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Assessment of soil fertility status based on NPK levels: A case study at agricultural research farm, Malakandher, Peshawar

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ABSTRACT

This study aims to evaluate the fertility status of soils at the Agricultural Research Farm, Malakandher, Peshawar, focusing on key macronutrients and physicochemical properties affecting crop productivity. Soil samples (0-15 cm depth) were collected from twelve representative farm blocks and analyzed for nitrogen, phosphorus, potassium, organic matter, soil pH, and electrical conductivity using standard laboratory procedures. The Kjeldahl method was used for nitrogen estimation, AB-DTPA extraction for phosphorus and potassium, Walkley-Black method for organic matter, and saturation extract techniques for pH and electrical conductivity. Results indicated significant variability in nutrient levels across fields: nitrogen ranged from 0.12% to 0.29%, phosphorus from 0.43 to 3.01 mg/kg, potassium from 97.5 to 151.9 mg/kg, and organic matter from 0.80% to 1.10%. Soil pH was moderately alkaline (7.08 to 7.29), while electrical conductivity values (0.53 – 0.66 dS/m) were generally sufficient. The findings suggest that while nitrogen and potassium levels are generally adequate, phosphorus deficiency requires attention. This study underscores the need for uniform and site-specific nutrient management strategies to improve fertilizer recommendations, enhance soil fertility, and support sustainable crop production in Malakandher and similar agroecological regions.

Contribution/Originality: This study contributes by providing a block-wise assessment of soil fertility at Malakandher Farm through integrated analysis of NPK, organic matter, pH, and EC. Unlike generalized surveys, it highlights spatial variability, offering location-specific nutrient management recommendations that can improve soil fertility and ensure sustainable crop production.

1. INTRODUCTION

Globally, there are significant variations in the fertility condition of soil due to a variety of factors, such as terrain, climate, geology, vegetation cover, and human activities. This is a broad summary: Certain areas are recognized for having very fertile soils, such as the Indo-Gangetic plains in South Asia, the Nile Delta in Egypt, the Pampas in Argentina, and the Midwest of the United States. Because of factors like sediment deposition from rivers or volcanic activity, these regions often have ideal weather, abundant rainfall or irrigation, and nutrient-rich soil. Additionally, there are areas with marginal soils, where salinity, aridity, soil erosion, or low nutrient content limit fertility. Examples include regions of the Amazon rainforest, central Australia, and the Sahara Desert, where the soil may be severely weathered and nutrient-leached. In addition to land and water, three essential nutrients nitrogen (N), phosphorus (P), and potassium (K) are crucial to the world's food production. Because of its limited availability and low recovery rate, phosphorus (P) stands out among these nutrients [1, 2]. Since mechanistic models represent known physical and biological processes in crops and soil, they are frequently more sophisticated. The effect of soil P and K in interaction with N on cropping systems in various soil types is not well represented in models, in contrast to the abundance of models that currently exist to mimic the dynamics of N and carbon (C). A model called Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS), which is partially based on empirical and partially on theoretical correlations, has been used to study yield responses to NPK fertilizer treatments in relation to soil fertility [3]. Pakistan's soil is deficient in nitrogen (N), potassium (30–40%), and phosphorus (80–90%). NPK is required for the yield of sesame. Utilizing nutrients to the maximum extent possible reduces production costs while increasing yield. As stated by Subrahmaniyan et al. [4]. Improving the yield characteristics and yield by 150% when the NPK concentration was increased. NPK enhances crop yield and growth [5]. The current study aimed to examine different NPK dosages administered to several sesame cultivars in order to determine how they impacted a number of growth metrics. For sustainable sesame cultivation, NPK® fertilizer provides a viable alternative to urea. NPK is essential for crop growth and is necessary for the development of sesame plants as well as biomass accumulation [6]. The mainstay of any economy is agriculture. Pakistan is primarily an agricultural country, with 47% of its land area used for farming and 61% of its rural people depending on farming for a livelihood. Crop development depends on properly maintaining the soil because it preserves fertility, increases production, and protects the environment. It is critical to examine the minerals in the soil to determine which crops thrive in certain types of soil. Good management of soil fertility involves identifying the nutrients that are currently deficient and monitoring fluctuations in soil fertility. Keeping the soil's fertility at its ideal level is essential for producing outstanding and lucrative yields. Crop reactions, farming systems, soil types, weather, and the level of fertilization influence outcomes. Proper management boosts nutrient uptake and decreases inorganic nitrogen leaching, preventing nitrification and denitrification losses [7].

2. MATERIAL AND METHODS

A random soil sample from different site locations of the Malakandher research farm was collected to determine its physiochemical properties. The soil samples were collected from the agronomy farm, horticulture farm, plant breeding and genetics farm, and plant pathology farm. Each farm was divided into three sections as shown in the diagram below. From each section of all farms, a random soil sample from 0-15cm was collected and brought to the lab of the Soil and Environmental Sciences Department. The following soil analyses were performed during the experiment. Figure 1 illustrates the division of Malakandher Research Farm into different sections, showing the locations where soil samples were collected for analysis.

Figure 1. Layout of Malakandher Research Farm showing the division of fields into sections for soil sampling.

2.1. Site Descriptions

The Malakandher research farms of the University of Agriculture Peshawar, Pakistan, have the geographical location of 34.1°21' N, 71°28'5' E. The research site was semi-arid and moderately humid during summer (March-June) and the warm and humid rainy season (July-September), with more than 60% of rainfall occurring in these months (Figure 2). The lowest mean temperature of December was 4.9 °C, while the highest mean temperature of December was 12.4 °C. The lowest mean temperature of January was 4.8 °C, and the highest mean temperature of January was 10.7 °C. These months are the coldest of the year. The mean annual air temperature is 23 °C, and the annual rainfall ranges from 380 to 400 mm. The experimental area altitude above sea level is 350 m.

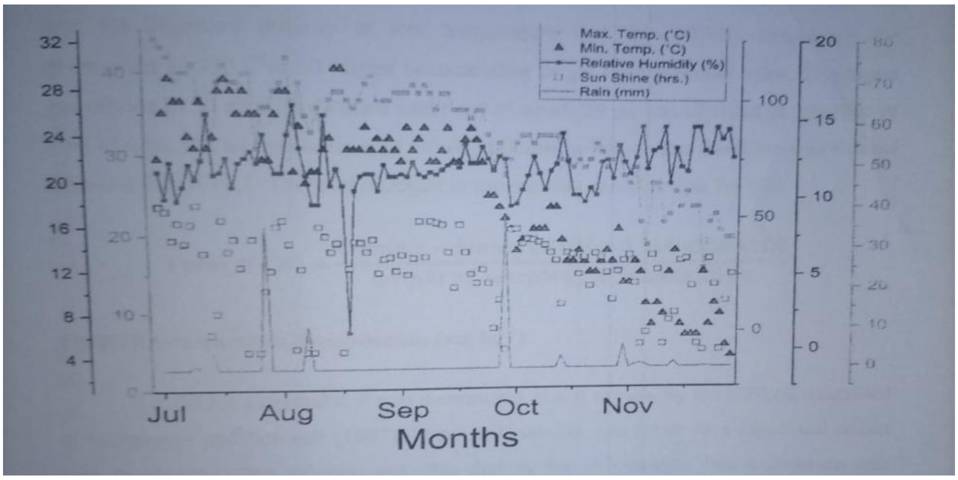

Figure 2. Weather conditions of malakandher farm, including highest and lowest temperatures, sunlight hours, rising degree days, and rainfall.

2.2. Soil Sampling

Soil samples will be obtained from various fields of Malakandher, Peshawar. Soil samples will be collected randomly from twelve different spots within the same field to create a composite sample from a depth of 0-15cm. A soil auger will be used for sampling purposes. The soil samples will be kept in plastic bags, labeled, and transported to the soil testing laboratory at The University of Agriculture, Peshawar for further analysis.

Table 1 presents the details of soil sampling sites, including field names, farmers, coordinates, and number of samples collected.

Table 1. Details of soil samples collected from different fields in Malakandher farm Peshawar.

S.no.	Field name	Farmer name	Latitude	Longitude	No. of samples
1	Agronomy farm 1	Liaquat Khan	36.7229	71.79527	3
2	Agronomy farm 2	Rose Zamin	36.229	71.73893	3
3	Agronomy farm 3	Sher Zamin	36.2559	71.7374	3
4	Horticulture farm 1	M. Amin	36.20916	71.7336	3
5	Horticulture farm 2	Momin Khan	37.2187	71.7055	3
6	Horticulture farm 3	Noor Karim	37.12679	71.76517	3
7	PBG farm 1	Raza Khan	37.12212	71.74239	3
8	PBG farm 2	Zaitur Rahman	37.2204	71.4434	3
9	PBG farm 3	Ajmal Khan	34.19906	71.75748	3
10	Plant pathology farm 1	Sher Afzal	34.20293	71.77722	3
11	Plant pathology farm 2	Manan Khan	34.2377	71.7222	3
12	Plant pathology farm 3	Manan Khan	34.2512	71.7224	3

2.3. Soil Analysis

The collected soil samples were air-dried, ground, sieved, and prepared for analysis. They were then tested for key physicochemical properties, including pH, electrical conductivity (EC), total nitrogen, organic matter, and AB-DTPA extractable phosphorus and potassium.

2.4. Determination of Total N in Soil

Total nitrogen in the soil was determined using the Kjeldahl method as described by Bremner [8]. In this procedure, 0.2 g of air-dried, sieved soil was placed in a digestion tube along with 1.1 g of digestion mixture and 3 mL of concentrated sulfuric acid. The tubes were first heated at a low temperature and then gradually raised to 350 °C until the digest became clear or light green. The digest was diluted to 50 mL with distilled water, from which 20 mL was distilled in the presence of 4 mL of 40% NaOH into a boric acid–mixed indicator solution. The distillate was titrated against 0.005 N HCl, and the total nitrogen content was calculated using the following formula:

Total N (%) = ((Sample - blank) x 0.005 x 0.014 x 100 x 100) / (Weight of sample (g) x Volume taken)

2.5. AB-DTPA Extractable Phosphorus (mg kg^-1)

AB-DTPA extractable P was determined in soil sample by the method described in Soltanpour and Schwab [9]. A 1.0 g soil sample was taken in a flask and added to 20 ml of AB-DTPA solution, then shaken for 15 minutes. The suspension was filtered through Whatman filter paper No. 42. Phosphorus was determined using ammonium molybdate color reagent and measured at 880 nm wavelength using a spectrophotometer.

2.6. AB-DTPA Extractable Potassium (mg kg^-1)

The AB-DTPA extractable K was measured in the extract obtained for K measurement, described alone on a Flame Photometer (Sherwood) model after calibration with K standards.

2.7. Organic Matter

Organic matter in the soil samples was determined using the Walkley-Black method. [10]. In this procedure, 1.0 g of soil was placed in a 500 mL flask and treated with 10 mL of 1N $K_2Cr_2O_7$ solution, followed by 20 mL of concentrated H_2SO_4. The mixture was shaken thoroughly to ensure complete oxidation of organic matter and left to stand for 30 minutes. Afterward, 200 mL of distilled water was added, and the suspension was filtered using acid-resistant filter paper (Whatman No. 540). The filtrate was titrated against 0.5 N $FeSO_4$ solution in the presence of an ortho-phenanthroline indicator. A blank determination was also carried out under the same conditions without soil. The percentage of organic matter was calculated using the following formula:

OM (%) = ((mL K2Cr2O7 – mL FeSO4) × N × 0.69) / Weight of soil sample (g)

Whereas 0.69 is a correction factor obtained from the assumption that OM contains 58% C, the meq. Wt of C in OM is 0.003 (i.e., oxidation state is 0), and 75% of OM is recovered in this process.

2.8. Soil pH

Soil pH was determined in soil saturation extract. 1:5 soil water suspensions were used to measure the soil pH. Take 10 g of air-dried soil in a beaker and add 50 ml of distilled water, then keep on a shaker machine for 15 minutes. After shaking, transfer it into a suction funnel with filter paper and apply vacuum. Then, collect the extract in a labeled bottle and save it for further analysis.

2.9. Soil Electrical Conductivity (EC)

EC of the soil samples was analyzed using an EC meter. Before running the EC meter, the instrument was calibrated with a standard buffer solution of EC 4.2 dS/m and 12.6 dS/m. After calibration, the samples were analyzed [11].

3. RESULT AND DISCUSSION

Results of the physico-chemical properties of Malakandher farm are presented from Table 2 to Table 7.

3.1. Total Soil Nitrogen (%)

The data presented in Table 2 shows the concentration of total nitrogen (N) in soil samples collected from various locations within the new developmental farm of The University of Agriculture Peshawar. The table indicates that the nitrogen content in the soil of Malakander farm ranged from 0.12% to 0.29%. The maximum nitrogen concentration of 0.29% was recorded in the agronomy farms of Malakander. This value is significantly higher than those recorded at other farm locations within the Agriculture University, suggesting that the agronomy farm 3 has a notably high nitrogen content. The overall average nitrogen concentration across Malakander agronomy farms is approximately 0.21%. In the horticulture farms, the lowest nitrogen concentration recorded was 0.17% in Horticulture 2 farm, while the highest was 0.52% in Horticulture farm 1. The average nitrogen concentration in horticulture farms is approximately 0.306%. Farms dedicated to plant breeding and genetics exhibited an average nitrogen concentration of 0.416%. The lowest value recorded was 0.10% in PBG 1 farm, and the highest was 0.92% in PBG farm 2. Farms involved in pathology studies showed an average nitrogen concentration of 0.24%. The lowest nitrogen concentration across Malakander farms was observed in untreated soils used for moving machining or field border lines, with a value of 0.12%.

Table 2. Percentage of Nitrogen in the New Developmental Farm of Agricultural Soil.

Soil sample	Minimum value	Maximum value	Mean
Agronomy farm 1	0.12	0.15	0.12 f
Agronomy farm 2	0.24	0.27	0.24 e
Agronomy farm 3	0.62	0.63	0.62 a
Horticulture farm 1	0.29	0.30	0.30 b
Horticulture farm 2	0.17	0.17	0.17 e
Horticulture farm 3	0.23	0.25	0.23 c
PBG farm 1	0.10	0.17	0.10 f
PBG farm 2	0.26	0.29	0.29 c
PBG farm 3	0.21	0.23	0.21 e
Plant pathology farm 1	0.14	0.16	0.14 f
Plant pathology farm 2	0.35	0.37	0.35 c
Plant pathology farm 3	0.12	0.13	0.12 f

The means followed by different letters in each column are significantly different from each other at $\alpha = 0.05$.

Table 2a. Classification of soil samples based on total N concentration.

Category	Nitrogen (%)	No. of samples
Very high	1.0	0
High	0.5 – 1.0	2
Medium	0.2 – 0.5	5
Low	0.1 – 0.2	5
Very low	<0.1	0

3.2. Soil Phosphorus Concentration

Data present in Table 3 shows the concentration of P in soil collected from various locations of the new developmental farm of The University of Agriculture Peshawar. The table indicates that the phosphorus range in the soil of Malakander farm was from 0.43 to 8.01 mg kg^{-1}. The maximum concentration of phosphorus, 8.01 mg kg^{-1}, was recorded in the agronomy farms of Malakander. This value is significantly higher than those in other farm locations of Agriculture University Peshawar. It was observed that the agronomy farm 3 had high phosphorus content at 8.01 mg kg^{-1}, while the minimum P concentration was recorded in agronomy farm 2, showing 2.72 mg kg^{-1}. The average phosphorus concentration in the agronomy farms was approximately 5.09 mg kg^{-1}. In contrast, the horticulture farms had an average phosphorus concentration of 2.47 mg kg^{-1}. The lowest P concentration of 1.08 mg kg^{-1} was recorded in Horticulture 1 farm, and the highest concentration of 4.17 mg kg^{-1} was recorded in Horticulture farm 3. The farms of plant breeding and genetics had an average phosphorus concentration of 1.79 mg kg^{-1}, with the lowest P concentration of 1.17 mg kg^{-1} in PBG 2 farm and the highest of 2.45 mg kg^{-1} in PBG farm 3. The farms of pathology had an average phosphorus concentration of 1.72 mg kg^{-1}. The lowest phosphorus concentration across Malakander farm was recorded in untreated soil used for moving machining or field border lines, at 0.43 mg kg^{-1}.

Table 3. Concentration of phosphorus in the new developmental farm of agricultural soil.

Soil sample	Minimum value	Maximum value	Mean
Agronomy farm 1	4.52	4.56	4.54 b
Agronomy farm 2	2.71	2.73	2.72 e
Agronomy farm 3	7.97	8.04	8.01 a
Horticulture farm 1	1.07	1.08	1.07 j
Horticulture farm 2	2.18	2.20	2.19 g
Horticulture farm 3	4.13	4.17	4.15 c
PBG farm 1	1.76	1.78	1.77 h
PBG farm 2	1.16	1.17	1.17 i
PBG farm 3	2.43	2.45	2.44 f
Plant pathology farm 1	3.49	3.52	3.51 d
Plant pathology farm 2	1.21	1.22	1.22 i
Plant pathology farm 3	1.41	1.43	1.43 k

The means followed by different letters in each column are significantly different from each other at $\alpha = 0.05$.

Table 3a. Classification criteria for AB-DTPA extractable phosphorus (P) in mg kg^{-1} values into low, medium, and high ranges.

Category	Range	No. of samples
Low	<3	8
Medium	3-7	3
High	7	1

Source: Rashid and Ahmad [12] and Rashid et al. [13].

3.3. Soil Potassium (K) Concentration

The data presented in Table 4 shows the concentration of potassium (K) in soil samples collected from various locations of the new developmental farm of The University of Agriculture Peshawar. The table indicates that the potassium levels in the soil of Malakander farm ranged from 97.5 to 151.9 mg kg^{-1}. The maximum concentration of 151.9 mg kg^{-1} was recorded in the agronomy farms of Malakander, which is significantly higher than other farm locations within the Agriculture University. This suggests that the agronomy farm 3 has a notably high potassium content. The overall average potassium concentration across Malakander agronomy farms was approximately 143.4 mg kg^{-1}. The lowest potassium concentration of 109.1 mg kg^{-1} was observed in Horticulture 2 farm, while the highest phosphorus (P) concentration of 149.3 mg kg^{-1} was recorded in Horticulture farm 1. The lowest potassium concentration in horticulture farms was recorded in Horticulture 2, with an average of 130.7 mg kg^{-1}. The plant breeding and genetics farms exhibited an average potassium concentration of 114.76 mg kg^{-1}, with the lowest value of 109.2 mg kg^{-1} in PBG 2 farm and the highest of 122.3 mg kg^{-1} in PBG farm 3. The pathology farms showed an average potassium concentration of 146.5 mg kg^{-1}.

Table 4. Concentration of potassium in the new developmental farm of agricultural soil.

Soil sample	Minimum value	Maximum value	Mean
Agronomy farm 1	151.2	152.6	151.9 a
Agronomy farm 2	125.4	126.5	126.0 e
Agronomy farm 3	151.6	153.0	152.3 a
Horticulture farm 1	148.6	149.9	149.3 b
Horticulture farm 2	108.6	109.6	109.1 h
Horticulture farm 3	133.2	134.4	133.8 d
PBG farm 1	121.2	122.3	121.7 f
PBG farm 2	108.2	109.2	108.7 h
PBG farm 3	113.4	114.4	113.9 g
Plant pathology farm 1	143.4	144.7	144.0 c
Plant pathology farm 2	148.4	149.7	149.1 b
Plant pathology farm 3	97.1	98.0	97.5 i

The means followed by different letters in each column are significantly different from each other at α = 0.05.

Table 4a shows that most soil samples fall in the high potassium range, a few in the medium range, and none in the low range, indicating generally adequate potassium levels at Malakandher Farm.

Table 4a. Classification of soil samples based on potassium (K) concentration at Malakandher Farm.

Category	Range	No. of sample
Low	<60	0
Medium	60-120	4
High	120	8

Source: Rashid and Ahmad [12] and Rashid et al. [13].

Table 5. Percentage of organic matter in the new developmental farm of agricultural soil.

Soil sample	Minimum value	Maximum value	Mean
Agronomy farm 1	0.93	0.94	0.93 c
Agronomy farm 2	1.00	1.01	1.00 b
Agronomy farm 3	1.10	1.11	1.10 a
Horticulture farm 1	0.51	0.51	0.51 f
Horticulture farm 2	0.65	0.66	0.65 e
Horticulture farm 3	0.72	0.73	0.72 e
PBG farm 1	0.31	0.31	0.31 g
PBG farm 2	0.51	0.51	0.51 f
PBG farm 3	0.69	0.70	0.69 e
Plant pathology farm 1	0.75	0.76	0.75 d
Plant pathology farm 2	0.93	0.94	0.93 c
Plant pathology farm 3	0.80	0.81	0.80 d

3.4. Organic Matter (%)

Data present in Table 5 shows organic matter in soil collected from various locations of the new developmental farm of The University of Agriculture Peshawar. The table indicates that the range of organic matter in the soil of Malakander farm was from 0.80% to 1.10%. The maximum percentage of organic matter, 1.10%, was recorded in the agronomy farms of Malakander. This value is significantly higher than those of other farm locations of the Agriculture University, indicating that Agronomy Farm 3 has a higher organic matter content. The average organic matter concentration across the Malakander agronomy farms is approximately 1.01%. The lowest organic matter of 0.51% was recorded in Horticulture 1 farm, while the highest concentration of 0.72% was observed in Horticulture Farm 3. The average organic matter concentration in horticulture farms is 0.62%. The farms of Plant Breeding and Genetics have an average organic matter concentration of 0.50%, with the lowest value of 0.31% recorded in PBG 1 farm and the highest of 0.69% in PBG Farm 3. The farms of Pathology have an average organic matter concentration of 0.84%.

3.5. Soil pH

The data presented in Table 6 shows soil samples collected from various locations of the new developmental farm of the University of Agriculture Peshawar. The table indicates that the pH value concentration in the soil of Malakander farm ranged from 7.08 to 7.29. The maximum pH value of 7.29 was recorded in the agronomy farms of Malakander. The average pH concentration across the Malakander agronomy farms is approximately 7.25. The lowest pH value of 7.2 was recorded in Agronomy Farm 1, while the highest of 7.29 was observed in Agronomy Farm 3. In the horticulture farm, the average pH value was around 7.60. The lowest pH value of 7.36 was recorded in Horticulture Farm 1, and the highest of 7.77 was observed in Horticulture Farm 3. The farms dedicated to plant breeding and genetics had an average pH value of 7.73. The lowest pH value in this category was 7.56, recorded in PBG.

Table 6. pH value in the new developmental farm of agricultural soil.

Soil sample	Minimum Value	Maximum Value	Mean
Agronomy farm 1	7.17	7.23	7.20 g
Agronomy farm 2	7.24	7.30	7.27 f
Agronomy farm 3	7.26	7.32	7.29 f
Horticulture farm 1	7.33	7.40	7.36 c
Horticulture farm 2	7.65	7.72	7.68 bc
Horticulture farm 3	7.74	7.81	7.77 a
PBG farm 1	7.59	7.66	7.62 cd
PBG farm 2	7.68	7.75	7.71 b
PBG farm 3	7.53	7.60	7.56 d
Plant pathology farm 1	7.62	7.69	7.65 bc
Plant pathology farm 2	7.64	7.71	7.67 bc
Plant pathology farm 3	7.05	7.11	7.08 h

The means followed by different letters in each column are significantly different from each other at $\alpha = 0.05$.

Table 6a. Classification of soil pH ranges in the studied area.

Range	Acidity/Alkalinity	No. of sample
<4.0	Very strongly acidic	-------
4-5	Strongly acidic	-------
5-6	Moderately acidic	-------
6-7	Slightly acidic	-------
7.0	Neutral	-------
7-8	Slightly alkaline	12
8-9	Moderately alkaline	-------
9-10	Strongly alkaline	-------
10-11	Very strongly alkaline	-------

Farm 3 and the highest pH value concentration (7.71) were recorded in PBG Farm 2. The farms of pathology have an average pH value concentration of (7.37). Table 6a indicated that the soil of Malakandher is slightly alkaline in nature.

3.6. Soil Electrical Conductivity (EC) Results

The data presented in Table 7 shows soil samples collected from various locations of the new developmental farm of The University of Agriculture Peshawar. The table indicates that the range of electrical conductivity (EC) concentration in the soil of Malakander farm was from 0.53 to 0.66 dSm^{-1}. The maximum EC value of 0.66 dSm^{-1} was recorded in the agronomy farms of Malakander, with Agronomy Farm 1 exhibiting the highest EC value.

Table 7. EC value in the new developmental farm of agricultural soil.

Soil sample	Minimum value	Maximum value	Mean
Agronomy farm 1	0.66	0.67	0.66 d
Agronomy farm 2	0.58	0.59	0.58 e
Agronomy farm 3	0.61	0.62	0.61 e
Horticulture farm 1	1.01	1.02	1.01 b
Horticulture farm 2	1.03	1.04	1.03 b
Horticulture farm 3	0.98	0.99	0.98 b
PBG farm 1	1.07	1.08	1.07 a
PBG farm 2	1.12	1.13	1.13 a
PBG farm 3	1.03	1.04	1.03 b
Plant pathology farm 1	0.84	0.85	0.84 c
Plant pathology farm 2	0.79	0.80	0.79 c
Plant pathology farm 3	0.53	0.53	0.53 f

The average EC concentration across the Malakander agronomy farms was approximately 0.616 dSm^{-1}. In contrast, the lowest EC value of 0.53 dSm^{-1} was recorded in Horticulture 3 farm, while the highest EC value of 1.03 dSm^{-1} was observed in Horticulture Farm 2. The average EC concentration in horticulture farms was recorded at 1.012 dSm^{-1}. The farms dedicated to plant breeding and genetics showed an average EC value of 1.06 dSm^{-1}. The lowest EC value in this category was 1.03 dSm^{-1} in PBG 3 farm, and the highest was 1.13 dSm^{-1} in PBG Farm 2. The farms of pathology had an average EC value, which was not specified in the provided data.

The means followed by different letters in each column are significantly different from each other at $\alpha = 0.05$.

Table 7a presents the classification of soil electrical conductivity (EC) values into normal, saline, sodic, and saline-sodic categories, which indicates that all studied soils fall within the normal range.

Table 7a. Guideline use for interpretation of soil electrical conductivity.

Nature of soil	EC (dS m^{-1})	ESP	SAR
Saline	≥4	<15	<15
Sodic	<4	≥15	≥15
Saline-sodic	≥4	≥15	≥15
Normal soil	<4	<15	<15

4. CONCLUSION

The following conclusions were drawn from the study: the nitrogen levels are moderate to high, indicating adequate fertility for crop growth. The phosphorus levels are variable, with some areas showing deficiency, while others have adequate to high levels. The potassium levels are generally high, indicating good fertility.

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