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Soil Fertility Status under Soils of Sugarcane-Ratoon-Wheat Cropping System of Meerut District of 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 os soils under sugarcane-ratoon-wheat cropping system. Soil samples were collected from farmers fields at three depths *viz.,* 0-15 cm, 15-30 cm and 30-45 cm and analysed for various soil properties. Results revealed that soils were sandy clay loam to clay loam in texture, neutral in soil reaction and non saline in salt content. Mean values of CEC 15.96, 13.13 and 10.80 C mol (p+) kg^{-1}, SOC 4.57, 3.93 and 2.95 g kg^{-1}, available nitrogen 263.01, 209.90 and 173.73 kg ha^{-1}, available phosphorus 15.37, 12.49 and 9.00 kg ha^{-1}, available potassium 156.43, 118.16 and 102.11 kg ha^{-1}, DTPA Zn 0.49, 0.35 and 0.21 mg kg^{-1}, DTPA Fe 9.53, 7.71 and 5.28 mg kg^{-1}, DTPA Mn 8.20, 6.80 and 5.20 mg kg^{-1} and DTPA Cu 0.99, 0.74 and 0.56 mg kg^{-1} were recorded at 0-15 cm, 15-30 cm and 30-45 cm, respectively. Soils under this cropping system were low in available nitrogen content and medium in available phosphorus and potassium content. Among DTPA extractable micronutrients soil were deficient in available zinc while sufficient in available iron, manganese and copper content.

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Keywords: Soil available nutrients; sugarcane-ratoon-wheat cropping system; DTPA micronutrients.

1. INTRODUCTION

Cropping systems have a substantial impact on the physicochemical properties of soil, which eventually affect agricultural yields. Cropping systems and management practices have a positive effect on soil properties. Adopting diverse cropping systems is vital not only for crop production optimization, but also for soil health improvement by balancing soil biodiversity, boosting soil nutrient efficiency, and lowering soil-borne pathogens [1]. Over exploitation of natural resources and the indiscriminate and irrational use of synthetic inputs like inorganic fertilizers in order to produce more and more from a unit piece of land are being increasingly realized, which have seriously impaired the ecological balance and resulted in deteriorating the soil health [2]. Sugarcane-ratoon-wheat is the most predominant cropping system followed by rice-wheat cropping system in western U.P. Nearly 95% soils were deficient in available N, 64% medium in available P and 31% were deficient in available zinc content [3]. Micronutrients play a vital role in enhancing crop productivity and improving quality of crops. Although micronutrients are needed in much smaller quantities as compared to primary nutrients, they play major role in terms of their impact on crop growth and productivity. The importance of micronutrients need to be viewed from the context of food and nutritional security, as their inclusion in balanced fertilization schedule would optimize micronutrient supply and availability in the entire food consumption cycle. In Uttar Pradesh on an average 22.27, 15.56, 2.84, 15.82 and 20.61% of soils were deficient in Zn, Fe, Cu, Mn and B, respectively [4]. Stagnation or decrease in yield has been observed in multiple cropping sequences in multiple locations of the country due to nutrient depletion, impaired usage of plant nutrients and sub-optimal addition of both organic and inorganic fertilizers to soil [5]. Under continuous cropping, changes in soil fertility and the resultant crop productivity can be related with nutrient imbalances, which have been recognized as one of the most important factors that limiting crop yield. With this background a study was taken up to know the fertility status of soils under sugarcane-ratoon-wheat cropping system in western Uttar Pradesh.

2. MATERIALS AND METHODS

2.1 Study Area

The present study was undertaken in Meerut district of Uttar Pradesh. Geographic coordinates of district Latitude, Longitude and Altitude 28°44' to 29°18' N, 77°8' to 78°8' E and 205-240m, and average annual rainfall 915 mm respectively.

Table 1. Analytical methods employed during chemical analysis

Sl. No	Parameter	Method adopted	Reference
1	Mechanical composition	Hydrometer method	[6]
2	Soil reaction	Soil water suspension (1:2.5)	[7]
3	Electrical conductivity	Soil water extract (1:2.5)	[7]
4	Organic carbon	Wet oxidation method	[8]
5	Cation exchange capacity	Sodium acetate method	[6]
6	Calcium carbonate	HCl method	[9]
7	Available nitrogen	Alkaline $KMnO_4$ method	[10]
8	Available phosphorus	0.5M $NaHCO_3$ method	[11]
9	Available potassium	Neutral *N* Ammonium acetate extraction	[6]
	DTPA Zn		[12]
10	DTPA Fe	Atomic Absorption Spectrophotometer	
11	DTPA Mn		
12	DTPA Cu		

2.2 Collection, Preparation and Analysis of Soil Samples

Soil samples from 0-15cm, 15-30cm and 30-45cm depth at ten random points were collected with the help of auger after the completion of cropping sequence on each sampling site (Farmer field) during 2020 from sugarcane-ratoon-wheat cropping sequence. The sampled soils were composited and total of eighteen samples collected from six farmers filed (plots). This prominent cropping sequence was running on same fields continuously since 10-12 years. Soil samples brought to laboratory air dried in shade, ground to pass through 2 mm sieve, then mixed thoroughly and stored for different nutrient analysis. Physico-chemical properties were estimated for these soil samples using standard methodology (Table 1). The data was analysed as per the standard statistical procedure using MS excel 2010.

3. RESULTS AND DISCUSSION

3.1 Mechanical Composition of Soil

Per cent sand was ranged from 53-61, 42-52 and 36-50 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 57, 46 and 42, respectively. Per was ranged from 21-28, 26-38 and 23-35 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 24, 30 and 31, respectively. Per cent clay content was ranged from 18-22, 20-26 and 23-32 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 19, 23 and 27, respectively (Table 2). Soils under sugarcane-ratoon-wheat cropping systems were sandy clay loam to clay loam. The greater clay content was observed that might be due to the higher stratified nature of these soils [13]. Soils under this cropping system possess a finer texture, i.e., higher clay corresponds to more organic matter addition and higher microbial activity, thereby improving soil fertility and more productivity as compared to undisturbed land-use systems [14]. These results were in accordance with [15].

3.2 Soil Physico-chemical Properties

The data regarding soil physico-chemical properties under sugarcane-ratoon-wheat cropping system was presented in Table 2.

3.2.1 Soil reaction (pH)

The surface soils recorded a slightly lower pH and increased with depth. Soil pH was ranged from 7.1 to 7.45, 7.12-7.41 and 7.1 to 7.48 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 7.20, 7.28 and 7.30, respectively (Table 2). Comparatively lower pH of in surface soils might be due to the continuous addition of organic matter in these soils through crop residues and leaf litter and also due to the release of weak organic acids with litter decomposition [16]. A slight increase in soil pH with depth may be due to the leaching of bases and salts to the deeper layer of soils [12]. Simialr results were reported by [15,17,3].

3.2.2 Electrical conductivity (EC)

Soil EC was ranged from 0.070-0.130, 0.070-0.110 and 0.050-0.100 dS m^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.110, 0.090 and 0.070 dS m^{-1}, respectively (Table 2). The higher EC on the surface layer was due to the higher amount of nutrient ions at the surface, and with the decrease in nutrient ions with depth, the EC decreased. Similar results were reported by [18-20,3].

3.2.3 Calcium carbonate ($CaCO_3$)

Soil $CaCO_3$ content ranged from 0.130-0.380, 0.120-0.250 and 0.120-0.250 % at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.210, 0.190 and 0.170 % (Table 2). The Higher $CaCO_3$ in surface soils may be due to higher portion of sand in particle size distribution of soils because most of the $CaCO_3$ resides in sand fraction. Similar results reported by [15,20].

3.2.4 Cation exchange capacity (CEC)

Soil CEC was ranged from 14.44-`17.49, 11.74-14.33 and 10-11.16 C mol (p+) kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 15.96, 13.13 and 10.80 C mol (p+) kg^{-1}, respectively. High SOC soils have the capacity to add more cations, making them sufficiently rich in calcium, magnesium, and other cations, increasing the soils CEC. Similar results were reported by [15].

3.2.5 Soil organic carbon (SOC)

Soil SOC was ranged from 4.29-4.86, 3.71-4.14 g kg^{-1} and 2.57-3.28 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 4.57, 3.93 and 2.95 g kg^{-1}, respectively. The highest SOC in surface soils might be due to due to exogeneous supply of organic matter through leaf litter and crop residues (roots, stubbles) that decreased with depth [21]. Similar results were reported by [17,19,15,3].

Table 2. Soil physico-chemical properties and available nutrient status under soils of sugarcane-ratoon-wheat cropping system

Soil properties	Range			Mean			S.D			CV		
	0-15 cm	**15-30 cm**	**30-45cm**	**0-15 cm**	**15-30 cm**	**30-45 cm**	**0-15 cm**	**15-30 cm**	**30-45cm**	**0-15 cm**	**15-30 cm**	**30-45cm**
Soil reaction (pH)	7.1-7.45	7.12-7.41	7.1-7.48	7.20	7.28	7.30	0.123	0.093	0.143	1.71	1.28	1.96
EC (dS m^{-1})	0.070-0.130	0.070-0.110	0.050-0.100	0.110	0.090	0.070	0.019	0.015	0.021	18.03	17.20	26.80
$CaCO_3$ (%)	0.130-0.380	0.120-0.250	0.120-0.250	0.210	0.190	0.170	0.093	0.062	0.057	44.72	33.33	33.17
CEC [C mol (p+) kg^{-1}]	14.44-`17.49	11.74-14.33	10-11.16	15.96	13.13	10.80	0.950	0.873	0.411	5.95	6.65	3.81
SOC (g kg^{-1})	4.29-4.86	3.71-4.14	2.57-3.28	4.57	3.93	2.95	0.218	0.137	0.256	4.77	3.48	8.69
Avail. N (kg ha^{-1})	229.56-187.56	.95.69-220.77	163.07-180.63	263.01	209.90	173.73	18.43	7.69	5.46	7.01	3.66	3.14
Avail. P (kg ha^{-1})	12.16-22.83	10.68-15.71	6.82-11.05	15.37	12.49	9.00	3.55	1.94	1.41	23.10	15.50	15.69
Avail. K (kg ha^{-1})	131.04-185.92	89.60-141.12	87.36-126.56	156.43	118.16	102.11	18.79	18.41	15.08	11.99	15.58	14.78
DTPA Zn (mg kg^{-1})	0.460-0.520	0.336-0.367	0.153-0.244	0.49	0.35	0.21	0.022	0.009	0.033	4.41	2.64	16.06
DTPA Fe (mg kg^{-1})	9.20-10.06	7.12-8.19	4.62-5.90	9.53	7.71	5.28	0.271	0.356	0.414	2.84	4.62	7.85
DTPA Mn (mg kg^{-1})	7.59-9.16	6.36-7.16	4.42-5.67	8.20	6.80	5.20	0.503	0.285	0.430	6.14	4.19	8.27
DTPA Cu (mg kg^{-1})	0.830-1.180	0.660-0.804	0.492-0.612	0.99	0.74	0.56	0.111	0.050	0.041	11.23	6.82	7.39
Sand (%)	53-61	42-52	36-50	57	46	42	2.60	3.15	4.77	4.61	6.81	11.49
Silt (%)	21-28	26-38	23-35	24	30	31	2.20	3.98	3.94	9.12	13.14	12.65
Clay (%)	18-22	20-26	23-32	19	23	27	1.38	1.92	2.82	7.22	8.24	10.36

3.3 Soil Available Macro Nutrient

The data regarding soil available macronutrient status under sugarcane-ratoon-wheat cropping system was presented in Table 2.

3.3.1 Available nitrogen

Soil available nitrogen content was ranged from 229.56-187.56, 195.69-220.77 and 163.07-180.63 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 263.01, 209.90 and 173.73 kg ha^{-1}, respectively. The surface and sub-surface soils low in available N status which might be due to intensive cropping practices and the sugarcane crop's high N needs. Additionally, the soil becomes deficient in nitrogen as a result of the skewed reliance on high analyses fertilizers for N supplementation, which results in increased N loss through a variety of mechanisms, such as nitrate leaching, surface run-off, and to the atmosphere through ammonia (NH_3) volatilization and nitrous oxide (N_2O) emission [17-19].

3.3.2 Available phosphorus

Soil available phosphorus content was ranged from 12.16-22.83, 10.68-15.71 and 6.82-11.05 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 15.37, 12.49 and 9.00 kg ha^{-1} respectively. The higher availability of P in areas with intensive crop production may be attributed to the release of P that has been organically bound during the breakdown of organic matter and the solubilization of P in the soil by organic acids created during the breakdown of root biomass [22]. Similar results were reported by [17,19,15,3].

3.3.3 Available potassium

Soil available potassium content was ranged from 131.04-185.92, 89.60-141.12 and 87.36-126.56 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 156.43, 118.16 and 102.11 kg ha^{-1}, respectively. The greater content of available K may be due to the governance of K-rich minerals and also the addition of OM that helped in the replenishment of nutrient status in soil [13]. However the soils under this cropping system were low in available K status. Similar results were reported by [23,17,19,15,3].

3.4 Soil DTPA Extractable Micronutrients

The data regarding soil DTPA extractable micronutrients status under sugarcane-ratoon-wheat cropping system was presented in Table 2.

3.4.1 DTPA extractable zinc

Soil DTPA Zn was ranged from 0.460-0.520, 0.336-0.367 and 0.153-0.244 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.49, 0.35 and 0.21 mg kg^{-1}, respectively. The higher DTPA Zn values in surface soils could be attributed to the addition and recycling of Zn through the accumulation and decomposition of organic residues added to the soil in the form of litter and root residues, which leads to increased microbial activity in the soil and thus facilitates the release of micronutrients [23]. However soils under this cropping system were deficient in available zinc content which might be due to high soil pH, mining of the nutrients by intensive crop cultivation. Similar results were reported by [19,18].

3.4.2 DTPA extractable iron

Soil DTPA Fe was ranged from 9.20-10.06, 7.12-8.19 and 4.62-5.90 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 9.53, 7.71 and 5.28 mg kg^{-1}, respectively. The higher the concentration of organic matter in soils, the greater the amount of DTPA extractable Fe in surface soil layers [13]. The higher Fe content might also be attributed to the increased input of organic residues, which improved soil aeration, provided chelating agents, and reduced Fe precipitation and oxidation, improving the availability of micronutrients in soils [24,25]. The soils under this cropping system were sufficient in available iron content. These results were in agreement with [18,3].

3.4.3 DTPA extractable manganese

Soil DTPA Mn was ranged from 7.59-9.16, 6.36-7.16 and 4.42-5.67 90 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 8.20, 6.80 and 5.20 mg kg^{-1}, respectively. The greater DTPA extractable manganese in these soils could be attributed to the higher level of organic residues, which protects micronutrients from oxidation and precipitation into bound forms and also provide soluble chelating agents for the solubilization of micronutrients [26,21]. The soils under this cropping system were sufficient in available manganese content. These results were in agreement with [18,3].

3.4.4 DTPA extractable copper

Soil DTPA Cu was ranged from 0.830-1.180, 0.660-0.804 and 0.492-0.612 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.99, 0.74 and 0.56 mg kg^{-1}, respectively. The results revealed that the distribution of DTPA-Cu slightly decreased with increasing depth. The fact that organic matter in the form of crop residues has been added to the surface layer of soils, reducing pH, may be the cause of the greater Cu content on surface soils [13]. The soils under this cropping system were sufficient in available copper content. These results were in agreement with [18,3].

4. CONCLUSION

The outcome of present study showed that soils under sugarcane-ratoon-wheat cropping system were neutral in soil reaction and non-saline in salt content. Further the results revealed that soils are deficient available nitrogen, and available zinc These soils were These soils were medium in available phosphorus and potassium content and sufficient in DTPA extractable iron, manganese and copper content. However all the soil parameters decreased with increase in depth except soil pH. To conclude that the soils under this cropping sequence were poor in nutrient status proper integrated nutrient management practices need to followed by the farmers in order to improve soil health, which ultimately improves farmers economic status by higher production and productivity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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