26.2”	Maize	Sugarcane
Hs13	31°57'32.3”	75°40'08.4”	Bajra	Berseem
Hs14	31°53'54.7”	75°37'39.1”	Bajra	Wheat
Hs15	31°50'19.7”	75°39'12.1”	Bajra	Wheat
Hs16	31°49'18.6”	75°40'13.9”	Paddy	Berseem
Hs17	31°47'08.7”	75°40'59.4”	Maize	Sugarcane
Hs18	31°46'15.5”	75°45'08.0”	Bajra	Berseem
Hs19	31°43'25.9”	75°47'42.4”	Oilseeds	Sugarcane
Hs20	31°41'12.3”	75°47'38.4”	Maize	Wheat
Hs21	31°36'45.1”	75°51'36.4”	Maize	Wheat
Hs22	31°38'56.0”	75°49'46.6”	Maize	Wheat
Hs23	31°32'00.5”	75°56'14.8”	Paddy	Potato
Hs24	31°28'44.8”	76°00'41.3”	Maize	Wheat
Hs25	31°32'00.8”	75°55'08.9”	Rice	Bajra
Hs26	31°31'01.2”	75°57'18.4”	-------	Berseem
Hs27	31°31'02.4”	75°57'16.3”	Paddy	Potato
Hs28	31°31'05.7”	75°571'5.7”	-------	Sugarcane

4.1.1 Soil colour and soil texture

Soil colour helps to distinguish soil and its other parameters. Perhaps soil colour is the primary physical parameter noted from different agricultural fields at first sight from the naked eye. Soil texture is also the physical parameter analyzed by the sedimentation method and feel method which was represented in Table 4.[9,10].

Soil texture estimates the composition of sand, silt and clay in the soil and their amount was entertained to estimate the type of soil texture.

4.1.2 Electrical conductivity

The soil's fertility also depends on the amount of salt solubility[11]. The salinity of the soil was estimated by using a water extract from a water-to-soil suspension of ratio 2.5:1. After giving the mixture a good stir, it is left alone for 24 hours so the water may remove the highest possible concentration of soluble salt from the soil. A digital conductivity meter is used to check the level of electric conductivity.

Table 2 — Representing the sampling sites of Nawanshahr district with their crop cycle

Sample code	Latitude	Longitude	Kharif crop	Rabi crop
Ns1	31°07'51.7"	76°21'01.8"	Maize	Wheat
Ns2	31°07'27.1"	76°19'17.0"	--------	Sugarcane
Ns3	31°06'04.9"	76°19'18.8"	Paddy	Wheat
Ns4	31°05'27.6"	76°17'21.1"	Maize	Wheat
Ns5	31°05'02.3"	76°16'23.1"	Paddy	Wheat
Ns6	31°08'21.4"	76°19'51.9"	Sorghum	Berseem
Ns7	31°10'49.7"	76°06'01.9"	Maize	Wheat
Ns8	31°10'13.0"	76°05'13.5"	Paddy	Wheat
Ns9	31°10'06.0"	76°06'47.3"	Maize	Wheat
Ns10	31°10'32.4"	76°03'60.0"	Sorghum	Wheat
Ns11	31°10'32.4"	76°03'60.0"	Maize	Wheat
Ns12	31°07'06.7"	76°04'39.8"	---------	Sugarcane

Table 3 — Methods of analysis of physicochemical parameters

Sr. No.	Parameter	Method Used
1	Soil Texture	Sedimentation testand feel method[9,10]
2	pH	Glass electrode pH metre[11]
3	Electrical conductivity	EC Meter[11]
4	Organic carbon	Walkley and Black's method[12]

Table 4 — Classification of soil texture by feel method[10]

Sr. No.	Experience	Stickiness	Texture	Textural class
1.	Forming very smooth, hard balls.	Definitely stains the fingers	Heavy	Clay
2.	Forming smooth and moderately hard balls	Stains the fingers	Moderately heavy	Clay loam
3.	Forming a powdery and firm balls	Stains the fingers	Medium	Loam
4.	Forming a moderately gritty and easily broken balls	Stains the fingers	Moderately light	Sandy loam
5.	Forming gritty and do not form a ball at all	Stains finger slightly	Light	Loamy sand
6.	Forming very gritty, and no formation of the balls	No staining	Very light	Sand

4.1.3 Soil pH

Soil pH, also known as soil reaction, is the negative logarithm of hydrogen ion activity[13] *i.e.*

$$pH = log_{10}\left(\frac{1}{aH^+}\right) = -log_{10}(aH^+) \quad \ldots (1)$$

where aH^+ is the activity of hydrogen ion in gram ion per liter.

2 gm of air-dried soil sample and 50 ml distilled water were shaken for half an hour, then the pH of the filtered extract of soil water suspension was determined by a glass electrode pH meter, which was calibrated using a buffer solution of pH=4 and pH=7.

4.1.4 Organic Carbon

Organic carbon (OC) is the main constituent of organic matter present in the field. Organic matter comprises various decomposable things, and flora and fauna excrete. Finding the existence of organic carbon is the next step in estimating the amount of organic matter. The rapid and fine method to analyze organic carbon concentration is the wet combustion method. In this, 2 gm of soil sample was added to 10 ml of 1N potassium permanganate and 20 ml sulphuric acid (conc.). The solution was mixed with 100 ml of distilled water and drops of diphenylamine indicator were added. This solution was then titrated with N/2 ferrous ammonium sulphate upto endpoint. The quantity of carbon content was then determined by the quantity of potassium permanganate reduced[10,12].

4.2 Macronutrient Analysis

The macronutrient in the soil sample was estimated using various methods, as shown in Table 5

4.2.1 Nitrogen

Nitrogen is primarily responsible for healthy vegetative development and crop output. Exchangeable ammonium and nitrates are two of the few nitrogen forms in the soil that plants may use[14]. Determination of available nitrogen for plants and crops was done by alkaline–permanganate method. This method converts organic nitrogen to ammonium forms and calculation of the available nitrogen for plants was done by using Kjeldahl assembly.

Table 5 — Representing method of analyzing macronutrients

Sr. No.	Macronutrient	Method
1.	Nitrogen(N)	Alkaline permanganate method[14]
2.	Phosphorous(P)	Olsen method[15]
3.	Potassium(K)	Flame photometer[11]

4.2.2 Phosphorous

Phosphorous available to plants are HPO_4^{2-}, $H_2PO_4^-$ ion, and some inorganic forms. To determine the available phosphorous Olsen method was used[15].

4.2.3 Potassium

Although a large amount of potassium is present in mineral form. However, the liberation of potassium is a long process and is insignificant to plant growth. The available potassium for plant growth is water-soluble and exchangeable potassium. Its assessment was accomplished through a flame photometer using soil, and ammonium acetate solution suspension in a ratio of 1:5[11].

5 Results and Discussions

5.1 Physicochemical parameters

Mostly, the soil colour in both districts was a solid brown colour with a specific variation of pale yellow colour. It was discovered that in the Nawanshahr district, 58% of soil samples had sandy loam texture, and the rest 25% and 17% of samples had clay loam and silt loam texture, respectively. In the Hoshiarpur district, it was found that 53% of the samples were sandy loam, 14% silt loam and 33% clay loam, indicated in Table 6. This indicates that both districts had a large proportion of sand, followed by clay and silt. The results showed that the soil mostly had higher infiltration and leaching rates, as sandy soil has more significant pore separation.A bar graph and box whisker plots was presented and demonstrating in Fig. 3 and Fig. 4 respectively.

The Electrical conductivity (EC) for the Hoshiarpur district was found in the range 0.1 mS/cm to 0.8 mS/cm with mean and standard deviation both 0.19 mS/cm, whereas in the Nawanshahr district, the electrical conductivity varied from 0.1 mS/cm to 0.4 mS/cm with mean 0.2 mS/cm and the standard deviation is about 0.09 mS/cm.From Table 7, it can be concluded that EC is low but suitable for all types of crops. The low EC might be due to rainfall as it washes out soluble cations from the soil.

Soil pH, also known as soil reaction, affects the soil and plant's nutrients[11]. The pH value of the soil

Table 6 — Representing the average composition of soil in Nawanshahr and Hoshiarpur district

Sample code	Mean Soil composition in %		
	sand	silt	clay
NS01 to NS12	41.16	23.41	35.33
HS01 to HS28	38.71	27.92	33.37

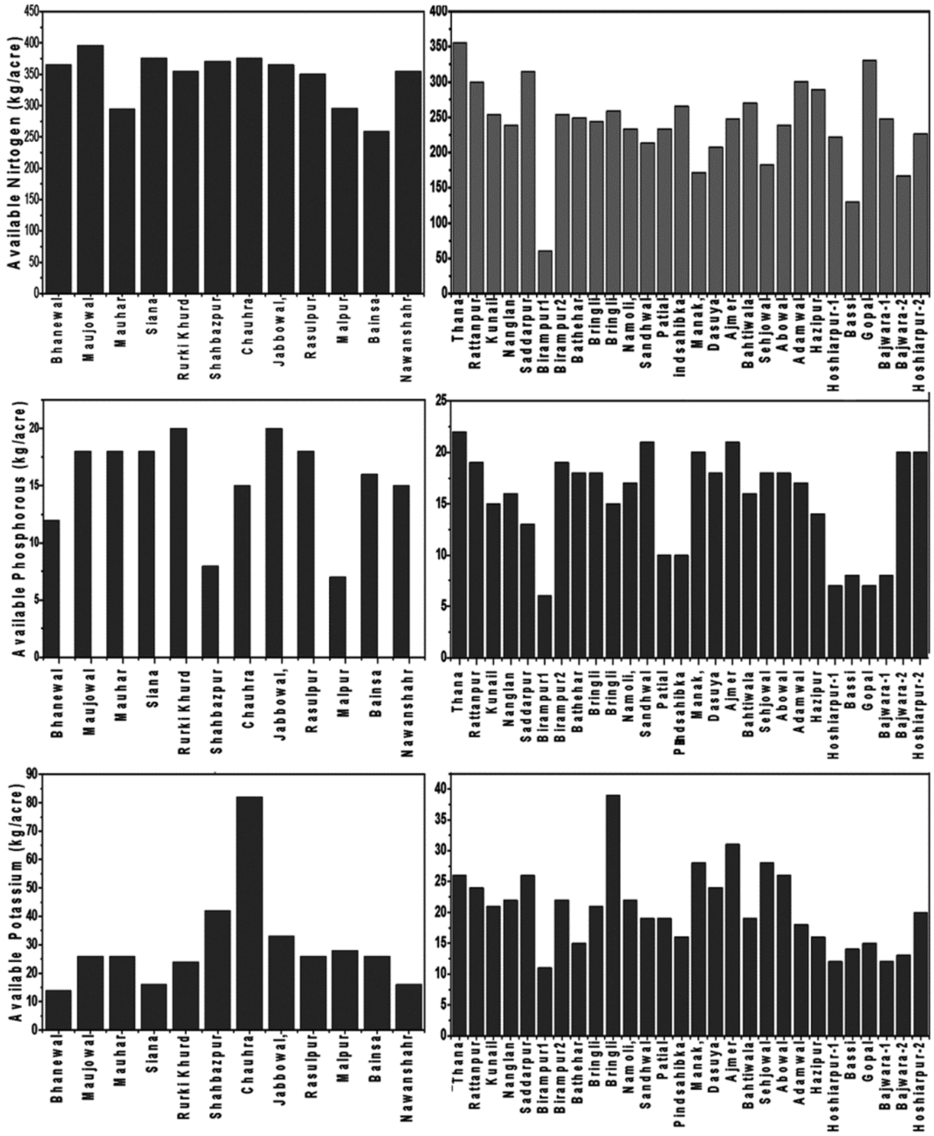

Fig. 3 — Showing the bar graph of the concentration of macronutrients in different study area sites of Nawanshahr and Hoshiarpur districts.

samples for the Hoshiarpur district ranged from 6 to 8.2, with a standard deviation of 0.65. The highest pH was found for the soil samples of village Birampur-1, 2, *i.e*., 8.2, and the lowest was for Thana *i.e*.,6.0. Fig. 4 shows that about 75 % of the Hoshiarpur district soil samples were alkaline. In the Nawanshahr district, the soil sample's pH ranges from 6.4 to 7.8. Around 60% of soil samples were neutral, 32% were alkaline, and around 7% were acidic(<6.5). The highest pH was found in villages Mauhar (8.3) and Rasulpur (8.3) and the lowest in Moujowal (6.4) (Table 8). Fig. 4 shows that in Hoshiarpur, a pH of 7.25 or above accounts for more than half of the soil samples, whereas in Nawanshahr, the number is 8.1.The description of various different locations within study area along with their respective physicochemical parameters and macronutrient levels were shown in Table 9.

This study examined that organic carbon (in %) in the Hoshiarpur region varied from 0.34 to 0.82 with a standard deviation of about 0.15 (Table 10). Only two samples are found with less percentage (< 0.40) of organic carbon *i.e*., 0.34 (Thana) and 0.38 (Bathehar). Meanwhile, in Nawanshahr district, only one village named Mauhar had a low percentage of organic carbon *i.e*., 0.36; otherwise, both districts have a sufficient amount of organic content. Application of manure, dunk-manure and time-to-time tilling may lead to good OC content in the soil samples.

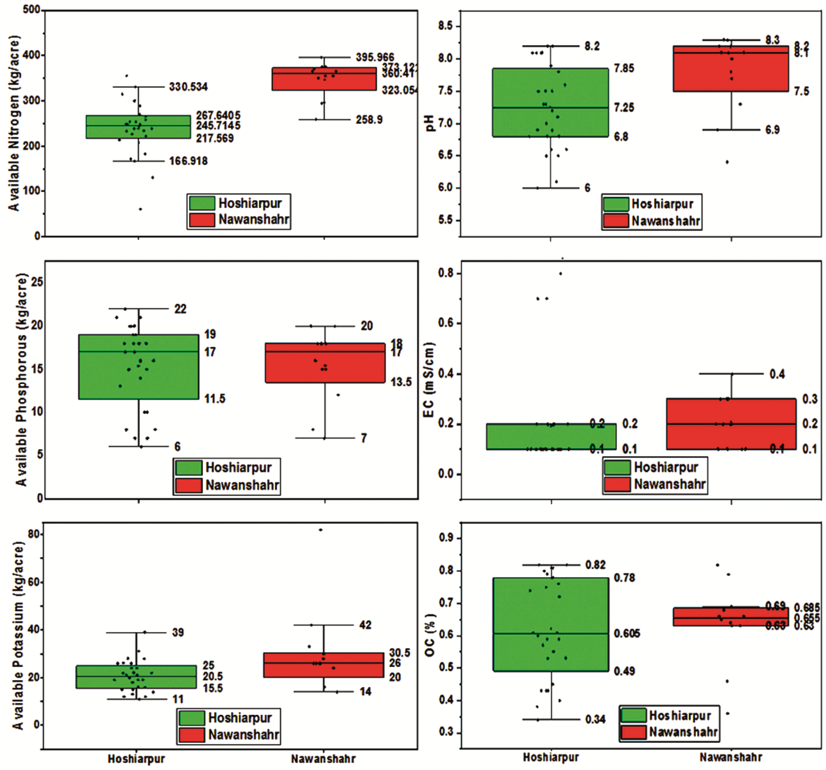

Fig. 4 — Box whisker plots for macronutrients and physicochemical parameters of Hoshiarpur and Nawanshahr district.

Table 7 — Guidelines of various physicochemical parameters and macronutrients[17]

Classification of Organic carbon (%)	% of organic carbon	<0.40	0.40-0.75	>0.75	
	Rating	Low	Medium	High	
Classification of Electrical conductivity(mS/cm)	EC in mS/cm	Below 0.8	0.8-1.6	1.6-2.5	Above 2.5
	Soil category	Normal-suitable for all the crops	Critical for salt-sensitive crops	Critical for salt-tolerant crops	Injurious to all crops
Classification of available Nitrogen (kg/acre)	Amount of available N (kg/acre)	<110	110-220	>220	
	Rating	Low	Medium	High	
Classification of available Phosphorous (kg/acre)	Amount of available P (kg/acre)	<5	5-9	9-20	>20
	Rating	Low	Medium	High	Very high
Classification of available Potassium (kg/acre)	Amounts of available K (kg/acre)	<54	54-135	>135	
	Rating	Low	Medium	High	

Table 8 — Representing study area sites of Nawanshahr district with physicochemical parameters and macronutrients

Sample Code	Sample sites	pH	EC (mS/cm)	OC (In %)	N (kg/acre)	P (kg/acre)	K (kg/acre)	Soil composition (sand-silt-clay) in %	Soil Texture
NS1	Bhanewal	8.1	0.1	0.66	365.50	12	14	45-20-35	Sandy loam
NS2	Maujowal	6.4	0.3	0.46	395.966	18	26	51-10-39	Sandy loam
NS3	Mauhar	8.3	0.1	0.36	294.436	18	26	20-25-55	Clay loam
NS4	Siana	8.0	0.4	0.63	375.660	18	16	32-15-53	Sandy loam
NS5	RurkiKhurd	7.3	0.1	0.63	355.322	20	24	38-19-42	Clay loam
NS6	Shahbazpur	8.2	0.1	0.66	370.583	8	42	45-23-32	Sandy loam
NS7	Chauhra	8.1	0.3	0.79	375.660	15	82	29-56-15	Silt loam
NS8	Jabbowal,	6.9	0.2	0.82	365.507	20	33	30-20-50	Clay loam
NS9	Rasulpur	8.3	0.2	0.68	350.277	18	26	45-3025	Sandy loam
NS10	Malpur	8.2	0.2	0.64	295.832	7	28	65-25-10	Sandy loam
NS11	Bainsa	8.1	0.3	0.65	258.900	16	26	54-18-28	Sandy loam
NS12	Nawanshahr	7.7	0.2	0.69	355.048	15	16	40-20-40	Loam

Table 9 — Representing study area sites of Hoshiarpur district with physicochemical parameters and macronutrients

Sample Code	Sample sites	pH	EC (mS/cm)	OC (in %)	N (kg/acre)	P (kg/acre)	K (kg/acre)	Soil composition (Sand-Silt-clay) in %	Soil Texture
HS1	Thana	6.0	0.2	0.34	355.35	22	26	50-25-25	Sandy loam
HS2	Rattanpur	7.5	0.1	0.43	299.51	19	24	37-47-16	Silt loam
HS3	Kunail	8.1	0.1	0.43	253.82	15	21	56-20-24	Sandy loam
HS4	Nanglan	7.6	0.2	0.53	238.59	16	22	45-20-35	Sandy loam
HS5	Saddarpur	8.1	0.1	0.61	314.74	13	26	30-25-45	Clay loam
HS6	Birampur-1	8.2	0.2	0.55	60.91	6	11	41-25-34	Sandy loam
HS7	Birampur-2	8.2	0.2	0.43	253.82	19	22	42-25-33	Sandy loam
HS8	Bathehar	8.1	0.1	0.38	248.74	18	15	60-10-30	Sandy loam
HS9	Bringli	6.6	0.1	0.78	243.67	18	21	54-16-30	Sandy loam
HS10	Bringli	6.5	0.1	0.59	258.90	15	39	25-25-50	Clay loam
HS11	Namoli,	6.9	0.1	0.60	233.51	17	22	30-25-45	Clay loam
HS12	Sandhwal	6.8	0.1	0.74	213.21	21	19	45-45-10	Sandy loam
HS13	Patial	6.1	0.1	0.61	233.51	10	19	36-25-39	loam
HS14	PindSahibka	7.8	0.8	0.72	265.49	10	16	47-35-18	Sandy loam
HS15	Manak,	8.1	0.1	0.57	171.73	20	28	40-19-41	Sandy loam
HS16	Dasuya	7.9	0.1	0.81	207.34	18	24	20-33-47	Clay loam
HS17	Ajmer	7.2	0.1	0.78	247.75	21	31	50-25-25	Sandy loam
HS18	Bahtiwala	7.5	0.2	0.81	269.78	16	19	15-25-60	Clay loam
HS19	Sehjowal	7.1	0.1	0.76	182.97	18	28	41-11-48	Clay loam
HS20	Abowal	7.3	0.1	0.75	238.66	18	26	25-36-39	loam
HS21	Adamwal	7.0	0.1	0.79	300.345	17	18	47-25-28	Sandy loam
HS22	Hazipur	6.9	0.2	0.45	289.10	14	16	30-40-30	Silt loam
HS23	Hoshiarpur-1	6.8	0.1	0.40	221.92	7	12	41-25-34	Sandy loam
HS24	Bassi	6.6	0.1	0.82	130.08	8	14	25-45-30	Silt loam
HS25	Gopal	6.8	0.2	0.53	330.53	7	15	34-25-41	Clay loam
HS26	Bajwara-1	7.5	0.7	0.82	247.85	8	12	26-45-29	Silt loam
HS27	Bajwara-2	6.5	0.7	0.59	166.91	20	13	45-25-30	Sandy loam
HS28	Hoshiarpur-2	7.3	0.1	0.80	226.47	20	20	47-35-18	Sandy loam

Table 10 — Classification of various parameters and macronutrients of Hoshiarpur and Nawanshahr district

		Hoshiarpur				Nawanshahr			
Sr. No.	Parameters	Mean	Maximum	Minimum	Std. deviation	mean	Maximum	minimum	Std. deviation
1	pH	7.24	8.2	6	0.65	7.8	8.3	6.4	0.61
2	OC(%)	0.62	0.82	0.34	0.15	0.63	0.82	036	0.12
3	EC(mS/cm)	0.19	0.8	0.1	0.19	0.2	0.4	0.1	0.09
4	N(kg/ acre)	239.4	355.35	60.91	60.53	346.5	395.96	258.9	41.08
5	P(kg/ acre)	15.39	22	6	4.87	15.41	20	7	4.33
6	K(kg/ acre)	20.67	39	11	6.48	29.91	82	14	18.11

5.2 Macronutrients

5.2.1 Nitrogen

A macronutrient, *i.e.*, nitrogen, is vital for the soil to make the crop look healthier and yield more. In our study, it was founded that soil samples are the victim of excessive use of synthetic fertilizers as it was found that in the Hoshiarpur district, the available nitrogen to plants lies between 60.91 to 355.35 kg N per acre with mean and standard deviation 239.47 and 60.53 kg N per acre, respectively. In Nawanshahr, they varied between 258.90 to 395.96 kg N per acre with mean and standard deviations of 346.55 and 41.08 kg N per acre, respectively. From the findings, it was imitated that in Nawanshahr, 100% of the sample had a very high value (>220 kg N per acre) of available nitrogen, and the highest available nitrogen was found in Maujowal having a value of 395.96 kg N per acre followed by village Siana, Chaura and Shahbazpur others as tabulated and described in Table 8 and Fig. 3 respectively. Meanwhile, in Hoshiarpur, 21.4% of soil samples had a moderate level of available nitrogen, and only one village, Birampur-1, has 60.91kg N per acre (< 110 kg N per acre), which shows low availability of available nitrogen. The high values are found in villages like Thana (355.35 kg N per acre), Saddarpur (314.74 kg N per acre), and Adamwal (300.345 kg N per acre) and followed by others, as pointed out in Table 9. It may imitate the findings that synthetic Nitrogen fertilizers may be exploited. As there are almost 16 nutrients plants require to yield and grow ideally phosphorous, potassium are other essential nutrients which are also vital for agricultural land.

5.2.2 Phosphorous

It was found that in Hoshiarpur, the range of phosphorous varied between 6 to 22 kg P per acre with a standard deviation of about 4.87 kg P per acre and a mean of 15.39 kg P per acre. Almost 17.8% had adequate phosphorous availability, while other samples were nourished in excess. The highest value was found in a village named Thana, with 22 kg P per acre, followed by Sandhwal (21 kg P per acre), Ajmer (kg P per acre) and others described in Table 9. In the Nawanshahr district, predilection is similar to the former one. The available phosphorous varied between 7 to 20 kg P per acre; the standard deviation and mean values are 4.33 and 15.41 kg P per acre, respectively. 16% of soil sample lay in the moderate and medium range of P, while other samples had a high level of phosphorous content when compared with Table 7. The highest value was found in Rurkikhurd and Jabbowal, having 20 kg P per acre.

5.2.3 Potassium

The study found that in the district of Hoshiarpur, the available potassium varied from 11 to 39 kg K per acre, with a standard deviation of 6.48 kg K per acre and a mean of 20.67 kg K per acre. It was discovered that no soil sample was found with an adequate value of potassium.The lowest value *i.e*. 11 kg K per acre, was founded in village Birampur. A similar analysis of the Nawanshahr region showed that the amount of accessible potassium varied from 14 to 82 kg K per acre, with a standard deviation of 18.11 kg K per acre and a mean value of 29.91 kg K per acre. When compared with the guidelines (Table 7) for potassium it was found that only one soil sample from the village of Chaura had a potassium content of 82 kg K per acre, well within the medium range meanwhile the lowest value of available potassium found in Bhanewal village with the value 14 kg K per acre.

6 Conclusions

From the above results and discussion, it is clear that every sample moderately or largely deviated from the composition of macronutrients from the standard table showing the range values of nitrogen, phosphorous and potassium. In this study, it was founded that in the Hoshiarpur district, the average value of nitrogen, potassium and phosphorous is 239.17 kg/acre, 15.37 kg/acre and 20.6 kg/acre. Similarly, in the Nawanshahr district, the average value was 344.88 kg N, 15.4 kg P and 30 kg K each per acre. All these values are not residing in the standard range values. This result indicates a significant imbalance of nutrients in agricultural soil. The presence of available nitrogen in the Hoshiarpur district was roughly 1.5 times, and in the Nawanshahr district, it was twice the mean of the ideal range value.

Similarly, phosphorous is roughly five times the mean value of the permissible phosphorous range in both districts. Potassium is lacking in both districts as it is only 21% and 31% of the mean of ideal range values in Hoshiarpur and Nawanshahr, respectively. This nutrient imbalance may also imprint on crops and thus disturb nutritious values in food and fodder. Using the nitrogen and phosphorous fertilizers indiscriminately may produce harmful effects on human health. Thus, it is suggested that the authorities not only make a referendum but also take some concrete steps indulging the government and private agricultural firms in making farmers vigilant about the adversity regarding the overuse of synthetic fertilizers and the necessity of soil testing. It is recommended that there can be a diversification of fertilizers offered at a marginal cost to the farmers since the low price of fertilizers like urea after subsidy leads to its intensive application, only enriching agricultural soil for specific particular nutrients, leading to substantial imbalance.

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