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Status of soil nutritional health in rice (*Oryza sativa*) fields: A study of Ludhiana District in Punjab

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***Abstract*---**Soil is an important component of the human environment and is a significant component of terrestrial ecosystems. Over utilization and consuming all its minerals and nutrients by repetitive agricultural tasks along with the higher doses of agro chemicals affect the health of the soil and hamper the growth of the plants. Its health status needs to be regularly evaluated for understanding the magnitude of the available nutrients to plants in soil. To understand this important health status of soil, a study was conducted in Ludhiana District in Punjab for testing the soil samples for all its important parameters in rice growing fields. Four samples sites as Site 1- Dhande village, Machchhiwara Block,, Site 2-Ghuman village, Sudhar Block, Site 3- Nizampur village, Khanna Block and Site 4- Selioni village, Jagraon were taken for the study. There were fourteen parameters tested in soil samples comprising of primary macro-nutrients (Nitrogen-N, Phosphorus- P, and Potassium-K), secondary macro-nutrients (Sulfur-S, Magnesium - Mg, and Calcium - Ca), and micronutrients (Iron -Fe, Manganese - Mn, Zinc - Zn, Copper - Cu, Molybdenum - Mo, Boron - B, Chlorine - Cl and Cobalt - Co)along with soil pH, Electric Conductivity (EC) and Soil Moisture. Forty soil samples were collected from twenty rice growing fields at four villages as Sites in four blocks of the district in two Phases. Variability in the magnitude of tested parameters in both the phases for all the sites calculated for comparing the percent change in the magnitude of the concerned parameters. Soil samples were also drawn from the IPM fields in the study region from each Site. Variability in the magnitude of tested parameters in both the phases for all the sites calculated for comparing the percent change in the magnitude of the concerned parameters. Soil samples were also drawn from the IPM fields in the

study region from each Site. Maximum variability in the mean magnitude (ppm) of primary macro-nutrients in all the fields in both the Phases shown by N followed by P and K indicated in terms of SD respectively as 416.31, 254.36 and 241.78, while among secondary macro-nutrients Ca shows maximum variability followed by Mg and S respectively as 453.71, 345.78 and 56.47. Micronutrients (Fe, Mn, Zn, Cu, Mo, B, Cl, Co) indicate variability in their magnitude in terms of SD in all the fields in both Phases respectively as 1336.80, 92.10, 0.59, 0.54, 7.95, 12.81 and 0.40. Soil pH found to be close to neutral in the study region in all the fields, soil are not deficient making the nutrients available to plants. The mean magnitude of pH, EC and soil moisture content percent in all four IPM field respectively in Phase 1 and Phase 2 indicated the values as 7.04, 214.30, 13.53 and 7.11, 269.20, 12.76. The comprehensive and precise assessment of magnitudes of soil nutrients is a very important component for precise farming, in particular, and for the wise management of sustainable agricultural practices, in general. This investigation facilitates the identification of the available content and extent of the required elements in soil for the potential agricultural uses of the area.

***Keywords*---**Soil, health, nutrients, magnitude, deficient, moisture, rice.

Introduction

Soil is a valuable natural resource full of solid minerals and organic matter, liquids and gasses that occur on the surface. The basic requirements of moisture and nutrients for plant growth, habitats for organisms is provided by soil. It is indeed the basis of the production in agriculture and forestry. Soil is an important component of the human environment and is a significant component of terrestrial ecosystems. One of the key facts emphasized by the food and agricultural organization was that sustainable management of soils can lead to a 58% increase in food production, and healthy soils are the basis for healthy food production (FAO, 2015). Soil nutrient composition plays a key role in determining the goodness of a soil. A healthy soil will have all the essential elements in the right proportions to support healthy plant growth throughout its life cycle (Soil Nutrients, 2016). Over utilization and consuming all its minerals and nutrients by repetitive agricultural task along with the higher doses of agro chemicals affect the health of the soil and hamper the growth of the plants. Its health status needs to be regularly evaluated for understanding the magnitude of the nutrients available to plants. All its macro as well as micro nutritional elements along with important parameters like pH, EC and moisture content must be tested through scientific soil sampling of the study region. To understand this important health status of soil, a study was conducted in Ludhiana District in Punjab by testing the soil samples for all its important parameters such as primary macro-nutrients (Nitrogen-N, Phosphorus- P, and Potassium-K), secondary macro-nutrients (Sulfur-S, Magnesium - Mg, and Calcium - Ca), and micronutrients (Iron -Fe, Manganese - Mn, Zinc - Zn, Copper - Cu, Molybdenum - Mo, Boron - B, Chlorine - Cl and Cobalt - Co)along with soil pH, Electric Conductivity (EC) and Soil

Moisture. Forty soil samples were collected from twenty rice growing fields at four villages as Sites in four blocks of the district in two Phases. Variability in the magnitude of tested parameters in both the phases for all the sites calculated for comparing the percent change in the magnitude of the concerned parameters. Soil samples were also drawn from the IPM fields in the study region from each Site.

Ludhiana district with Sudhar, Raikot, Machhiwara and Doraha blocks selected taking four villages namely Ghuman in Sudhar, Nizampur in Doraha, Dhande in Machhiwara and Siloani in Raikot block. A total of twenty rice fields taking five rice fields from each village for quantification of concentration of the pesticides from organophosphorus group in soil and water was undertaken for the stduy. Soil and water samples were collected twice from these fields at two phases at transplanting stage and harvesting stage with an interval of three and a half months in the kharif season during 2020 with a total number of 80 samples for pesticide magnitude analysis in water and soil samples.

All plants require 17 elements to complete their life cycle, and an additional four elements have been identified as essential for some plants (Havlin *et al.* 2005). With the exception of C, H, and O, which plants obtain from air and water, plants derive the remaining 14 elements from the soil or through fertilizers, manures, and amendments (Parikh & James 2012). Nitrogen (N), Potassium (K), and Sulfur (S) are major plant nutrients that appear to be less affected directly by soil pH than many others, but still are to some extent. Phosphorus (P), however, is directly affected. At alkaline pH values, greater than pH 7.5 for example, phosphate ions tend to react quickly with calcium (Ca) and magnesium (Mg) to form less soluble compounds. At acidic pH values, phosphate ions react with aluminum (Al) and iron (Fe) to again form less soluble compounds. Most of the other nutrients (micronutrients especially) tend to be less available when soil pH is above 7.5, and in fact are optimally available at a slightly acidic pH, e.g. 6.5 to 6.8. The exception is molybdenum (Mo), which appears to be less available under acidic pH and more available at moderately alkaline pH values (Jensen *et al.* 2010). Soil pH affects other soil variables and controls the soil physical, chemical, and biological properties (Neina D, 2019 and Brady *et al.*, 2008).

Methodology

Study Area

Ludhiana district with Sudhar, Raikot, Machhiwara and Doraha blocks selected taking four villages namely Ghuman (30.781901N, 75.660682E) in Sudhar, Nizampur (30.654590N, 75.024303E)in Doraha, Dhande (30.858829N, 75.136613E) in Machhiwara and Siloani (30.670569N, 75.553125E) in Raikot block. A total of twenty rice fields taking five rice fields from each village for quantification of magnitude the soil nutrients was undertaken for the study. Soil samples were collected twice from these fields at two phases at transplanting stage and harvesting stage with an interval of three and a half months in the K*harif* season during 2020 with a total number of forty samples for nutritional magnitude analysis in soil samples.

Collection of field data

All the required information for this study have been collected through visiting the selected sampling fields with the help of the concerned farmers by personal interview. Demarcation and assigning a sampling code to a patch of paddy as a sampling field of an acre was done to collect soil and water samples along with the associated required information crop husbandry, pesticide application, dose etc.

Soil Sampling

All the soil samples were collected as per standard procedure based on Patiram*et.al.* (2007) and Agricultural Department, Punjab Government (2012), BIS (2010). Quartering, discarding, again mixing to get about a half kg of soil as the representative field sample, then placing in a clean cloth bag and bringing the samples from the fields for records, processing, preparation and analysis. Transferred samples were prepared and made available for nutritional magnitude evaluation for lab testing with the help of Rock Lab, CSRD, JNU, New Delhi; Sophisticated Industrial Materials Analytic Labs, New Delhi and ICAR-NCIPM New Delhi. All the soil samples for nutrients magnitude were analyzed using the standard protocols following the laid down procedures in *Methods of Soil Analysis, Part 2.(* Mclean, 1982), Soil and Water Analysis (Patiram *et.al.* 2007).
Soil moisture content as percent was by subtracting the weight of the dry soil from the weight of the moist soil, and then dividing by the weight of the dry soil and from the dried soil weight, weight of the measuring plate was deducted.

Results and Discussion
Magnitude of Nutrients in soil

Magnitude of primary macro-nutrients (Nitrogen-N, Phosphorus- P, and Potassium-K), secondary macro-nutrients (Sulfur-S, Magnesium - Mg, and Calcium - Ca), and micronutrients (Iron -Fe, Manganese - Mn, Zinc - Zn, Copper - Cu, Molybdenum - Mo, Boron - B, Chlorine - Cl and Cobalt - Co) was calculated in soil samples collected from all the twenty fields (F1-F20) form Sites 1-4 in both phases 1-2 (*Tables 1-2*).

Thus Nitrogen, Potassium, Phosphorus, Calcium, Magnesium, Sulfur as six elements indicated the magnitude of macro nutrient group while eight elements represented the micro nutrient group were Iron, Chlorine, Manganese, Boron, Zinc, Copper, Molybdenum and Cobalt (*Tables 1-2*).

Maximum variability in the mean magnitude (ppm) of primary macro-nutrients in all the fields in both the Phases shown by N followed by P and K indicated in terms of SD respectively as 416.31, 254.36 and 241.78, while among secondary macro-nutrients Ca shows maximum variability followed by Mg and S respectively as 453.71, 345.78 and 56.47. Micronutrients (Fe, Mn, Zn, Cu, Mo, B, Cl, Co) indicate variability in their magnitude in terms of SD in all the fields in both Phases respectively as 1336.80, 92.10, 0.59, 0.54, 7.95, 12.81 and 0.40. (*Tables 3, 4 and 5*).

While observing the maximum mean magnitude (ppm) of the nutrients in soil at all sites in Phase 1 and Phase 2, Nitrogen found with 1268.57 at Site 2 in Phase 2, Potassium (1011.94) at Site 3 in Phase 1

Table 1: Nutrients magnitude in soil (ppm) in all fields (1-20) at all Sites (1-4) in Phase 1
Nutrients in soil (ppm)

Site 1						Site 2				
Paramet	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
N	1165.	578.6	1647.3	1001.2	1671.9	1029.0	553.73	1363.3	502.27	747.74
K	636.5	647.0	1195.7	591.5	1205.6	705.03	675.98	513.54	562.88	1076.7
P	519.4	558.9	978.8	941.4	489.0	451.05	444.56	848.73	645.74	651.84
Ca	2497.	1331.	2234.3	2322.3	1504.2	2358.7	2197.2	1758.8	1680.9	1378.6
Mg	1040.	919.3	1157.8	1179.6	957.7	960.42	1136.3	1035.9	1074.3	1058.3
S	275.6	208.0	171.4	176.1	252.2	145.11	160.91	220.73	198.94	286.67
Fe	5963.	7493.	9727.8	9180.9	8068.9	9320.2	7703.3	8906.7	5299.6	7744.5
Cl	59.1	24.3	53.9	37.7	55.5	44.52	39.65	30.76	23.91	31.83
Mn	301.2	412.9	104.1	345.3	144.8	75.76	205.17	171.42	214.39	180.44
B	7.2	10.4	16.2	4.2	25.9	7.76	15.00	3.48	20.50	12.49
Z	5.9	13.0	6.5	10.0	17.9	15.28	6.77	11.61	13.25	15.73
Cu	2.5	2.1	2.1	2.4	1.0	2.10	1.27	1.52	0.90	1.83
M	2.0	0.6	0.7	0.2	1.3	1.03	0.12	0.82	1.26	1.73
Co	1.2	1.5	1.3	0.5	0.9	0.60	1.44	1.10	0.71	0.90

Site 3						Site 4				
Paramet	F11	F12	F3	F14	F15	F16	F17	F18	F19	F20
N	609.	894.82	1670.5	1711.1	1377.3	1127.8	1637.1	1368.0	685.64	715.00
K	877.	978.71	1068.9	873.26	1260.9	1104.7	545.82	594.60	933.49	948.71
P	976.	914.45	519.34	455.15	587.89	602.42	753.29	567.24	815.50	673.19
Ca	2237	1915.2	1558.8	1797.5	1160.9	1091.6	1093.3	1642.2	1519.9	1624.3
Mg	887.	1168.2	1105.8	1149.7	946.41	910.94	913.67	1067.2	1049.3	817.24
S	107.	113.25	269.23	284.56	113.07	130.46	232.55	259.95	200.68	270.01
Fe	6440	7652.7	6609.7	9090.0	5509.2	5934.8	8501.8	5822.9	8608.1	8675.5
Cl	20.5	41.33	59.84	25.77	25.35	20.77	27.89	53.06	26.44	45.21
Mn	309.	113.99	411.13	52.21	230.67	233.49	234.63	52.68	368.32	280.33
B	23.9	25.92	26.40	27.25	23.24	5.61	6.35	17.44	11.77	27.61
Z	10.2	17.04	8.85	8.91	16.52	14.39	5.43	13.45	11.46	18.07
Cu	2.24	0.76	0.77	2.14	1.70	2.48	0.53	2.22	2.05	1.70
M	1.25	1.81	1.66	0.71	1.63	1.35	1.39	1.69	0.73	0.57
Co	0.69	0.57	0.88	0.51	1.17	1.30	0.59	0.58	1.11	1.40

Phosphorus (941.81) at Site 1 in Phase 2, Calcium (1977.84) at Site 1 in Phase 1, Magnesium (1724.59) at Site 2 in Phase 2, Sulfur (218.73) at Site 4 in Phase 1, Iron (8415.27) at Site 2 in Phase 2, Chlorine (46.08) at Site 1 in Phase 1 , Manganese (261.65) at Site 1 in Phase 1, Boron (25.35) at Site 3 in Phase 1, Zink (19.67) at Site 3 in Phase 2, Copper (2.01) at Site 1 in Phase 1, Molybdenum (1.41) at Site 3 in Phase 1 and Cobalt (1.44) at Site 3 in Phase 2 (*Tables 1 & 2*). The typical iron concentrations in soils range from 0.2% to 55% (20,000 to 550,000 mg/kg) (Bodek *et al.*, 1988), and concentrations can vary significantly, even within localized areas. Here at the Study region in Ludhiana the magnitude as the highest value for Fe found to be 8415.27 at Site in Phase 1.

Table 2: Nutrients magnitude in soil (ppm) in fields (1-20) at all Sites (1-4) in Phase 2

Nutrients in soil (ppm)

Site 1						Site 2				
Paramet	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
N	946.	1317.9	1367.2	1782.7	430.12	1515.3	422.91	1304.0	1655.9	1444.6
K	412.	667.88	992.60	644.62	760.98	904.63	428.42	428.11	608.89	926.59
P	305.	1260.8	1238.0	893.50	1011.1	1099.8	1142.6	710.30	335.64	1084.6
Ca	1489	896.81	1349.9	1025.4	1709.0	1007.9	1575.2	1405.6	1953.6	1598.4
Mg	1527	1294.7	1396.3	1272.9	986.92	1433.6	1958.6	1562.7	1702.3	1965.6
S	112.	141.73	199.70	153.41	238.75	191.16	111.02	214.96	167.95	205.28
Fe	7362	6934.0	6948.8	8291.1	10920.	10290.	8360.1	6663.5	7661.1	9100.8
Cl	36.5	25.67	22.17	19.11	13.15	38.40	23.78	10.71	25.13	37.18
Mn	256.	227.85	152.42	154.11	255.25	241.90	275.88	185.21	111.39	193.67
B	22.4	24.30	8.67	3.98	11.43	7.31	12.71	8.57	22.27	13.97
Z	15.5	16.90	15.91	11.72	13.31	18.10	12.56	10.50	19.34	19.66
Cu	0.71	0.80	1.69	0.75	1.54	0.77	1.44	0.83	1.01	0.64
M	1.19	0.25	0.76	1.33	0.67	1.34	0.14	1.28	0.18	1.17
Co	1.15	0.80	1.00	1.92	1.03	1.34	0.80	1.09	1.66	0.87
Site 3						Site 4				
Paramet	F11	F12	F3	F14	F15	F16	F17	F18	F19	F20
N	1133	1286.7	750.99	705.57	1630.0	487.70	1052.4	1058.0	764.04	1004.6
K	653.	829.18	1023.1	1198.6	857.78	737.04	1091.6	722.85	410.45	887.91
P	990.	1037.4	965.22	596.96	529.68	675.00	1122.6	728.95	769.53	880.44
Ca	1701	1851.0	804.26	882.48	1562.4	850.12	1154.6	1607.6	1796.9	826.67
Mg	903.	1937.0	1347.3	1913.5	1228.5	1556.5	1606.2	1097.5	1973.5	902.77
S	119.	116.12	137.65	141.16	178.84	206.98	149.17	213.13	236.10	92.36
Fe	6695	6580.6	7823.8	9462.2	6230.2	9183.2	7734.9	8034.9	7439.6	7609.0
Cl	23.9	39.03	38.55	38.34	13.41	25.52	15.01	18.70	26.10	33.00
Mn	251.	227.55	116.27	92.85	138.63	172.43	143.78	117.11	117.56	103.93
B	18.5	24.22	18.16	17.39	4.27	7.93	23.82	5.28	4.51	12.53
Z	13.4	22.94	22.89	22.69	16.38	8.19	15.39	17.27	20.91	15.43

Cu	0.76	1.72	1.25	1.60	1.16	0.98	1.20	1.99	1.97	1.75	
M	0.18	0.33	0.52	0.81	0.97	0.93	0.17	0.17	1.50	1.06	
Co	1.97	1.26	1.20	0.97	1.79	1.82	1.49	0.76	0.82	0.81	

Most of soils samples found to be of alkaline in nature having pH ranged from 7.0-8.2. The value of Electrical Conductivity ranged between 123 – 331 in Phase 1 and 164 – 325 in Phase 2, which indicate the normal nature of soil in all the sampled fields. The minimum pH (6.10) was observed in field F17 at Site 4 in Phase 1 in Ludhiana District indicating the soil from this field as little acidic as compared to other fields. The maximum (pH-7.96) was found from soil sample of field F13 at Site 3 in Phase 2 (*Table 8*).

Percent change in the mean magnitude of nutrients in soil

Percent change in the mean magnitude of macro nutrients from Phase 1 to Phase 2 as shown through Table 5, indicated Magnesium with the highest percent change as 43.98 followed by Phosphorus (29.74) and Nitrogen (0.02) showed the increase in the magnitude while Calcium (-22.51), Sulfur (-18.39) and Potassium (-10.65) showed the reduced magnitudes over the same period.

Table 3: Variability in Soil Nutrients Magnitude (ppm)
All fields (F1-F20) at all Sites (1-4) in in Phase 1

Parameter	Mean	SD	Mean+SD	Mean-SD
Nitrogen	1102.88	429.60	1532.47	673.28
Potassium	849.88	248.36	1098.24	601.52
Phosphorus	669.72	183.66	853.38	486.05
Calcium	1745.26	439.21	2184.47	1306.05
Magnesium	1026.82	106.67	1133.48	920.15
Sulfur	203.87	61.54	265.41	142.33
Iron	7612.76	1409.71	9022.47	6203.04
Chlorine	37.36	13.44	50.80	23.93
Manganese	222.10	112.74	334.84	109.35
Boron	15.94	8.62	24.55	7.32
Zinc	12.02	4.09	16.10	7.93
Copper	1.71	0.63	2.34	1.09
Molybdenum	1.12	0.54	1.67	0.58
Cobalt	0.94	0.34	1.28	0.61

Table 4: Variability in Soil Nutrients Magnitude (ppm)
All fields (F1-F20) at all Sites (1-4) in in Phase 2

Parameter	Mean	SD	Mean +SD	Mean -SD
Nitrogen	1103.06	413.75	1516.81	689.31
Potassium	759.38	232.37	991.75	527.01
Phosphorus	868.91	279.62	1148.52	589.29
Calcium	1352.48	385.27	1737.74	967.21
Magnesium	1478.38	355.97	1834.35	1122.40
Sulfur	166.38	44.94	211.32	121.44
Iron	7966.43	1270.82	9237.25	6695.61
Chlorine	26.17	9.52	35.69	16.65
Manganese	176.81	60.17	236.98	116.64
Boron	13.61	7.27	20.88	6.35
Zinc	16.45	4.16	20.61	12.30
Copper	1.23	0.45	1.68	0.78
Molybdenum	0.75	0.47	1.22	0.27
Cobalt	1.23	0.41	1.64	0.82

Percent change in the mean magnitude of micro nutrients from Phase 1 to Phase 2 as shown through *Table 5* , indicated Zink with the highest percent change as 37.55 showed the increased amount while Chlorine with -49.38 percent change over the same period showed the reduced amount available as compared the Phase 1.

Table 5: Percent change in the mean magnitude of soil nutrients (ppm) at all Sites (1-4) from Phase 1 to Phase 2

Parameter	Phase 1	Phase 2	Change %
Nitrogen	1102.88	1103.06	0.02
Potassium	849.88	759.38	-10.65
Phosphorus	669.72	868.91	29.74

Calcium	1745.26	1352.48	-22.51
Magnesium	1026.82	1478.38	43.98
Sulfur	203.87	166.38	-18.39
Iron	7612.76	7966.43	4.65
Chlorine	37.36	26.17	-29.95
Manganese	222.10	176.81	-20.39
Boron	15.94	13.61	-14.58
Zinc	12.02	16.45	36.92
Copper	1.71	1.23	-28.29
Molybdenum	1.12	0.75	-33.51
Cobalt	0.94	1.23	29.95

Percent difference in magnitude of all the studied major and minor nutrients in both the stages indicated same trend with negligible change pattern in all the fields while compared their magnitude within the village or inter villages. In both the stages, the found magnitude of soil nutrients remained almost same which advocate no adverse effect of agro chemical and pesticides used in the area during raising rice crop in all the four selected villages in the study region.

Magnitude of Soil parameters: pH, EC and Moisture

The magnitude of Soil pH (0-14 Scale), EC in deciSiemens per meter (dS/m) and moisture content percent for all the twenty fields (F1 - F20) calculated for all the four sites for both Phases (Table 7 & 8).

Measurement of the amount of salts in soil (salinity of soil) is indicated as soil electrical conductivity (EC). It is an important indicator of soil health. Magnitude range of EC (dS/m) in Phase 1 in all the fields

Table 6: Variability in Magnitude of Soil Nutrients in Phase 1 & 2

All fields (F1-F20) at all Sites (1-4)				
Parameter	Mean	SD	Mean +SD	Mean -SD
Nitrogen	1102.97	416.31	1519.28	686.66
Potassium	804.63	241.78	1046.41	562.85
Phosphorus	769.31	254.36	1023.67	514.95
Calcium	1548.87	453.71	2002.58	1095.16
Magnesium	1252.60	345.78	1598.37	906.82
Sulfur	185.13	56.47	241.60	128.65
Iron	7789.59	1336.80	9126.39	6452.80
Chlorine	31.77	12.81	44.58	18.95
Manganese	199.45	92.10	291.55	107.35
Boron	14.77	7.95	22.73	6.82
Zinc	14.24	4.65	18.88	9.59

Copper	1.47	0.59	2.06	0.88
Molybdenum	0.94	0.54	1.47	0.40
Cobalt	1.09	0.40	1.48	0.69

Indicated the value of 123.20 – 331.00 while it found to be 164.20 – 325.30 in Phase 2 for all the fields. The mean magnitude of EC in all twenty fields respectively at Site 1, Site 2, Site 3 and Site 4 in Phase 1 indicated the values 188.52, 190.50, 263.70 and 183.02 with the mean magnitude of 206.44, while the values of EC (dS/m) in Phase 2 for all these twenty fields respectively at Site 1, Site 2, Site 3 and Site 4 are 236.14, 284.64, 209.54 and 262.45 with the mean magnitude of 248.19 (*Table 8*). Plant growth may be hindered by the excess salts affecting the soil-water balance (USDA, 1990). This soil parameter found not to be in excess at all the sites in all fields in both the Phases.

Magnitude range of pH in Phase 1 in all the fields indicated the value of 6.10 - 7.75 while it was 6.67 – 7.96 in Phase 2 for all the fields. The mean magnitude of pH in all the twenty fields respectively at Site 1, Site 2, Site 3 and Site 4 in Phase 1 indicated the values 7.50, 7.07, 7.12 and 6.66 with the mean magnitude of 7.09, while the values of EC in Phase 2 for all these twenty fields respectively at Site 1, Site 2, Site 3 and Site 4 are 7.56, 7.64, 7.74 and 7.34 with the mean magnitude of 7.57 (*Table 7 & 8*).

Neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5, and as soil pH found to be close to neutral in the study region in all the fields, soil are not deficient making the nutrients available to plants. It is a positive sign for healthy soils. Results reported that soil samples of the study area are slightly alkaline and non-saline in nature.
Magnitude range of soil moisture content in percent in Phase 1 in all the fields indicated the value of 11.11 – 33.33 while it was 8.81 – 41.54 in Phase 2 for all the fields. The mean magnitude of soil moisture content in percent in all the twenty fields respectively at Site 1, Site 2, Site 3 and Site 4 in Phase 1 indicated the values 23.73, 24.33, 25.56 and 20.65 with the mean magnitude of 23.57, while the values of soil moisture content in percent in Phase 2 for all these twenty fields.

respectively at Site 1, Site 2, Site 3 and Site 4 are 22.78, 28.08, 23.04 and 23.60 with the mean magnitude of 24.38 (Table 7 & 8).

Table 7: Magnitude of Soil parameters in Phase 1 at all Sites (1-4)						
Field	pH	EC	Plate wt (g)	Wet soil (g)	Dried soil (g)	Moisture (%)
F1	7.67	190.40	45.00	65.00	62.00	17.65
F2	7.70	193.30	48.00	68.00	64.00	25.00
F3	7.60	192.60	50.00	70.00	65.00	33.33
F4	7.50	148.30	43.00	63.00	59.00	25.00
F5	7.01	218.00	40.00	60.00	57.00	17.65
F6	6.90	181.10	52.00	72.00	67.00	33.33
F7	6.80	261.00	47.00	67.00	64.00	17.65
F8	7.75	236.00	44.00	64.00	59.00	33.33
F9	6.80	123.20	45.00	65.00	61.00	25.00
F10	7.08	151.20	38.00	58.00	55.80	12.36
F11	6.92	262.00	46.00	66.00	62.00	25.00
F12	7.23	137.50	47.00	67.00	62.00	33.33
F13	7.25	301.00	46.00	66.00	62.00	25.00
F14	7.14	331.00	43.00	63.00	58.00	33.33
F15	7.05	287.00	48.00	68.00	66.00	11.11
F16	6.30	180.40	45.00	65.00	61.00	25.00
F17	6.10	141.20	40.00	60.00	57.00	17.65
F18	7.58	256.00	44.00	64.00	61.50	14.29
F19	6.32	136.50	44.00	64.00	59.00	33.33
F20	7.02	201.00	38.00	58.00	55.70	12.99

The mean magnitude of pH, EC and soil moisture content percent in all four IPM field respectively in Phase 1 and Phase 2 indicated the values as 7.04, 214.30, 13.53 and 7.11, 269.20, 12.76 (*Table 9*). Soil moisture percent representing as the range of magnitude for Site 1, Site 2, Site 3 and Site 4 in Phase 1 found respectively as 17.65 - 33.33, 12.36-33.33, 11.11- 33.33 and 12.99 -33.33, while these are 14.55 - 37.55, 12.99 - 41.54, 14.68 - 29.79 and 8.81 - 30.98 respectively for Site 1, Site 2, Site 3 and Site 4 in Phase 2 (*Table 7 & 8*).

Table 8
Magnitude of Soil parameters in Phase 2 at all Sites (1-4)

Field	pH	EC (dS/m)	Plate wt (g)	Wet soil (g)	Dried soil (g)	Moisture (%)
F1	7.65	193.40	45.43	65.43	61.50	24.46
F2	7.62	196.50	43.49	63.49	59.90	21.88
F3	7.66	198.50	51.10	71.10	68.42	15.47
F4	7.72	191.80	44.46	64.46	59.00	37.55
F5	7.15	270.90	45.83	65.83	63.29	14.55
F6	7.50	265.20	43.74	63.74	58.88	32.10

F7	7.85	275.60	44.29	64.29	59.33	32.98
F8	7.84	220.40	46.59	66.59	60.72	41.54
F9	7.87	164.20	42.66	62.66	59.22	20.77
F10	7.12	255.30	44.90	64.90	62.60	12.99
F11	7.92	273.00	43.38	63.38	59.85	21.43
F12	7.80	198.20	40.64	60.64	56.05	29.79
F13	7.96	325.30	46.18	66.18	62.20	24.84
F14	7.92	325.30	43.70	73.70	67.80	24.48
F15	7.12	301.40	45.33	65.33	62.77	14.68
F16	6.67	300.00	39.22	59.22	55.41	23.53
F17	7.80	195.40	44.52	64.52	59.79	30.98
F18	7.56	273.10	45.80	65.80	61.50	27.39
F19	7.62	294.56	45.74	65.74	61.45	27.31
F20	7.05	249.20	43.98	63.98	62.36	8.81

Table 9
Mean Magnitude Soil pH, Moisture and EC

Phase 1	pH	Moisture %	EC (dS/m)
Site 1	7.50	23.73	188.52
Site 2	7.07	24.33	190.50
Site 3	7.12	25.56	263.70
Site 4	6.66	20.65	183.02
All Sites	7.09	23.57	206.44

Phase 2	pH	Moisture %	EC (dS/m)
Site 1	7.56	22.78	236.14
Site 2	7.64	28.08	284.64
Site 3	7.74	23.04	197.83
Site 4	7.34	23.60	262.45
All Sites	7.57	24.38	248.19

Table 10: Mean magnitude in IPM Fields

Phase	pH	Moisture %	EC (dS/m)
1	7.04	13.53	214.30
2	7.11	12.76	269.20

Conclusion

The comprehensive and precise assessment of magnitudes of soil nutrients is a very important component for precise farming, in particular, and for the wise management of sustainable agricultural practices, in general. This investigation facilitates the identification of the available content and extent of the required elements in soil for the potential agricultural uses of the area. Soil health is affected by agricultural practices primarily as the side effects of chemical applications on agricultural crops, which, in turn, affect the physical, chemical, and fertility properties of the soil. This study presented this approach in understanding the health of the soil in terms of the important nutrients available in the soil samples of the rice fields covering the period of transplanting as well as

harvesting. The soil as an important environmental element and it was as per the results provided. Neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5, and as soil pH also was found to be close to neutral in the study region in all the fields. Soil are not deficient in making the nutrients available to plants. It is a positive sign for healthy soils. Deviation in terms of magnitude availability of all the studied nutrients at all sites from the initial growing period to the final harvesting stage was found within the permissible limits and causing no adverse effect on soil health. Evaluation of the status of micro flora and fauna in the soil may be taken in addition to the studied elements for understanding the soil health in greater extent and depth. This information is needed for optimum production, to avoid transferring undesirable levels of some nutrients into the environment and to ensure a suitable nutrient content in crop products.

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