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Evaluation of Soil Fertility and Physico-chemical Properties of the Semi-arid Region of Eastern Jaipur Rajasthan, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation on GPS-based soil chemical properties and fertility status of three different blocks and each block 3 villages (Chomu, Sanganer, Shahpura) of Jaipur district was undertaken during the year 2021-22. 27 soil samples were collected at three different depths (0-15, 15-30, 30-40 cm) and analysed. Different results were reported. The colour of soil samples changed with the depth. The pH of soils ranged between (pH 7.40 - 7.58). The electrical conductivity of the soil of the entire studied area was less than 1 dSm^{-1}. The soil organic carbon status was low to medium, ranging from 0.10 to 0.25 % and organic matter ranged from 0.17 – 0.43%. The available nitrogen content of the entire studied area was low (166.37 to 192.75 kg ha^{-1}). The available phosphorus and

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potassium content varied between 13.24 to 37.77 kg ha^{-1} and 146.88 to 232.32 kg ha^{-1}. The available zinc, iron, copper and manganese of the soil ranged between 0.56 to 0.32 mg kg^{-1}, 2.23 to 2.97 mg kg^{-1}, 0.40 to 0.67 mg kg^{-1} and 2.17 to 2.95 mg kg^{-1}. The fertility database would be very useful for extension functionaries, agricultural officers, scientists and above all the farmers for sustainable crop production.

Keywords: Physico-chemical properties; pH; E.C.; O.C.; nitrogen; potassium; phosphorus; soil analysis; Jaipur district.

1. INTRODUCTION

Soil is the most vital and precious natural resource that sustains life on the earth. It takes almost 1000 years to produce an inch of topsoil [1]. The most important constituents in soil are organic matter, an appreciable amount of it in soil tremendously increases soil fertility. Decay of organic matter release nitrogen, phosphorus and mineral nutrients in forms available to plants. Organic carbon is also positively correlated with total and available nitrogen in all soil groups. Similarly, the soil reaction (pH) and electrical conductivity have a marked effect on plant growth (Verma et al., 1980).

Micronutrients are also essential for crop growth but are not regularly applied in the soil along with the common fertilizers used by the farmers. Their removal from the soil had been for centuries without any systematic replenishment [2].

Micronutrient deficiencies were first reported at the end of the 19th century and today it is well known that the extensive areas of our soils are capable of supplying plants with sufficient amounts of micronutrients. The application of fertilizer in the soil having only major nutrients, the loss of micronutrients thought plant uptake and leaching, the decreasing proportion of farm yard manure and other organic manures in comparison with fertilizers, and several other factors collectively contribute towards the deficiency of micronutrients in soils [3].

2. MATERIALS AND METHODS

The soil samples will be collected from various villages at least 10 km. apart from different blocks of Jaipur district having variations in slope/topography, colour and cropping pattern and behaviour. Three depth-wise samples viz., 0 to 15 cm, 15 to 30 cm and 30 to 45 cm will be collected and analyzed. Samples will be collected only from the open places. A separate sampling calendar has been made for each parameter to be studied. The samples will be analysed for morphological, phsico - chemical properties. A sample collection sheet is prepared for proper tagging and packing of the samples on the site. Jaipur is the capital city as well as the largest city in the state of Rajasthan. Geographically, Jaipur district lies at Longitude 26°9'1.24" N and latitude75°7'8.73" E. Total geographical area of the district is 11,06,148 ha. or 11061.48 sq km. The total Gross Cropped Area of the city is 8,48,313 ha with Net Sown Area being 6,63,167 ha out of which only 3,02,428 ha is Net Irrigated Area. Jaipur district falls in agro-climatic zone 3-A semi-arid eastern plain zone. The district is characterized by mild winter and hot summer. The mean maximum & minimum temperature of the area is 40.6 Degree centigrade and 6.2 Degree centigrade respectively. The temperature fluctuates as high as 47 degrees centigrade in the month of May & June and as low as 1.0 Degree centigrade in the month of January. Jaipur district receives around 650 mm rainfall annually and hence the climate here is typically humid. Monsoon occurs from June to September. Heavy rains and thunderstorms are observed in the monsoon season. Throughout the year, the temperature remains on the higher side.

Collection of Soil Sample: Soil samples were collected randomly from a site using Khurpi and Phawrah at the depth of (a) 0-15cm, (b) 15-30cm, (c) 30-45 cm. Composite soil samples (by the process of conning and quartering method) were collected by Stratified soil sampling method [4-6] and processed to analyze the Physico-chemical properties and available nutrient content. The detailed information is as follows. The grid soil samples at desired depth were taken as per the objective of the experiments. Records of latitude and longitude were maintained using GPS. The soil samples were collected with Khurpi, Phawrah and Soil Auger.

Process of Soil Sampling: After collecting the soil samples, they were brought to the laboratory. These samples were dried under shade. After that the processing was done as follows: After the air drying under the shade the unwanted materials like roots, stones, and others are should be discarded. The clods in the sample would be broken by using the wooden mallet. After that the samples should be sieved with 2 mm sieve. Sieved samples should be stored in polybags for further estimation of different physico-chemical parameters.

All the precautions were followed as the procedure described by Jackson, and the standard procedure outlined by the Page et al. [7] was used to estimate the chemical properties of the soil.

Analysis of soil: The physico-chemical properties and available nutrient content of soil are to be analyzed by the following standard protocols in Table 3.

The implementing design for the experiment was CRD (Completely Randomized Design) which is the most flexible and simplest design. It is used when the experimental units are homogenous as it involves two basic principles of the design of the experiment namely Replication and Randomization.

Methods of Analysis: The methods of analysis of different soil parameters are discussed in Table 2.

3. RESULTS AND DISCUSSION

The pH of soil w/v (1:2.5): The Table 2 and Fig. 1 depicts the statistical analysis of pH of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum pH found was 8.08 at 30-45 cm in the village Goner (V_4) and the minimum pH was 6.22 at 0-15 cm in the village Nwalpura (V_9). The increase in pH with depths of soil is possibly due to the leaching down of salts from upper soil depths to lower soil depths, which is the accumulation of salts in lower depths of soil and an increase in soil pH. Similar results were reported by Mehta et al. [9], Gill et al. [10] and Maheshwari and Sharma, [11].

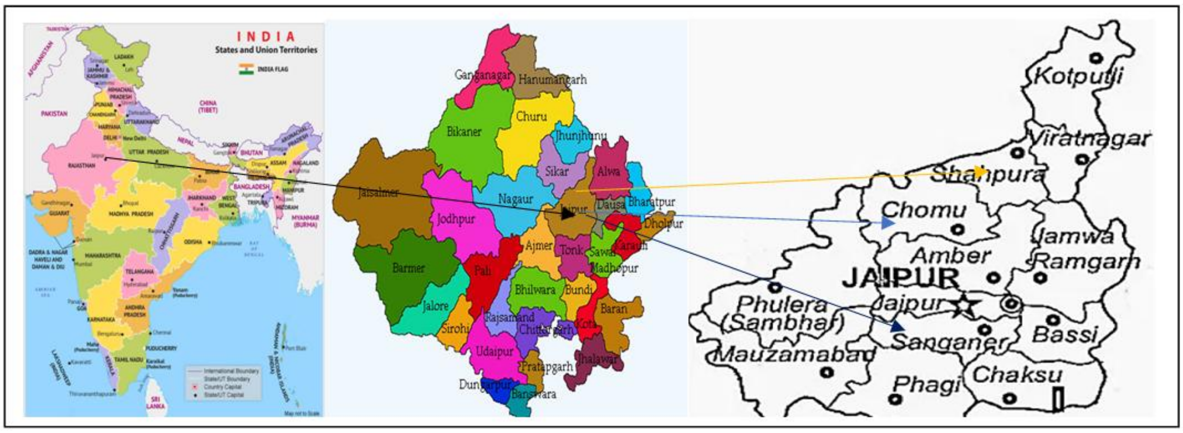

Fig. 1. Sites of study area

Table 1. Soil samples collection site

S. No.	Blocks	Village	Latitude (^{0}N)	Longitude (^{0}E)
1.	Chomu (B_1)	Keshav Nagar (V_1)	26.9039^0	75.7844^0
		Morija (V_2)	27.2068^0	75.7582^0
		Nindola (V_3)	27.3185^0	75.7081^0
	Sanganer (B_2)	Goner (V_4)	26.8865^0	75.8341^0
2.		Shrikishanpura (V_5)	26.7998^0	75.8582^0
		Durgapura (V_6)	26.8518^0	75.7862^0
	Shahpura (B_3)	Shivpuri (V_7)	26.9426^0	75.7526^0
3.		Manoharpur (V_8)	26.2994^0	75.9571^0
		Nwalpura (V_9)	26.8103^0	75.8365^0

Table 2. Methods of analysis of different soil parameters

S. No.	Parameters	Method	Scientist
1.	Soil pH	Digital pH meter	Jackson, [21]
2.	Electrical conductivity (dSm^{-1})	Digital EC meter	Wilcox,1950
3.	Organic Carbon (%)	Rapid Titration	Walkley and Black, 1947
4.	Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate	Subbiah and Asija, 1956
5.	Available Phosphorous (kg ha^{-1})	Colori meter	Olsen et al.,1954
6.	Available Potassium (kg ha^{-1})	Flame photometer	Toth and Prince,1949
7.	Micro nutrients (Fe, Cu, Mn, Zn)	DTPA extractable method by AAS	Lindsay and Norvell, 1978

(Source: Jaiswal, [8])

Electrical conductivity (dSm^{-1}): The Table 2 and Fig. 1 depicts the statistical analysis of the electrical conductivity of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum electrical conductivity was found to be 0.62 dSm^{-1} at 0-15 cm in village Manoharpur (V_8) and minimum electrical conductivity was found to be 0.36 dSm^{-1} at 30-45 cm in village Goner (V_4). The low EC may be due to good drainage conditions which favoured the removal of released bases by percolating and drainage water. Similar results were reported by Mehta et al. [9], Gill et al. [10] and Ram et al. [12].

Organic carbon (%): The Table 2 and Fig. 1 depicts the statistical analysis on organic carbon of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum organic carbon found was 0.25 % at 0-15 cm in village Nwalpura (V_9) and the minimum organic carbon was found 0.10 % at 30-45 cm, and in village Nindola (V_3). organic carbon content of these soils was found to be and ranging from 0.10 to 0.25. The organic carbon content decreased with depths and this is due to the addition of plant residues in surface horizons than in the lower horizons. Similar results were reported by Mehta et al. [9], Gill et al. [10], Maheshwari and Sharma [11].

Organic matter (%): The Table 2 and Fig. 1 depicts the statistical analysis on organic matter of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum organic matter found was 0.43 % at 0-15 cm in village Nwalpura (V_9) and the minimum organic matter was found 0.17 % at 30-45 cm in village Nindola (V_3). The organic matter content of these soils was found to be low to medium and ranging from 0.17 to 0.43%. The organic matter content decreased with depths and this is due to the addition of plant residues surface horizons than in the lower horizons. Similar results were reported by Mehta et al. [9], Gill et al. [10], and Maheshwari and Sharma [11].

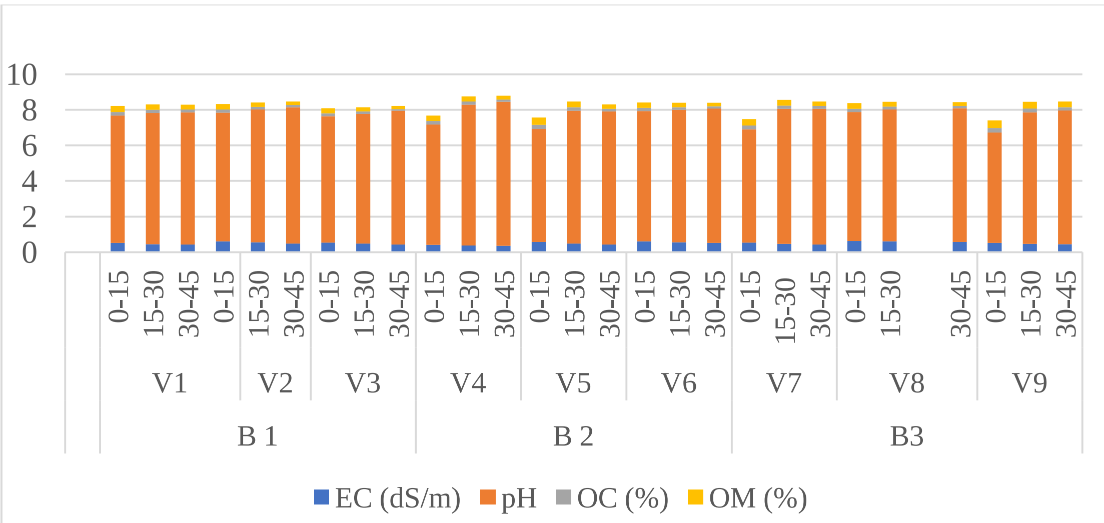

Fig. 2. Fertility status at study area

Table 3. Electrical conductivity (E.C), pH, organic carbon (OC), organic matter (OM), nitrogen (N), phosphorus (P), potassium (K), zinc (Zn), iron (Fe), copper (Cu), manganese (Mn) available of soil in different villages of Jaipur at 0-15 cm, 15-30 cm and 30-45 cm depths

	Villages	Depth (cm)	EC (dS/m)	pH	OC (%)	OM (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (mg/ kg)	Fe (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
B_1	**V_1**	**0-15**	0.51	7.17	0.20	0.34	187.92	22.14	180.61	0.43	2.55	0.59	2.05
		15-30	0.45	7.36	0.18	0.31	180.86	20.45	169.80	0.40	2.41	0.56	1.99
		30-45	0.42	7.44	0.16	0.27	171.74	18.30	155.29	0.38	2.58	0.53	1.86
		0-15	0.60	7.24	0.18	0.31	175.36	18.36	175.98	0.41	2.46	0.50	2.75
	V_2	**15-30**	0.55	7.46	0.15	0.25	169.12	15.70	163.33	0.38	2.42	0.48	2.63
		30-45	0.48	7.67	0.12	0.20	162.76	13.24	146.88	0.36	2.39	0.47	2.50
	V_3	**0-15**	0.53	7.10	0.17	0.29	170.17	19.40	203.81	0.42	2.38	0.56	2.80
		15-30	0.48	7.29	0.14	0.24	163.10	17.99	195.30	0.36	2.35	0.53	2.70
		30-45	0.42	7.52	0.10	0.17	158.94	15.62	172.40	0.32	2.23	0.51	2.64
B_2	**V_4**	**0-15**	0.41	6.76	0.19	0.32	193.89	28.92	209.10	0.49	2.95	0.52	2.72
		15-30	0.38	7.91	0.17	0.29	183.09	25.22	197.99	0.47	2.82	0.49	2.59
		30-45	0.36	8.08	0.13	0.22	172.14	22.39	179.84	0.45	2.79	0.47	2.46
	V_5	**0-15**	0.57	6.35	0.24	0.41	198.30	32.44	221.21	0.46	2.88	0.58	2.86
		15-30	0.48	7.47	0.19	0.32	186.33	29.63	217.70	0.44	2.75	0.55	2.72
		30-45	0.42	7.49	0.15	0.25	173.99	26.10	189.56	0.41	2.71	0.53	2.68
	V_6	**0-15**	0.61	7.31	0.18	0.31	178.13	21.15	189.80	0.52	2.45	0.49	2.45
		15-30	0.56	7.43	0.15	0.25	163.44	18.79	175.04	0.47	2.34	0.46	2.31
		30-45	0.52	7.55	0.12	0.20	157.56	15.29	162.16	0.32	2.27	0.44	2.28
B_3	**V_7**	**0-15**	0.53	6.37	0.21	0.36	182.13	30.97	236.64	0.44	2.77	0.60	2.59
		15-30	0.47	7.59	0.18	0.31	173.44	27.17	224.50	0.41	2.70	0.57	2.46
		30-45	0.42	7.64	0.15	0.25	167.56	24.88	190.99	0.39	2.58	0.56	2.32
	V_8	**0-15**	0.62	7.25	0.19	0.32	192.21	26.64	217.27	0.49	2.60	0.54	2.34
		15-30	0.60	7.42	0.16	0.27	185.81	22.08	199.69	0.46	2.54	0.41	2.21
		30-45	0.57	7.51	0.13	0.22	178.66	18.51	186.07	0.42	2.41	0.40	2.17
	V_9	**0-15s**	0.51	6.22	0.25	0.43	198.11	37.77	232.32	0.56	2.97	0.67	2.95
		15-30	0.46	7.39	0.22	0.37	192.79	34.21	225.54	0.52	2.90	0.64	2.82
		30-45	0.44	7.52	0.19	0.32	187.37	29.64	208.61	0.48	2.82	0.61	2.73
F-test	Due to depths		S	S	S	S	S	S	S	S	S	S	S
	Due to site												
S.Ed.(±)	Due to depths		0.04	1.75	0.05	0.15	8.08	3.71	13.15	0.02	0.04	0.02	0.04
	Due to site		0.55	5.42	0.07	0.23	13.11	7.15	39.68	0.03	0.63	0.07	0.42
C.D.at 5%	Due to depths		0.007	0.007	0.012	0.038	0.008	0.021	0.003	0.001	0.003	0.006	0.008
	Due to site		0.002	0.004	0.018	0.043	0.009	0.018	0.009	0.002	0.006	0.003	0.006

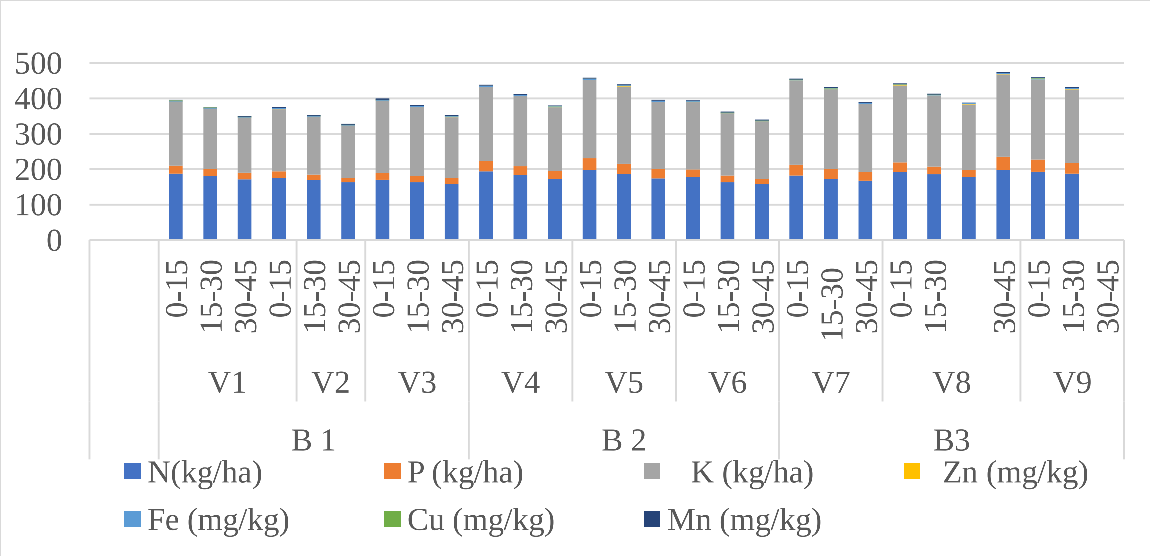

Fig. 3. Available nutrient at study area

Available nitrogen (kg ha^{-1}): The Table 2 and Fig. 2 depicts the statistical analysis on available nitrogen of villages and depths which was found to be significant due to depths and due to site. In soil depths, the maximum available nitrogen found was 198.11 kg ha^{-1} at 0-15 cm in village Nwalpura (V_9), and the minimum available nitrogen found was 157.56 kg ha^{-1} at 30-45 cm in village Durgapura (V_6). The available nitrogen status in the entire area was found to be low to medium. The reason may be attributed to the fact that nitrogen content is positively correlated with organic matter content which decreases with depths. Similar results were reported by Misnra et al. [13], Dash et al. [14], and Digal et al. [15].

Available phosphorus (kg ha^{-1}): The Table 2 and Fig. 2 depicts the statistical analysis of available phosphorus of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum available phosphorus found was 37.77 kg ha^{-1} at 0-15 cm in village Nwalpura (V_9) and minimum available phosphorus (P) found was 13.24 kg ha^{-1} at 30-45 cm in village Morija (V_2). The available P varied from 13.24 to 37.77 kg ha^{-1} in different depths and villages, which is low to medium content of phosphorus in soil. The maximum P content was observed in the surface horizons and decreased with depths. Similar results were reported by Meena et al. [16], Dash et al. [14], and Digal et al. [15].

Available potassium (kg ha^{-1}): The Table 2 and Fig. 2 depicts the statistical analysis of the available potassium of villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum available potassium was found 232.32 kg ha^{-1} at 0-15 cm in village Nwalpura (V_9), and the minimum available potassium found was 146.88 kg ha^{-1} at 30-45 cm in village Morija (V_2). The available potassium in soil varied in a high range (146.88 to 232.32 kg ha^{-1}). The maximum K content was observed in the surface horizons and showed more or less decreasing trend with depths. This might be attributed to more intense weathering, the release of liable K from organic residues, the application of K fertilizers and upward translocation of K from lower depths along with the capillary rise of ground water. Similar results were reported by Urmila et al. [17], Sharma and Chaudhary [2] and Digal et al. [15].

Available zinc (mg kg^{-1}): The Table 2 and Fig. 2 depicts the statistical analysis of available zinc in villages and depths which was found to be significant due to depths and due to site. Low values of available zinc were recorded in all the sites. In soil depths the maximum available zinc found was 0.56 mg kg^{-1} at 0-15 cm in village Nwalpura (V_9), and the minimum available zinc found was 0.32 mg kg^{-1} at 30-45 cm in village Nindola (V_3). The available zinc in the soil varied in the high range (0.56 to 0.32 mg kg^{-1}). Low values of zinc may be due to the high availability of phosphorus which has an antagonistic effect on zinc. Similar results were reported by Urmila et al. [17] and Singh et al. [18].

Available iron (mg kg^{-1}): The Table 2 and Fig. 2 depict the statistical analysis of available iron in villages and depths which was found to be significant due to depths and due to site. Low values of available iron were recorded in all the sites. In soil depths the maximum available iron found was 2.97 mg kg^{-1} at 0-15 cm in village Nwalpura (V_9) and the minimum available iron found was 2.23 mg kg^{-1} at 30-45 cm in village Nindola (V_3). The available iron in soil varied in the high range (2.23 to 2.97 mg kg^{-1}). Deficiency of iron in an acidic soil is usually due to the effect of deficiency of another nutrient as in this case, of calcium deficiency and manganese toxicity. Iron values varied significantly with depths. Similar results were reported by Yadav et al. [19] and Singh et al. [18].

Available copper (mg kg^{-1}):- The Table 2 and Fig. 2 depicts the statistical analysis of available copper in villages and depths which was found to be significant due to depths and due to site. Low values of available copper were recorded in all the sites. In soil depths the maximum available copper found was 0.67 mg kg^{-1} at 0-15 cm in village Nwalpura (V_9) and the minimum available copper was found 0.40 mg kg^{-1} at 30-45 cm in village Manoharpur (V_8). The available copper in the soil varied in the high range (0.40 to 0.67 mg kg^{-1}). Low levels of copper may be attributed to high organic matter content while high values may be the result of low soil pH. Similar results were reported by Yadav et al. [19] and Meena et al. [20].

Available manganese (mg kg^{-1}): The Table 2 and Fig. 2 depicts the statistical analysis of available manganese in villages and depths which was found to be significant due to depths and due to site. In soil depths the maximum available manganese found was 2.95 mg kg^{-1} at 0-15 cm in village Nwalpura (V_9) and the minimum available manganese found was 2.17 mg kg^{-1} at 30-45 cm in village Manoharpur (V_8) [21]. The available manganese in the soil varied in the high range (2.17 to 2.95 mg kg^{-1}). Low levels of manganese may be attributed to high organic matter content while high values may be the result of low soil pH. Similar results were reported by Baishya et al*.* [*2*2] and Meena et al. [20].

4. CONCLUSION

In the present study area the soil pH was acidic to moderately acidic, the main reason is the increasing trend of using nitrogenous fertilizer in the area and very normal with respect to soluble salt content. Physico-chemical properties of soil are to be affected by the management practices adopted by the farmers and the degree of manure and fertilizer usage over a period of time. The variable concentrations of various parameters and irregular distributions of micronutrients may be attributed due to the added fertilizers during crop production. It is concluded for that there is a need of proper nutrition and management approaches to attain optimum economic yield and maintain soil fertility.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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