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Availability of N, P, K and Their Relationship between Organic Carbon under Sugarcane-Ratoon-Wheat Cropping System in Western Uttar Pradesh Provinces, 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

A study was conducted in the Meerut district of western Uttar Pradesh to evaluate the Soil characterization of sugarcane- ratoon- wheat cropping system**.** The soil samples were analyzed for various parameters in the laboratory. The status of available NPK in soils and other soil properties like pH, electrical conductivity (EC) and organic carbon (OC) content were assessed. Results reveal that the soils of the study area were sandy loam in texture, slightly alkaline in reaction and non-saline in nature. Nutrient status regarding available nitrogen is low in surface (0-15 cm) and subsurface (15-30 cm) soil while phosphorous and potassium low to medium in ranged at surface and subsurface also show that the availability of nutrient is decline gradually with increasing soil depth. A positively significant correlation of N, P, and K with organic carbon content was found.

Keywords: Nutrients; soil; sugarcane and organic carbon.

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1. INTRODUCTION

Cropping systems are designed and managed to grasp human goals so that they are purposeful systems. It includes every spatial and sequential aspect of managing an agricultural system. Cropping system-level study isn't only useful to know the overall sustainability of the agricultural system, but also it helps in generating many important parameters which are useful in global climate change impact assessment. Within the past, cropping systems were designed to maximize yield, but modern agriculture is progressively more concerned with promoting environmental sustainability in cropping systems. The major cropping systems in western Uttar Pradesh are sugarcane, ratoon wheat mostly cultivated in this area. However, rice-wheat is that the predominant cropping system, occupying about 10 million ha. Soil fertility management becomes more complex in intensive cropping thanks to the residual effect of nutrients applied to the previous crops and climatic condition to possible effect of ratoon within the system, complementary and competitive interaction from the component crops and influence of crop residues left within the soil [1,2].

The quality of soil resources has historically been closely related to soil productivity. Cropping systems were initially designed to maximize yield from agro-systems, but modern agriculture has become increasingly concerned about the environmental sustainability of cropping systems. Traditionally, physicochemical properties like soil texture, depth, bulk density, water holding capacity, porosity, pH, electrical conductivity, organic matter, cation exchange capacity, and nutrient content were used as soil health indicators. Soil biological properties, particularly microbial properties have become increasingly used due to their ecological relevance, quick response, sensitivity, and capacity to integrate information and responses from various environmental factors. Within the past, researchers and farmers were mostly concerned about soil quality and crop production [3,4]. Since the 1990s, the concept of soil health assessment has focused on specific soil properties and therefore the soil's ability to keep up a variety of ecological functions in its appropriate ecosystem, supporting long-term sustainable cropping systems.

The sugarcane crop requires 10-18 months for its maturity in India. Generally, a 12-month crop duration is most common. The time of planting is governed by the weather conditions. In India, sugarcane planting is done during different months, called planting seasons. In subtropical India, planting seasons are autumn (October), spring (February–March), and summer (April-May). Spring planted crop is also known as Suring Maharashtra and Eksali in Gujarat and Andhra Pradesh. Autumn Planting in the Peninsular zone is done during October-November. Autumn planting is also known as Pre-seasonal planting in Maharashtra and Gujarat. Adsali planting is preferred in Maharashtra and Karnataka and one during July-August and the crop matures after 16-18 months. There is an increase in yield as well as sugar recovery because of the extended growing season. The biggest advantage of Adsali is that it passes through only one summer season. In the present scenario, the area under Adsali planting is declining because of the less availability of irrigation water. Late planting is common in western Uttar Pradesh where sugarcane is planted after wheat harvest. It has been observed that autumn planting covers only 10-12% area of sugarcane in north India [1,5].

In recent years the productivity of sugarcane has been declined due to the availability of nutrients in adequate amounts for crop growth. The loss in organic matter availability in soil sugarcane root zone area cause a decline in factor productivity. Soil organic matter is directly related to maintaining soil fertility as it is a reservoir of nutrients and provides metabolic energy for biological processes. Re-establishment of organic matter is thus, required for maintaining soil health and improving productivity. Nitrogen has been predictable as a generally deficient in the soil. The nitrogen content in soil is not uniformly distributed in profile. Therefore, due both to the nature of this crop and extensive cropping, the soils of the Indo-Gangetic plains are becoming nutrient-deficient. To maintain productivity, major nutrients – N, P and K – are replenished each year at the recommended application rates, which in the sub-tropical part of India are 150 kg N ha^{-1} for the sugarcane plant crop and 220 kg N ha^{-1} for its ratoon crop as well as 60 kg each of P_2O_5 and K_2O ha^{-1} for both the plant and ratoon crops. However, the effectiveness of sugarcane to utilize applied N ranges between 16 and 45% as large quantities of applied N leach down through the soil layers due to the amount of irrigation required by the sugarcane crop [6]. In addition, the unremitting use of chemical fertilizers is causing perceptible deficiency in other micronutrients. In recent years, the yields of sugarcane crops productivity have declined, with a reduction in soil organic matter status and deterioration in the physicochemical and biological properties of the soil considered to be the prime reasons for the declining yield and factor productivity [7].

2. MATERIALS AND METHODS

The study area falls in the Meerut district of western Uttar Pradesh. The area is situated at a latitude of 29° 40′ North and longitude of 77° 42′ East with an elevation of 237 m above mean sea level. Soil samples from two depths (0-15 and 15-30 cm) from 12 blocks of Meerut district under different cropping patterns were collected with the help of an auger and stored in polythene bags. Collected soil samples were air-dried in shade crushed gently with a wooden roller and then pass through a 2.0 mm sieve to obtain a uniform representative sample. Samples were properly labeled with the aluminum tag and stored in polythene bags for analysis. The processed soil samples were analyzed by standard methods for pH and electrical conductivity (1:2 soil water suspensions), organic matter [8], available nitrogen [9], available phosphorus, available potassium [10]. The correlation was worked out by the Pearson correlation method of analysis through OPSTAT software. All the analytical work was carried out in the laboratory of the Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology Meerut (U.P), India.

3. RESULT AND DISCUSSION

The availability of NPK after harvesting of sugarcane -ratoon-wheat cropping system the analysis was done which show (Table 2) some changes in soil properties. Data regarding the soil pH of the surface and subsurface are presented in the table. The soil samples of surface and subsurface were usually found normal to alkaline reaction and the pH ranged at the surface from 7.51 - 7.97 with a mean of 7.74 while, the pH at subsurface (15-30 cm) ranged from 7.52 -7.98 with a mean of 7.76. A similar finding was observed by Rajeswar et al., [11]. Data presented in Table 2 shows that about the overall location the soil pH was slightly alkaline at surface and subsurface soil. This may be due to the influence of parent material, rainfall and topography [12]. In other soil properties, electrical conductivity (E.C) value under this cropping system varied from 0.21 - 0.48 dSm^{-1} for surface soil (0 -15 cm) while 0.21 - 0.50 dSm^{-1} in subsurface soil (15-30 cm) with an average value of 0.35 and 0.34 dSm^{-1} for surface and subsurface soil, respectively. Electrical conductivity declined consistently with increasing soil depth. Based on the limits suggested by Muhar et al., [8] for judgin13 the salt problem of soils, most of the samples were found normal (EC).

The organic carbon content in surface (0-15 cm) and subsurface soil (15-30 cm) varied from 0.29 - 0.37 and 0.16 - 0.23 percent with an average value of 0.32 and 0.20 percent soil respectively. Based on the rating suggested by Singh et al. [14], Most of the soil samples were low in organic carbon status at the surface, while subsurface soil was also low in organic carbon.

The available nitrogen content in surface (0-15 cm) and subsurface soil (15-30 cm) varied from 158.84 - 195.04 and 118.80.26- 152.64 kg ha^{-1} with an average value of 175.93 and 133.84 kg ha^{-1} respectively. Available nitrogen in soil showed a regular decreasing trend with increasing soil depth. Based on the rating suggested by Subbiah and Asija [9] over all the soil samples were low (<250 N kg ha^{-1}) in nitrogen content. While available nitrogen content in the surface was maximum compared to the subsurface of soil decreased regularly with soil depth, which might be due to the accumulation of plant residues, debris at the surface which contributed through mineralization. These observations are following the findings of Prasuna Rani et al. [15]. Correlation studies show that a significant positive correlation was found between organic carbon and available nitrogen. This might be because most of the soil nitrogen is found in organic forms. Similar results were also reported by Kanthalia & Bhatt [16]; Paliwal [17].

The available phosphorus in surface (0-15 cm) and subsurface soil (15-30) cm varied from 16.78 - 21.67 and 11.94 - 16.85 kg ha^{-1} with an average value of 18.94 and 14.01 kg ha^{-1} respectively. The range is quite large which might be due to variation of soil properties viz., pH, calcareousness, organic matter content, texture and various soil management and agronomic practices. Based on the limit suggested by Muhr et al., [13] overall available phosphorus soil samples were rated medium in range (16-25 P_2O_5 kg ha^{-1}). However, the highest available phosphorus was observed in the surface horizons and decreased regularly with depth. Higher phosphorus in the surface

Table 1. Correlation studies between OC and available N, P and K under different depth

Soil Properties	Surface (0-15 cm)				Subsurface(15-30 cm)			
	O.C	**N**	**P**	**K**	**O.C**	**N**	**P**	**K**
O.C	1.000				1.000			
Avail. N	0.965**	1.000			0.961**	1.000		
Avail. P	0.945**	0.994**	1.000		0.966**	0.996**	1.000	
Avail. K	0.945**	0.978**	0.981**	1.000	0.987**	0.990**	0.994**	1.000

** Significance level ($p \leq 0.05$)*

Table 2. Depth wise soil characterizations of the various parameter of soil at a different location under Sugarcane- Ratoon -Wheat Cropping system

Surface Soil (0-15 cm)Depth														
S. No.	**Soil Parameters**	**Blocks**												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**
A	**pH**	7.51	7.66	7.90	7.97	7.68	7.80	7.71	7.70	7.75	7.88	7.61	7.77	7.74
B	**E.C (dSm^{-1})**	0.28	0.48	0.21	0.26	0.38	0.37	0.33	0.37	0.38	0.39	0.33	0.40	0.35
C	**Organic Carbon (%)**	0.29	0.31	0.32	0.31	0.30	0.32	0.34	0.35	0.34	0.37	0.35	0.30	0.32
D	**Nitrogen (kg ha^{-1})**	158.84	171.97	172.84	164.44	160.14	176.42	189.91	191.65	181.35	195.04	186.01	162.62	175.93
E	**Phosphorous (kg ha^{-1})**	16.78	18.57	18.35	17.12	16.20	19.03	20.98	21.53	19.74	21.67	20.36	16.99	18.94
F	**Potassium (kg ha^{-1})**	157.95	167.77	165.89	160.68	154.63	166.73	182.27	182.84	178.46	183.15	181.07	158.05	169.96
Sub Surface Soil (15-30 cm)Depth														
S. No.	**Soil Parameters**	**Blocks**												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**
A	**pH**	7.52	7.68	7.90	7.98	7.70	7.82	7.73	7.72	7.78	7.92	7.64	7.78	7.76
B	**E.C (dSm^{-1})**	0.29	0.50	0.21	0.24	0.39	0.33	0.29	0.39	0.41	0.37	0.36	0.36	0.34
C	**Organic Carbon (%)**	0.17	0.19	0.19	0.17	0.16	0.19	0.22	0.22	0.21	0.23	0.22	0.17	0.20
D	**Nitrogen (kg ha^{-1})**	118.80	129.12	129.46	125.87	122.66	134.77	144.95	146.53	137.33	152.64	141.42	122.56	133.84
E	**Phosphorous (kg ha^{-1})**	11.94	13.35	13.46	12.63	12.11	14.09	15.90	15.88	14.49	16.85	14.93	12.46	14.01
F	**Potassium (kg ha^{-1})**	113.55	122.17	123.10	116.82	112.44	125.12	137.20	136.66	129.97	142.48	133.52	114.34	125.61

Blocks Detail: 1(Daurala) 2(Shardhana) 3(Sururpur) 4(Rohta) 5(Kharkhoda) 6(Hashtinapur) 7(Jani) 8(Rajpura) 9(Meerut) 10(Parikshitgarh) 11(Machara) 12(Mavana) horizons might be due to the confinement of crop cultivation to this layer and supplement of the depleted phosphorus through external sources i.e. fertilizers [11]. Similar results were reported by Thangaswamy et al. [12].

Available potassium in surface (0-15 cm) and subsurface soil (15-30 cm) varied from 154.63 - 183.15 and 113.55 - 142.48 kg ha^{-1} with an average value of 169.96 and 125.61 kg ha^{-1} respectively. Due to unawareness about potassium application and more removal from soils by crops available K is lower. In grasslands, wastes land and forest soils, probably loss K removal by plants, maintained a comparatively higher K in soils [18]. According to Muhr et al. [13], no sample was found in the low range (<125 K_2O kg ha^{-1}) however overall soil samples were medium range (125–300 kg $ha^{-1}K_2O$ the surface (0-15 cm) and Subsurface (15-30 cm). A significant positive correlation was observed between organic carbon and available potassium content. This might be due to the creation of a favorable soil environment with the presence of high organic matter. Similar results were also reported by Paliwal et al. [17]; Chouhan et al. [19].

3.1 Relationship of pH and OC with Soil Properties

Relationships of Organic carbon with some soil properties like Available N, P and K were established by the determination of correlation coefficient values (Table 1).

Organic carbon (OC) significantly and positively correlated with available nitrogen (N), phosphorous (P) and potassium (K) within two depths (0-15 cm and 15-30 cm) of soil samples (r = 0.965, 0.945, 0.945 and subsurface, r = 0.961, 0.966 and 0.987 respectively). Similar results available micronutrient status and their relationship with soil properties of Jhunjhunu Tehsil, Rajasthan were observed by Kumar et al. [20].

4. CONCLUSION

Under the sugarcane- ratoon -wheat cropping system the properties of soil indicates that the soils of the study area were neutral to slightly alkaline in reaction and non-saline in nature. Nutrient status in surface and subsurface depth of soil indicates that soils are low in available N and medium in available P and available K in surface and subsurface soil layer of the profiles. Availability of nutrients decreases with increase depth. Relationships of Organic carbon with Available N, P, and K were possibly highly correlated. Similar results were observed by Kumar et al., [20].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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