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Assessment of Soil Fertility Status of the Soils of KVK -Muzaffarnagar, Uttar Pradesh, 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

The present study was undertaken to assess the soil fertility status of the soils of KVK Muzaffarnagar. Soil samples were collected from two depths viz., 0-15 cm and 15-30 cm and analysed for various soil properties. Results revealed that soils were sandy loam in texture, neutral to slightly alkaline in reaction, non-saline and low in soil organic carbon content. Mean values of CEC, SOC, available nitrogen, available phosphorus, available potassium and available sulphur were 11.22 and 9.62 C mol (p+) kg^{-1}, 0.17 and 0.13 g kg^{-1}, 260.16 and 208.14 kg ha^{-1}, 30.86 and 27.30 kg ha^{-1}, 100.94 and 107.89 kg ha^{-1} and 13.51 and 12.84 kg ha^{-1} recorded at 0-15cm and 15-30 cm depth, respectively. The mean of DTPA extractable zinc, DTPA extractable iron, DTPA extractable manganese and DTPA extractable copper were 0.28 and 0.31 mg kg^{-1}, 0.97 and 1.22

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mg kg^{-1}, 2.14 and 1.78 mg kg^{-1} and 0.23 and 0.19 mg kg^{-1} recorded surface and sub-surface depths, respectively. Soils are low in available nitrogen and potassium and medium in available phosphorus status. Cationic micronutrients such as iron, copper and zinc contents were found deficient in range, whereas manganese content was found to be sufficient.

Keywords: Soil available nutrients; exchangeable bases; DTPA micronutrients.

1. INTRODUCTION

"Soil is one of the most valuable natural resources on Earth. Its physical, chemical, and biological qualities are highly variable, thus scientists and farmers must understand these properties in order to maximize crop yield" [1]. "Managing soil health is a key component for sustainable agriculture. The capacity of soil to function as an essential living system is known as soil health. This is due to the biological components found in soil, which are necessary for ecosystems to function within the constraints of land use. These processes can maintain the biological productivity of soil, safeguard the surrounding water and air quality, and enhance the well-being of people, animals, and plants. Soil quality is the ability of a soil to support plant and animal productivity, preserve or enhance the quality of the water and air, and support human health and habitation within a natural or managed ecosystem. It is also frequently employed to demonstrate how the chemical and physical characteristics of soil impact plant development and the functioning of the ecosystem. Determining the optimal land use is crucial to maximizing agricultural output and providing enough food for India's expanding population. The key to preserving soil health and ensuring long-term food security is the wise use of both natural and man-made inputs in comprehensive land management. Imbalanced use of fertilizers by the farming community leading to deteriorate soil health and reduce crop yields if they don't know how fertile the soil is and what nutrients the crops need. Understanding the fundamentals of soil's physico-chemical characteristics is crucial" [2]. Study area Muzaffarnagar is a leading sugarcane producing place in Uttar Pradesh.Since wheat, rice and sugarcane are higher nutrient-absorbing crops that are produced in exhaustible cropping systems, the soil eventually becomes deficient in macro and micronutrients. Deficiency of essential plant nutrients to different extent in soils of Muzaffarnagar had been reported by Sharma et al. [3]. With this background a study was undertaken to know the fertility status of soils of KVK, Muzaffarnagar in western Uttar Pradesh.

2. MATERIALS AND METHODS

2.1 Study Area

The present study was undertaken in Meerut district of Uttar Pradesh. The geographic coordinates of the district are between 28°44' to 29°18' N latitude and 77°8' to 78°8' E longitude, with an altitude ranging from 205 to 240 meters.

Table 1. Analytical methods employed during chemical analysis

Sl. No	Parameter	Method adopted	Reference
1	Mechanical composition	Hydrometer method	[13]
2	Soil reaction	Soil water suspension (1:2.5)	[3]
3	Electrical conductivity	Soil water extract (1:2.5)	[20]
4	Organic carbon	Wet oxidation method	[35]
5	Cation exchange capacity	Sodium acetate method	[3]
6	Available nitrogen	Alkaline $KMnO_4$ method	[30]
7	Available phosphorus	0.5 M $NaHCo_3$ method	[12]
8	Available potassium	Neutral *N* Ammonium acetate extraction	[2]
9	Available Sulphur	Turbidometry method	[3]
10	Calcium	Versanate titration method	[3]
11	Magnesium	Versanate titration method	[3]
12	DTPA Zn	Atomic Absorption Spectrophotometer	[5]
13	DTPA Fe		
14	DTPA Mn		
15	DTPA Cu		

2.2 Collection, Preparation and Analysis of Soil Samples

The surface contaminated soil material was scraped and removed using spade and the soil samples were collected from 0-15 and 15-30 cm depths. Soil samples collected were air dried in shade, gently ground using wooden pestle and sieved through 2 mm sieve. Sieved samples were collected in plastic bags and stored for further analysis. Soil physical, physico-chemical and chemical properties were estimated for these soil samples using standard methodology (Table 1) [4,5].

3. RESULTS AND DISCUSSION

3.1 Mechanical Composition of Soil

Data indicated (Table 2) that in surface soil, percentage of sand, silt and clay were ranged from 76 to 64.77, 18.3 to 41.85 and 2 to 9 with a mean value of 64.77, 29.94 and 5.31 respectively and in sub-surface soils percentage of sand, silt and clay ranged from 50 to 79, 12 to 41 and 2.45 to 13 with a mean value of 71.4, 19.77 and 8.83 respectively. Majority of soils were sandy loam in texture. The high content of sand in these soils might be due to the presence of granite type of parent material. Similar reports were presented by Shruthi et al. [6]. Higher per cent of sand and lower per cent of clay may leads to higher infiltration rate and lower water holding capacity. It was reported by Kumar et al. [7]

3.2 Soil Physico-Chemical Properties

The data regarding soil physico-chemical properties of KVK Khatuali was presented in Table 2.

3.2.1 Soil reaction (pH)

The pH of the soil was neutral to slightly alkaline in nature. The pH value for surface soils (0-15 cm) ranged from 6.43 to 7.78 and in sub-surface soils ranged from 6.86 to 7.9 with the mean values of 7.00 and 7.25 respectively (Table 2). Results further revealed that soil pH increased with increase in depth. The relative neutral pH of the soils might be due to high degree of base saturation. Similar results were also reported by Noman [8] and pH increased with depth it may be due to upper horizons receive maximum leaching by rainfall and the presence of dissolved carbonic acids [9].

3.2.2 Electrical conductivity (EC)

The EC value for surface soil (0-15 cm) ranged from 0.1 to1.1 $dSm^{-1}$and sub-surface soil ranged from 0.1to 0.6 dSm^{-1} with mean value of 0.32 and 0.24 respectively (Table 2). The low electrical conductivity was due to free drainage conditions which favoured the removal of released bases by percolating and drainage water. In maximum of the samples, salt content increased with soil depth, the high content of salt may be due to irrigation with saline water [10,11].

3.2.3 Cation Exchange Capacity (CEC)

In surface soils, CEC was ranged from 8.61 to 14.2 cmol(p+) $kg^{-1}$of soil with the mean value of 11.22 cmol(p+) $kg^{-1}$of soil. In sub-surface soils, it was ranged from 8.33 to 11.84 cmol(p+) $kg^{-1}$of soil with the mean value of 9.62 cmol(P+) kg^{-1} of soil which corresponds to clay content, type of clay mineral and organic carbon content present in these soils [12].According to Singh et al. [13] who reported that CEC between 10 and 15 is typical and usually adequate for plant growth, CEC in this soil was found to be sufficient for normal growth and development of the plants [14,15].

3.2.4 Soil organic carbon (SOC)

The soil organic carbon content was ranged from 0.039 to 0.429 % with the mean value of 0.17 % and 0.058 to 0.253 % with the mean value of 0.13% at surface and sub-surface soils, respectively. The quantity of organic carbon content was found low in all the samples and it was decreasing with depth. Low organic carbon content may be due to high rate of oxidation of organic matter due to prevailing high temperature due to semi-arid condition and good aeration. Similar result was reported by Vandenriessche et al. [16] and it may be attributed to the poor vegetation.

3.3 Soil Available Macro Nutrient

The data regarding soil available macronutrient status of KVK Khatuali was presented in Table 2.

3.3.1 Available nitrogen

Soil available nitrogen content was ranged from 86 to 415.20 and 61.46 to 405.17 at 0-15 cm and 15-30 cm with mean values of 260.16 and 208.14 kg ha^{-1}, respectively. As per the ratings suggested by [17] data indicated that majority of the samples of surface and subsurface soil were low (< 280 kg N ha^{-1}) and deficit in available nitrogen. Climate has a major effect on availability of nitrogen, and it may be due to leaching as ammonia and denitrification into oxides of nitrogen in dry climate or it may be due to low usage of Farm yard manure, compost, green manures bio fertilizers and low usage of nitrogenous fertilizers. Similar result was reported by Gurjar et al. [18]. Another possible reason may be due to low organic matter content in these areas leading to N deficiency. It was reported by Singh and Mishra [19]. It was found to be more in surface horizons and decreased regularly with soil depth, which might be due to accumulation of plant residue and debris in surface soil. These observations are accordance with the findings of Wani et al. [20].

3.3.2 Available phosphorus

Soil available phosphorus content was ranged from 15.12 to 82.14, 13.34 to 56.04 kg ha^{-1} at 0-15 cm, 15-30 cm with mean values of 30.86 and 27.90 kg ha^{-1} respectively. According to Tautua et al. [21], maximum of the soil samples were high in available phosphorus (>25 kg ha^{-1}). Higher level of available phosphorous could be attributed with favourable soil pH. Similar finding were reported by Muhr et al. [22]. High concentration in the soil leads to good growth of plants Meena et al. [23]. It was decreased with depth, this may be due to the accumulation of plant residue and application of the depleted phosphorus through external sources i.e. fertilizers. Similar results were reported by Rao et al. [24].

3.3.3 Available potassium

Soil available potassium content was ranged from 72 to 162 and 77 to 163kg ha^{-1} at 0-15 cm, 15-30 cm with mean values of 100 and 107 kg ha^{-1}, respectively. According to Rao et al. [24], data indicated that maximum of the soil samples were falling under low category (<141 kg ha^{-1}) it may be due to lower amount of organic matter or due to the absence of potash bearing minerals (muscovite, biotite and feldspar). Similar result was reported by It is reported that highest [25] content of potassium found in surface soil than in sub surface soil. it may be due to intense weathering, release of K from organic sources and upward translocation of potassium through capillary rise of ground water to surface layers. Similar findings were reported by Veer et al. [26].

3.3.4 Available sulphur

“Soil available sulphur content was ranged from 9.89 to 17.9 and 9.32 to 15.98 kg ha^{-1} at 0-15 cm, 15-30 cm with mean values of 13.51 and 12.84 kg ha^{-1}, respectively [27,28]. Maximum of the soil samples were falling under low category (<22.4 kg ha^{-1}). this may be due to low amount of organic matter in soils or lack of sulphur addition through sulphur containing fertilizers, continuous removal of sulphur by crops and use of high analysis complex fertilizers without sulphur” [29]. The amount of sulphur available to plant is largely depend upon the amount of organic matter present in soil and decomposition rate of organic matter by bacteria and other soil organism. The available sulphur decreases with the increasing depth might be due to greater plant and microbial activities and mineralization of organic matter in surface layer. Similar findings were reported by Lindsay and Norvell [30].

3.4 Exchangeable Bases

The data regarding Exchangeable bases status of KVK Khatuali was presented in Table 2.

3.4.1 Exchangeable calcium

Calcium content was ranged from 2.12 and 3.15 and 1.73 to 3.34 cmol p (+) kg^{-1} of soil with the mean value of 2.69 and 2.56 cmol p (+) kg^{-1} of soil, respectively. The exchangeable calcium decreases with the increasing depth due to the attribute of high pH.

3.4.2 Exchangeable magnesium

Magnesium content was ranged from 1.14 to 1.83 and 1.13 to 1.84 cmol p(+) kg^{-1} of soil with the mean value of 1.44 and 1.43 cmol p(+) kg^{-1} of soil, respectively. The amount of Mg content decreased with increased in depth. It may be attributed with pH. Similar results were observed by [29].

3.5 Soil DTPA Extractable Micronutrients

The data regarding soil DTPA extractable micronutrients status of KVK Khatuali was presented in Table 2.

Table 2. Soil physico-chemical properties and available nutrien

Soil properties	Range		Mean		Standard Deviation		Coefficient of variation	
	0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
Soil reaction (pH)	6.43-7.78	6.86-7.90	7.07	7.25	0.38	0.28	5.37	3.86
EC (dS m^{-1})	0.1-1.1	0.1-0.6	0.32	0.24	0.26	0.15	81.25	62.5
CEC (Cmol (p+) kg^{-1})	8.61-14.2	8.33-11.84	11.22	9.62	1.65	1.00	680	962
SOC (g kg^{-1})	0.04-0.42	0.25-0.06	0.17	0.13	0.10	0.06	58.82	46.15
Avail. N (kg ha^{-1})	86.55-415.22	61.46-405.17	260.16	208.14	87.88	100.14	33.77	48.11
Avail. P (kg ha^{-1})	15.12-82.14	13.34-56.04	30.86	27.30	15.30	13.28	49.57	48.64
Avail. K (kg ha^{-1})	72.80-162.40	77.28-163.52	100.94	107.89	30.18	26.25	29.89	24.33
Available sulphur (kg ha^{-1})	9.89-17.90	9.32-15.98	13.51	12.84	2.23	2.02	605.82	635.64
Exchangeable calcium(cmol(p+) kg^{-1})	2.12-3.15	1.73-3.34	2.69	2.56	0.36	0.46	747.22	556.52
Exchangeable magnesium(cmol(p+) kg^{-1})	1.14-1.83	1.13-1.84	1.44	1.43	0.22	0.20	654.54	715
Exchangeable sodium (meq/l)	1.54-3.48	1.52-2.37	2.32	1.91	0.46	0.23	504.3478	830.43
DTPA Zn (mg kg^{-1})	0.06-0.58	0.09-0.64	0.28	0.11	0.15	0.16	53.57	145.45
DTPA Fe (mg kg^{-1})	0.77-1.94	0.58-1.62	1.22	0.97	0.37	0.33	30.32	34.02
DTPA Mn (mg kg^{-1})	1.51-2.69	0.19-2.64	2.14	1.78	0.31	0.56	14.48	31.46
DTPA Cu (mg kg^{-1})	0.11-0.29	0.10-0.39	0.19	0.23	0.07	0.08	36.84	34.78
Sand (%)	49.60-76	50-79	64.77	71.40	9.33	8.51	14.40	11.91
Silt (%)	18.30-41.85	12-41	29.94	19.77	8.33	9.22	27.82	46.63
Clay (%)	2-9	2.45-13	4.97	8.29	2.53	3.42	50.90	41.25

3.5.1 DTPA extractable Zinc

Soil DTPA Zn was ranged from 0.06 to 0.57 and 0.09 to 0.64 mg kg^{-1}, at 0-15 cm, 15-30 cm with mean values of 0.28 and 0.31 mg kg^{-1}, respectively. According to Walkley and Black [31] maximum of the soil samples were falling under low in category (<0.6 mg kg^{-1}). this may be due to higher pH. The available Zn increased with decrease in pH and increase in OC content. Available Zn in soils decreased with increase in pH or it may be due to lack of Zn in parent material reported by Satyavathi and Reddy [32].

3.5.2 DTPA extractable iron

Soil DTPA Fe was ranged from 0.77 to 1.94, 0.58 to 1.63mg kg^{-1} at 0-15 cm, 15-30 cm with mean values of 1.22 and 0.97mg kg^{-1}, respectively. According to the critical limit 4.5 mg kg^{-1} soil as purposed by Walkley and Black [31] maximum of the soil samples were falling under low in available Fe content and it may be due to unavailability of iron in alkaline condition [32].

3.5.3 DTPA extractable manganese

Soil DTPA Mn was ranged from 1.51 to 2.69, 0.196 to 2.65 mg kg^{-1} at 0-15 cm, 15-30 cm with mean values of 2.14 and 1.78 mg kg^{-1}, respectively. According to the critical limit 1.0 mg kg^{-1} soil as purposed [31] maximum of the soil samples were found to be sufficient in available Mn content. A decreasing trend with depth was noticed in all the different locations, which might be due to its presence in the reduced form in the surface soils, these observations are in agreement with the findings of Nayaket al. [33].

3.5.4 DTPA extractable copper

Soil DTPA Cu was ranged from 0.29 to 0.11, 0.1 to 0.39 mg kg^{-1} at 0-15 cm, 15-30 cm with mean values of 0.19 and 0.23 mg kg^{-1}, respectively. According to Walkley and Black [31] Data revealed that maximum of the soil samples were deficient in copper availability. This may be due to low amount of organic matter in soils. These results were in agreement with findings of Rajeswar et al. [34]. “The higher amount of DTPA-Cu in surface layer might be due to higher biological activities and chelating effect” [35]. Similar results were observed by Ravikumar et al. [36].

4. CONCLUSION

As per study, soils were low in available nitrogen, organic matter, high in available phosphorus and low in available potassium. So external fertilizers are required for maintaining soil health and good productivity of the crops. Soils were deficient in available micronutrients such as Iron, Zinc and copper and sufficient in Manganese content. Deficient micronutrients should be replenished to avoid the crops suffering from the deficiency, so as to improve the growth of the crops. Based on the status of nutrients, fertilizer recommendations should be made which will result in enhancing the yield and reducing the cost of fertilizers so as to improve availability of nutrient for better growth and yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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