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Soil fertility status under soils of rice-wheat cropping system of Meerut district of Uttar Pradesh, India

Pallabi Kalita, Satendra Kumar, BP Dhyani, UP Shahi, RK Naresh and B Singh

Pallabi Kalita
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Satendra Kumar
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

BP Dhyani
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

UP Shahi
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

RK Naresh
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

B Singh
Department of Statistics, (Basic Science), Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Pallabi Kalita
Department of Soil Science and Agricultural Chemistry, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Abstract
The goal of the current study was to evaluate the soil fertility of soils in rice-wheat cropping system. In order to analyse different soil parameters, soil samples were taken from farmer's fields at three depths: 0-15 cm, 15-30 cm, and 30-45 cm. Results showed that the soils were neutral to slightly alkaline in soil reaction, non-saline in salt content, and sandy clay loam to clay loam in texture. Mean values of CEC 15.63, 12.33 and 10.49 C mol (p^+) kg^{-1}, Soil organic carbon 4.49, 3.88 and 2.80 g kg^{-1}, available nitrogen 261.42, 208.57 and 174.23 kg ha^{-1}, available phosphorus 14.04, 12.24 and 9.16 kg ha^{-1}, available potassium 155.78, 118.36 and 101.56 kg ha^{-1}, DTPA Zn 0.20, 0.34 and 0.47 mg kg^{-1}, DTPA Fe 5.60, 7.19 and 9.53 mg kg^{-1}, DTPA Mn 5.00, 6.88 and 8.14 mg kg^{-1} and DTPA Cu 0.55, 0.72 and 0.96 mg kg^{-1} were recorded at 0-15cm, 15-30 cm and 30-45cm, respectively. Soils in this cropping system had a low available nitrogen content and a medium available phosphorus and potassium content. Among the DTPA extractable micronutrients, soils were deficient in available zinc while sufficient in available iron, manganese, and copper content.

Keywords: Fertility, resource, management, deficient, cropping system

Introduction

Soil is a country's most important natural resource, and understanding its characteristics is critical for developing an optimal land use plan to maximise agricultural production. The morphological, physical, chemical, mineralogical, and biological properties of soils vary greatly. Because these characteristics control the response of soil to management practices, it is critical to understand these characteristics of each soil. It is critical to understand different macro and micro nutrients and their distribution in the root zone. Soil quality is generally determined by physicochemical properties and their interactions with one another. Variation in nutrient supply is a natural phenomenon, and it may be sufficient in some areas while being deficient in others.

Cropping systems have a significant impact on soil physicochemical properties, which in turn affect agricultural yields. Cropping systems and management practises influence soil properties positively. Adopting diverse cropping systems is critical not only for crop production optimization, but also for improving soil health by balancing soil biodiversity, increasing soil nutrient efficiency, and decreasing soil-borne pathogens (Barbieri *et al*, 2019) [1]. Rice-wheat is the most common cropping system in western U.P., followed by sugarcane-ratoon-wheat. Almost 95% of the soils were deficient in available N, 64% in available P, and 31% in available zinc content (Singh *et al.*, 2012) [16]. Micronutrients are essential for increasing crop productivity and improving crop quality. Although micronutrients are required in much smaller quantities than primary nutrients, they have a significant impact on crop growth and productivity. Micronutrients are important in terms of food and nutritional security because their inclusion in a balanced fertilisation schedule optimises micronutrient supply and availability throughout the food consumption cycle. In Uttar Pradesh, respectively, 22.27, 15.56, 2.84, 15.82, and 20.61% of soils were deficient in Zn, Fe, Cu, Mn, and B. (Shukla *et al.*, 2018) [17]. Changes in soil fertility and crop productivity under continuous cropping can be linked to nutrient imbalances, which have been identified as one of the most important factors limiting crop yield. With this in mind, a study was conducted to determine the fertility status of soils under the rice-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 and Latitude, Longitude and Altitude is 28°44' to 29°18' N, 77°8' to 78°8' E and 205-240m, and average annual rainfall 915 mm respectively.

2.2 Collection, Preparation and Analysis of Soil Samples

Soil samples from 0-15 cm, 15-30 cm and 30-45 cm 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 rice-wheat cropping sequence. The sampled soils were composited and total of eighteen samples collected from six farmers field (plots). Six samples collected from each depth of rice-wheat cropping system. This prominent cropping sequence was running on same fields continuously since 10-12 years. Soil samples were brought to laboratory, air dried in shade, ground, and passed through 2 mm sieve, then mixed thoroughly and stored in polythene bags 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.

Table 1: Analytical methods employed for chemical analysis of soils

Sl No.	Parameter	Method adopted	Reference
1	Mechanical composition	Hydrometer method	(Bouyoucos, 1962) [3]
2	Soil reaction	Soil water suspension (1:2.5)	(Jackson, 1973) [3]
3	Electrical Conductivity	Soil water extract (1:2.5)	(Jackson, 1973) [3]
4	Organic Carbon	Wet oxidation method	(Walkley and Black, 1934) [22]
5	Cation Exchange Capacity	Sodium acetate method	(Jackson, 1973) [3]
6	Calcium Carbonate	HCl method	(Hesse, 1971) [9]
7	Available Nitrogen	Alkaline KMnO4 method	(Subbiah & Asija 1956) [18]
8	Available Phosphorus	0.5M NaHCO3 method	(Olsen, 1954) [14]
9	Available Potassium	Neutral N Ammonium acetate extraction	(Jackson, 1973) [3]
10	DTPA Zinc	Atomic Absorption Spectrophotometer	(Lindsay & Norvell, 1978) [12]
11	DTPA Fe	Atomic Absorption Spectrophotometer	(Lindsay & Norvell, 1978) [12]
12	DTPA Mn	Atomic Absorption Spectrophotometer	(Lindsay & Norvell, 1978) [12]
13	DTPA Cu	Atomic Absorption Spectrophotometer	(Lindsay & Norvell, 1978) [12]

3. Results and Discussion

3.1 Soil Physico-chemical Properties

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

3.1.1 Soil reaction (pH)

The surface soils recorded a slightly lower pH and increased with depth. Soil pH ranged from 7.33 to 7.48, 7.30-7.67 and 7.10 to 7.56 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 7.40, 7.46 and 7.33, respectively (Table 2). Surface soils may have lower pH due to the ongoing supply of organic matter through crop residues and leaf litter, as well as the release of weak organic acids during litter decomposition. The leaching of bases and salts to the deeper layers of soils may cause a small increase in soil pH with depth. Similar findings were reported by (Verma *et al.*, 2013, Tiwari *et al*, 2020) [20, 19].

3.1.2 Electrical conductivity (EC)

Soil EC ranged from 0.07-0.16, 0.07-0.17 and 0.08-0.23 dS m^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.11, 0.11 and 0.14 dS m^{-1}, respectively (Table 2).

3.1.3 Soil organic carbon (SOC)

Soil SOC ranged from 4.27-4.71, 3.66-4.04 g kg-1 and 2.41-3.14 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 4.49, 3.88 and 2.80 g kg^{-1}, respectively. The highest SOC in surface soils may be attributable to an exogenous input of organic matter via leaf litter and agricultural residues (roots, stubbles) that decreased with depth **(**Bhople *et al*, 2020) [20]. Similar findings have been reported by (Tiwari *et al*, 2020, Kumar *et al*, 2016, Verma *et al*, 2013) [20, 11, 19].

3.1.4 Calcium carbonate ($CaCO_3$)

Soil $CaCO_3$ content ranged from 0.22-0.37, 0.13-0.25 and 0.11-0.13 % at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.26, 0.20 and 0.12 % (Table 2). The increased CaCO3 in surface soils could be attributed to a higher proportion of sand in the particle size distribution of soils, as most CaCO3 is found in the sand fraction. Similar findings were reported by (Verma *et al.,* 2013, Dwivedi *et al*, 2017) [20, 8].

3.1.5 Cation exchange capacity (CEC)

Soil CEC varied from 13.44-18.49, 10.74-14.33 and 9.99-11.36 C mol (p^+) kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 15.63, 12.33 and 10.49 C mol (p^+) kg^{-1} respectively. High SOC soils have the ability to add additional cations, making them adequately rich in calcium, magnesium, and other cations, hence boosting the soil's CEC. Similar findings have been reported by (Verma *et al.,* 2013) [20].

3.1.6 Mechanical Composition of Soil

Per cent sand varied from 50-59, 46-52 and 42-56 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 54.25, 49.81 and 46.74, respectively. Per cent silt ranged from 24-30, 24-32 and 21-34 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 26.74, 28.92 and 28.99, respectively. Per cent clay content ranged from 15-26, 20-23 and 22-27 at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 20.43, 21.17 and 24.27, respectively (Table 2). Soils under rice-wheat cropping systems varied from sandy clay loam to clay loam. The larger clay concentration was discovered, which could be attributed to the more stratified structure of these soils. When compared to undisturbed land-use systems, soils under this cropping system have a finer texture, i.e., more clay equates to more organic matter addition and higher microbial activity, hence boosting soil fertility and production (Dhaliwal *et al.,* 2009) [6]. These findings were consistent with (Verma *et al.,* 2013) [20].

3.2 Soil Available Macro Nutrient
The data regarding soil available macronutrient status under rice-wheat cropping system was presented in Table 3.

3.2.1 Available nitrogen
Soil available nitrogen content ranged from 225.06-288.26, 198.69-220.77 and 166.07-180.63 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 261.42, 208.57 and 174.23 kg ha^{-1}, respectively. The subsurface soils had poor accessible N status, which might be attributed to intensive cropping techniques and the wheat crop's high N requirements. Furthermore, as a result of the skewed reliance on high analyses fertilisers for N supplementation, the soil becomes nitrogen deficient, resulting in increased N loss through a variety of mechanisms, including nitrate leaching, surface run-off, and to the atmosphere via ammonia (NH_3) volatilization and nitrous oxide (N_2O) emission (Tiwari *et al*, 2020, Kumar *et al*, 2016, Dwivedi *et al*, 2017) [19, 11, 8].

3.2.2 Available phosphorus
Soil available phosphorus content ranged from 11.16-20.83, 10.90-14.03 and 7.01-11.55 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 14.04, 12.24 and 9.16 kg ha^{-1} respectively. The enhanced availability of P in intensive crop production areas may be due 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 produced during the breakdown of root biomass (Moharana *et al*, 2017) [13]. Similar findings have been reported by (Tiwari *et al*, 2020, Kumar *et al*, 2016, Singh *et al*., 2012) [19, 11, 16].

3.2.3 Available potassium
Soil available potassium content varied from 130.04-183.92, 99.60-138.12 and 85.36-128.96 kg ha^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 155.78, 118.36 and 101.56 kg ha^{-1}, respectively. The higher accessible K content might be attributed to the management of K-rich minerals as well as the addition of OM, which aided in the restoration of soil nutrient status (Dhaliwal *et al*, 2022) [7]. However, the soils under this cropping scheme had medium available K status in the first 15 cm and 30 cm, and low in the last 45 cm. Similar findings were reported by (Tiwari *et al*, 2020, Kumar *et al*, 2016, Singh *et al*., 2012) [19, 11, 16].

3.3 Soil DTPA Extractable Micronutrients
The data regarding soil DTPA extractable micronutrients status under rice-wheat cropping system was presented in Table 3.

3.3.1 DTPA extractable zinc
Soil DTPA Zn ranged from 0.17-0.24, 0.32-0.36 and 0.41-0.57 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.20, 0.34 and 0.47 mg kg^{-1}, respectively. 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 (Verma *et al*., 2016, Kumar *et al*, 2016) [20, 11].

3.3.2 DTPA extractable iron
Soil DTPA Fe varied from 4.62-8.20, 5.78-8.01 and 8.49-10.36 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 5.60, 7.19 and 9.53 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. The increased input of organic wastes, which promoted soil aeration, provided chelating agents, and reduced Fe precipitation and oxidation, may also be related to the higher Fe level (Singh, *et al*, 2018, Dhaliwal *et al*, 2019) [15, 5]. The soils in this farming system had adequate accessible iron concentration. These findings agreed with (Singh, *et al*, 2012) [16].

Table 1: Physico—chemical properties of soil

	pH	EC (dS m^{-1})	SOC (g Kg^{-1})	CaCO3 (%)	CEC cmol(p$^+$)kg^{-1}	Sand (%)	Silt (%)	Clay (%)
	7.33	0.07	4.28	0.37	13.44	50.00	24.00	26.00
	7.45	0.09	4.28	0.23	14.45	51.00	30.00	19.00
0-15 CM	7.48	0.12	4.27	0.25	16.61	57.00	28.00	15.00
	7.41	0.11	4.71	0.24	14.36	55.00	25.00	19.00
	7.38	0.16	4.71	0.22	16.42	54.00	25.00	20.00
	7.35	0.13	4.65	0.23	18.49	59.00	28.00	23.00
MEAN	7.40	0.11	4.49	0.26	15.63	54.25	26.74	20.43
SD	0.06	0.03	0.23	0.05	1.87	3.38	2.20	3.76
CV	0.78	27.72	5.08	21.18	12.00	6.22	8.24	18.40
	7.35	0.09	3.81	0.25	10.74	52.00	24.00	23.00
	7.67	0.07	3.66	0.21	11.28	52.00	26.00	22.00
15-30CM	7.30	0.08	3.76	0.25	12.51	46.00	32.00	22.00
	7.56	0.09	4.00	0.22	12.01	49.00	31.00	20.00
	7.44	0.17	4.00	0.15	13.11	50.00	30.00	20.00
	7.45	0.13	4.04	0.13	14.33	50.00	30.00	20.00
MEAN	7.46	0.11	3.88	0.20	12.33	49.81	28.92	21.17
SD	0.14	0.04	0.16	0.05	1.30	2.35	3.12	1.41
CV	1.82	36.01	4.07	25.99	10.51	4.72	10.78	6.67
	7.56	0.12	2.57	0.11	9.99	56.00	21.00	23.00
	7.42	0.23	2.41	0.12	10.60	45.00	30.00	25.00
30-45 CM	7.11	0.18	2.56	0.13	10.88	42.00	31.00	27.00
	7.56	0.12	3.14	0.13	10.02	43.00	34.00	22.00
	7.10	0.08	3.04	0.12	11.36	45.00	34.00	22.00
	7.23	0.09	3.09	0.11	10.06	50.00	25.00	26.00
MEAN	7.33	0.14	2.80	0.12	10.49	46.74	28.99	24.27
SD	0.21	0.06	0.32	0.01	0.56	5.36	5.14	2.19
CV	2.90	42.08	11.49	6.63	5.36	11.46	17.75	9.01

Table 2: Available macronutrient and micro-nutrient status of rice-wheat soils

	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	DTPA Zn (mg kg^{-1})	DTPA Mn (mg kg^{-1})	DTPA Fe (mg kg^{-1})	DTPA Cu (mg kg^{-1})
	225.06	11.16	130.04	0.17	4.23	8.20	0.42
	252.13	12.67	140.36	0.18	4.79	4.62	0.57
0-15 CM	263.42	11.85	145.48	0.19	5.18	4.98	0.53
	265.70	13.21	160.28	0.23	5.01	5.01	0.55
	273.97	14.51	174.58	0.24	5.42	5.35	0.57
	288.26	20.83	183.92	0.22	5.37	5.45	0.63
MEAN	261.42	14.04	155.78	0.20	5.00	5.60	0.55
SD	21.49	3.52	20.84	0.03	0.44	1.31	0.07
CV	8.22	25.09	13.38	14.31	8.85	23.35	12.72
	198.69	11.68	99.60	0.34	6.86	5.78	0.66
	203.98	10.90	102.16	0.33	6.55	7.02	0.80
15-30CM	207.48	10.97	112.44	0.32	6.73	7.29	0.72
	201.99	12.16	119.84	0.32	6.88	7.27	0.77
	218.50	14.03	138.00	0.36	7.19	7.78	0.78
	220.77	13.72	138.12	0.35	7.06	8.01	0.60
MEAN	208.57	12.24	118.36	0.34	6.88	7.19	0.72
SD	9.06	1.35	16.90	0.02	0.23	0.78	0.08
CV	4.35	11.02	14.28	4.59	3.32	10.85	10.51
	166.07	7.82	85.36	0.46	7.39	8.49	0.81
	171.85	7.01	89.36	0.42	7.77	9.26	0.88
30-45 CM	174.36	8.98	89.60	0.42	8.08	9.86	0.93
	175.62	9.44	104.52	0.41	8.30	9.56	1.02
	176.87	10.18	111.54	0.57	8.30	9.65	1.06
	180.63	11.55	128.96	0.52	9.01	10.36	1.06
MEAN	174.23	9.16	101.56	0.47	8.14	9.53	0.96
SD	4.94	1.63	16.81	0.07	0.55	0.63	0.10
CV	2.84	17.81	16.56	14.24	6.75	6.59	10.74

3.3.3 DTPA extractable manganese
Soil DTPA Mn ranged from 4.23-5.42, 6.55-7.19 and 7.39-9.01 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 5.00, 6.88 and 8.14 mg kg^{-1}, respectively. The increased amount of organic residues in these soils could be related to the higher level of DTPA extractable manganese, which shields micronutrients from oxidation and precipitation into bound forms while simultaneously providing soluble chelating agents for micronutrient solubilization (Chandel *et al*, 2018) [4]. This agricultural system's soils had an adequate manganese content. These findings corroborated (Singh *et al.*, 2012, Verma *et al*, 2016) [16, 20].

3.3.4 DTPA extractable copper
Soil DTPA Cu varied from 0.42-0.63, 0.60-0.80 and 0.81-1.06 mg kg^{-1} at 0-15 cm, 15-30 cm and 30-45 cm with mean values of 0.55, 0.72 and 0.96 mg kg^{-1}, respectively. The soils under this cropping system were sufficient in available copper content. These results were in agreement with (Singh *et al.*, 2012, Verma *et al*, 2016) [16, 20].

4. Conclusion
According to the findings of this study, soils under rice-wheat cropping systems were neutral to slightly alkaline in soil reaction and non-saline in salt content. Furthermore, the findings revealed that soils are deficient in available nitrogen and zinc. The soils had a medium amount of available phosphorus and potassium and a sufficient amount of DTPA extractable iron, manganese, and copper. To conclude that the soils under this cropping sequence had poor nutrient status, farmers must implement proper integrated nutrient management practises. To increase wheat productivity in Meerut district of Uttar Pradesh, there is a need for close monitoring of nutrients in the district and the use of nutrients according to fertiliser recommendations based on soil tests.

5. References

1. Barbieri P, Pellerin S, Seufert V, Nesme T. Changes in crop rotations would impact food production in an organically farmed world. Nature Sustainability. 2019;2(5):378-85.
2. Bhople BS, Sharma S. Seasonal variation of rhizospheric soil properties under different land use systems at lower Shivalik foothills of Punjab, India. Agroforestry Systems. 2020;94(5):1959-1976.
3. Bouyoucos GJ. Hydrometer method improved for making particle size analyses of soils 1. Agronomy Journal. 1962;54(5):464-475.
4. Chandel S, Hadda MS, Mahal AK. Soil quality assessment through minimum data set under different land uses of submontane Punjab. Communications in Soil Science and Plant Analysis. 2018;49(6):658-674.
5. Dhaliwal MK, Dhaliwal SS. Impact of manure and fertilizers on chemical fractions of Zn and Cu in soil under rice-wheat cropping system. J Indian Soc Soil Sci. 2019;67(1):85-91.
6. Dhaliwal SS, Singh B, Sharma BD, Khera KL. Soil quality and yield trends of different crops in low productive submontaneous tract and highly productive area in Punjab, India. Indian Journal of Dryland Agricultural Research and Development. 2009;24(2):39-45.
7. Dhaliwal SS, Sharma V, Kaur J, Shukla AK, Hossain A, Abdel-Hafez SH, *et al*. The Pedospheric Variation of DTPA-Extractable Zn, Fe, Mn, Cu and Other Physicochemical Characteristics in Major Soil Orders in Existing Land Use Systems of Punjab, India. Sustainability. 2022;14(1):29.

8. Dwivedi A, Kumar P, Kumar P, Kumar Y, Sharma YK, Kayastha AM. Soil sensors: detailed insight into research updates, significance, and future prospects. In New Pesticides and Soil Sensors. 2017;1:561-594.
9. Hesse PR, A textbook of soil chemical analysis. Chemical publishing Co; c1971.
10. Jackson ML. Soil chemical analysis prentice hall of India. Pvt. Ltd. New Delhi; c1973. p. 498.
11. Kumar P, Kumar A, Kumar P, Dhayni BP, Shahi UP, Kumar S, *et al*. Nutrients Status of Cultivated Soils of Ganga Canal Area of Meerut District of Uttar Pradesh. International Journal of Bio-Resource and Stress Management. 2016;7(4):606-613.
12. Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal. 1978;42(3):421-428.
13. Moharana PC, Naitam RK, Verma TP, Meena RL, Kumar S, Tailor BL, *et al*. Effect of long-term cropping systems on soil organic carbon pools and soil quality in western plain of hot arid India. Archives of Agronomy and Soil Science. 2017;63(12):1661-1675.
14. Olsen SR. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture; c1954.
15. Singh P, Benbi DK. Soil organic carbon pool changes in relation to slope position and land-use in Indian lower Himalayas. Catena. 2018;1:171-180.
16. Singh VK, Govil V, Singh SK, Dwivedi BS, Meena MC, Gupta VK, *et al*. Precision nutrient management strategies using GIS-based mapping in Western Uttar Pradesh. Better Crops-South Asia. 2012;6(1):15-18.
17. Shukla AK, Behera SK, Pakhre A, Chaudhari SK. Micronutrients in soils, plants, animals and humans. Indian Journal of Fertilisers. 2018;14(3):30-54.
18. Subbiah BV, Asija GL. A rapid method for the estimation of nitrogen in soil. Current Science. 1956;26:259-60.
19. Tiwari R, Tiwari PS, Singh A. Nutrient status of wheat growing soils in Meerut district of Uttar Pradesh. An Asian Journal of Soil Science. 2020;15(1):65-76.
20. Verma TP, Singh SP, Gopal R, Singh R, Katiyar DK, Dhankar RP. Soil fertility evaluation in alluvial soils of Western Uttar Pradesh in Gangetic Plains for sustainable crop production. Journal of Soil Salinity and Water Quality. 2013;5(1):14-19.
21. Verma RR, Srivastava TK, Singh KP. Fertility status of major sugarcane growing soils of Punjab India. J Indian Soc Soil Sci. 2016;64(4):427-31.
22. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science. 1934;37(1):29-38.