

Soil Fertility Status of Majhwa Block of Mirzapur District of Eastern UP, India

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ABSTRACT

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Soil samples were collected from different villages of Majhwa Block of Mirzapur district. The results showed that the available N, P, K and S content in surface (0-20 cm) soils was higher as compared to sub surface (20-40 cm). The mean content of available N, P, K and S in surface soils (0-20 cm) were 306, 18.4, 229 and 9.8 kg ha⁻¹, whereas, in subsurface soil (20-40 cm) it was 241, 20.4, 189 and 8.57 kg ha⁻¹, respectively. The mean DTPA extractable Fe, Cu, Mn, Zn and hot water soluble B content followed the similar pattern of distribution in the surface and subsurface soils. The maximum Fe, Cu, Mn, Zn and B content in top soils was 15.2, 6.2, 3.11, 2.63 and 1.47 mg kg⁻¹, respectively. The mean values of water soluble cations Ca, Mg, Na and K in surface soils (0-20 cm) were 19.3, 9.59, 9.07 and 11.7 m eq L⁻¹, respectively. The available B and Zn content in surface soils and available N and organic carbon content in subsurface soils were positively and significantly correlated.

Introduction

Soil is a critical component for the proper functioning of agricultural system. The fertility of a soil plays an important role in sustainable crop production. Due to continuous rice-wheat cultivation in Indo-Gangetic region, fertility of soil is deteriorating, raising a serious concern about the sustainability of Indian agriculture. The introduction of high yielding varieties, extensive tillage and imbalanced use of chemical fertilizers and pesticides caused disturbance in soil ecosystem. In post green revolution era there has been a continuous increase in use of chemical fertilizers,

irrigation along with modern high yielding varieties (Pathak, 2010). However, recent reports suggest a declining trend in production of rice and wheat in South Asia (Ladha *et al.*, 2003) which is mainly attributed to deficiency of micronutrients in soil.

It has been reported that deficiencies of available major and micronutrients are widespread in soils of Mirzapur districts of eastern Uttar Pradesh (Singh and Kumar, 2012). Deficiency of sulphur and boron to a tune of 63 and 61 % have been reported

(Singh *et al.*, 2015) in soils of Mirzapur district.

The increasing demand of food grain has forced farmers to use high doses of chemical fertilizers. Imbalanced use of chemical fertilizers is a serious threat to sustainable agricultural production system. Soil test-based fertilizer recommendation and management is an effective tool for increasing productivity of agricultural soils (Srinivasarao *et al.*, 2010; Sahrawat *et al.*, 2010). However, major constraints impede wide scale adoption of soil testing in most developing countries. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields (Doneriya *et al.*, 2013). The objective of this study was to prepare a comprehensive database about the fertility status of the soils of Majhwa block of Mirzapur. So as to arrest the declining trend in productivity by supplying balanced nutrition in crop production. The soils of the study regions are more prone to submergence due to frequent flood occurring in Ganga River. Thus the study of surface (0-20 cm) as well as subsurface (20-40 cm) soils becomes important for this particular area.

Materials and Methods

Site description and collection of sample

The Majhwa block is located in Vindhyan region of district Mirzapur, Uttar Pradesh. The soils of the block are red in colour which are formed on granitic parent material representing Alfisols. The detailed description of the study locations has been given in table 1.

A total of six villages were selected for this study. The detailed site description along with cropping pattern is presented in table 1. Forty soil samples from surface (0-20 cm) and subsurface (20-40 cm) were collected from every village representing total 480 samples.

The soil bulk density was estimated using the soil core sampler method (Blake, 1965). The samples were air dried, processed and passed through a 2 mm sieve. In general, the texture of the soils was either sandy loam or sandy clay loam. The soil pH and electrical conductivity (EC) were recorded in 1:2.5 soil to water suspension (Jackson, 1973). Different soil chemical properties determined were: soil organic carbon (OC) content by chromic acid wet oxidation method (Walkley and Black, 1934), available nitrogen (N) by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus (P) spectrophotometrically (Olsen *et al.*, 1954), available potassium (K) by flame photometrically (Hanway and Heidel, 1952), 0.15% CaCl₂ extractable sulphur (S) by turbidimetrically (Chesin and Yein, 1951), soil available micronutrients iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) by DTPA-extraction method (Lindsay and Norwell, 1978). Hot water soluble B in soil was extracted using 0.02M CaCl₂ (Aitken *et al.*, 1987). Water soluble ions were determined in 1:2.5 soil to water suspension, whereas, exchangeable ions in neutral normal ammonium acetate extract (Richards, 1954). The data on soil properties were correlated with nutrient status of the soil using SPSS.

Results and Discussion

Physico-chemical properties

In comparison to subsurface soil, the bulk density and particle density of surface soils (0-20 cm) was lower and it ranged from 1.21-1.39 and 2.40-2.48 Mg m³, respectively, whereas in subsurface soils (20-40 cm) it varied between 1.36-1.42 and 2.43-2.51 Mg m³, respectively (Table 2). The mean bulk density in surface and subsurface soil was 1.31 and 1.39 Mg m⁻³, respectively, whereas, particle density was 2.44 and 2.48 Mg m⁻³, respectively. The highest bulk density and particle density was recorded at Kachhwa and

Shivrani, respectively. The water holding capacity varied from 42 to 47% in surface soil and 39 to 45% in subsurface soil. The maximum water holding capacity in surface and subsurface soil was recorded in Kevtari (47%) and Shivrani (45%) village, respectively, whereas, the mean WHC was 45.2 and 41.3%, respectively.

The pH of surface and subsurface soils ranged between 7.5 to 8.2 and 7.8 to 8.4 with a mean of 7.78 and 8.08, respectively (Table 2). The maximum pH was 8.2 and 8.4 in surface and subsurface soil, respectively in Kevtari village. The EC ranged between 0.49 to 1.21 and 0.36 to 1.12 dS m⁻¹ with a mean of 0.84 and 0.73 dS m⁻¹ in surface and subsurface soil, respectively. The organic carbon content in soil ranged between 0.61 to 0.79 and 0.49 to 0.72% with a mean of 0.69 and 0.58%, respectively in surface and subsurface soil. The maximum organic carbon content was found in Shivrani in both surface and subsurface soil. The higher pH in soil might be due to presence of various salts which is also clearly visible from the EC values.

The soils had organic carbon content in medium range, this might be due to addition of organic manure by the farmers. Tiwari *et al.*, (2003) reported that C/ N ratio of the Vindhyan soils was higher in the low-laying areas than that of upland with terrace containing sand stone and lime stone shale. Also, high temperature during summer might be responsible for the rapid decomposition of organic matter, thus resulting in low organic C content of these soils.

Available major nutrients

The available N, P, K and S content in the surface soil (0-20 cm) ranged between 287-349, 17.3-19.3, 216-257 and 8.93-10.3 with a mean of 306, 18.4, 229 and 9.80 kg ha⁻¹, respectively (Table 3). The maximum value

of available N, P and K in surface soils was recorded in Bajaha, whereas, the maximum available sulphur was found in Kachhawa. The data shows that the available N, P and K content in surface soil was in medium category while, the soils had low available S. The available N, K and S content in surface soils was higher than the subsurface soil, while the content of available P in subsurface soil was higher than surface soil. The available N, P, K and S content in subsurface soils ranged between 216-278, 19.6 to 21.2, 169 to 211 and 7.21 to 9.61 kg ha⁻¹ with a mean of 241, 20.4, 189 and 8.57 kg ha⁻¹, respectively. The available K content in surface soil (0-20 cm) showed a positive and significant correlation ($r = 0.91^*$) with available P content. In subsurface soil (20-40 cm) available N content was positively significantly correlated with organic carbon. The soils of these regions are formed due to deposition of recent alluvium, therefore, they are rich in available N, P and K. The soils had organic carbon content in medium range, since organic matter content is an indicator of available N status of soils, thus the soils of the investigating area are also dominantly medium in respect of their available N (Verma *et al.*, 2005). The medium range of soils available P under study area may be mostly due to past fertilization, pH, organic matter content, texture and various soil management and agronomic practices (Elzinga and Sparks, 2007). Adequate level of available K in Alfisol of the study area may be ascribed to the prevalence of K-rich clay minerals like illite and kaolinite (Seal *et al.*, 2006)

Available micronutrients

The DTPA extractable Fe, Mn, Zn and Cu content in surface soils ranged from 10.6 to 15.2, 4.6 to 16.2, 2.53 to 3.11 and 1.82 to 2.63 mg kg⁻¹ with a mean of 13.6, 5.13, 2.78 and 2.11 mg kg⁻¹, respectively (Table 4).

Table.1 Detailed description of the study locations

Location No.	Village Name	Previous crop	Kharif crop	Rabi crops
1	Kachhawa	Mung	Rice, Maize, Sesamum, Mung, Urd	Wheat, Barley, Brinjal, Chilli, Onion, Cauliflower
2	Bajaha	Urd	mung, Urd, Surajmukhi	Wheat, Brinjal, Vegetable Pea, Mustard
3	Baraini	Pumpkin	Rice, Lady's finger, Pumpkin	Wheat, Potato, tomato, Lentil
4	Mitai	Bottlegourd	Rice, Bottle gourd, Sponge gourd	Wheat, Garlic, Chilli, Cauliflower
5	Shivrani	Ladys finger	Rice, Pumpkin, Lady's finger	Wheat, Brinjal, Onion, Mustard
6	Kevtari	Bitter gourd	Rice, Lobia, Pumpkin, bitter gourd	Wheat, Gram, Vegetable Pea

Table.2 Physico-chemical properties of soils of Mirzapur district

Village	BD (Mg m ³)		PD (Mg m ³)		WHC (%)		pH		EC (dS m ⁻¹)		OC (%)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Kachhawa	1.22	1.42	2.40	2.43	42	39	7.6	7.9	0.49	0.36	0.65	0.51
Bajaha	1.21	1.36	2.44	2.48	46	43	7.5	7.8	0.88	0.76	0.72	0.63
Baraini	1.36	1.39	2.41	2.46	44	41	7.9	8.3	0.95	0.82	0.68	0.49
Mitai	1.32	1.37	2.44	2.49	46	42	7.6	7.9	0.52	0.49	0.66	0.59
Shivrani	1.39	1.41	2.48	2.51	46	45	7.9	8.2	0.99	0.83	0.79	0.72
Kevtari	1.36	1.38	2.44	2.49	47	40	8.2	8.4	1.21	1.12	0.61	0.52
Range	(1.21-1.39)	(1.36-1.42)	(2.40-2.48)	(2.43-2.51)	(42-47)	(39-43)	(7.5 - 8.2)	(7.8-8.4)	(0.49-1.21)	(0.36-1.12)	(0.61-0.79)	(0.49-0.72)
Mean	1.31	1.39	2.44	2.48	45.2	41.3	7.78	8.08	0.84	0.73	0.69	0.58
SD	0.08	0.02	0.03	0.03	1.83	1.63	0.26	0.25	0.28	0.27	0.06	0.09
Variance	0.01	0.00	0.00	0.00	3.37	2.67	0.07	0.06	0.08	0.07	0.00	0.01

Table.3 Available N, P, K and S in soils of Mirzapur district

Village	Available N (kg ha ⁻¹)		Available P (kg ha ⁻¹)		Available K (kg ha ⁻¹)		Available S (kg ha ⁻¹)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Kachhawa	287	225	18.2	20.1	220	186	10.3	9.12
Bajaha	349	278	19.3	21.2	257	201	8.93	7.21
Baraini	300	216	18.6	20.3	221	174	9.98	8.34
Mitai	291	260	18.3	20.6	236	211	9.69	8.76
Shivrani	313	237	18.8	20.6	223	192	10.2	9.61
Kevtari	296	229	17.3	19.6	216	169	9.67	8.37
Range	(287-349)	(216-278)	(17.3-19.3)	(19.6-21.2)	(216-257)	(169-211)	(8.93-10.3)	(7.21-9.61)
Mean	306	241	18.4	20.4	229	189	9.80	8.57
SD	22.9	23.5	0.67	0.54	15.4	15.9	0.50	0.82
Variance	524	554	0.454	0.292	237	254	0.246	0.673

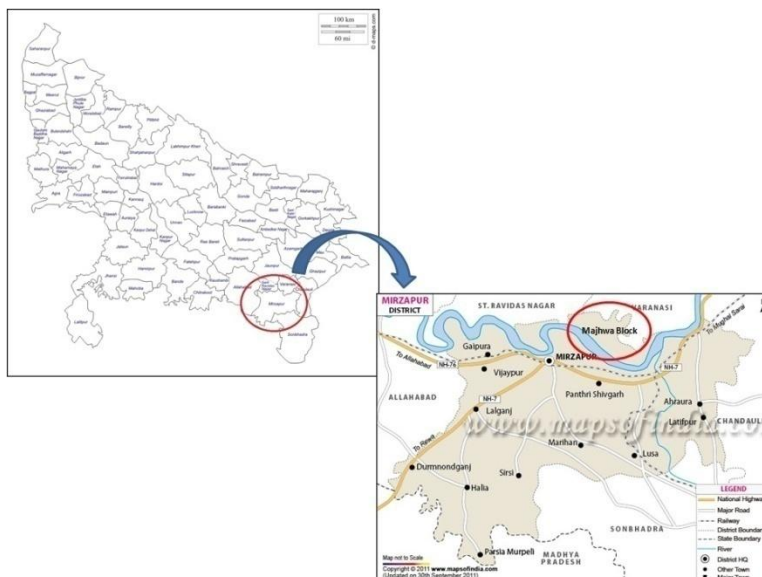
Table.4 DTPA extractable Fe, Mn, Zn, Cu and B in soils of Mirzapur district

Village	Available Fe (mg kg ⁻¹)		Available Mn (mg kg ⁻¹)		Available Zn (mg kg ⁻¹)		Available Cu (mg kg ⁻¹)		Available B (mg kg ⁻¹)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Kachhawa	15.1	12.3	6.2	3.3	2.61	1.26	1.93	1.21	1.26	0.96
Bajaha	14.3	11.2	5.2	2.6	2.81	1.23	1.82	1.16	1.39	1.11
Baraini	14.6	12.3	4.6	3.9	3.11	1.62	2.12	1.44	1.46	1.02
Mitai	15.2	13.1	5.3	5.1	2.53	1.24	2.63	1.32	1.23	0.97
Shivrani	11.6	10.9	4.6	3.9	2.91	1.46	2.36	1.42	1.47	1.03
Kevtari	10.6	9.3	4.9	2.9	2.72	1.43	1.82	0.98	1.29	1.04
Range	(10.6-15.2)	(9.3-13.1)	(4.6-6.2)	(2.6-5.1)	(2.53-3.11)	(1.23-1.62)	(1.82-2.63)	(0.98-1.44)	(1.23-1.47)	(0.96-1.11)
Mean	13.6	11.5	5.13	3.62	2.78	1.37	2.11	1.26	1.35	1.02
SD	1.96	1.35	0.60	0.90	0.21	0.16	0.33	0.17	0.10	0.05
Variance	3.86	1.83	0.36	0.80	0.04	0.02	0.11	0.03	0.01	0.00

Table.5 Water soluble cations (m eq L⁻¹) of the Mirzapur district

Village	Ca		Mg		Na		K		Total cation	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
Kachhawa	18.1	15.7	10.2	9.36	9.24	8.36	12	12	49.5	45.4
Bajaha	19.2	18.6	9.38	8.96	8.96	8.24	11.6	11.6	49.2	47.4
Baraini	20.1	19.3	9.69	8.76	9.12	8.32	10.3	10.3	49.2	46.7
Mitai	19.6	18.3	10.4	9.62	8.99	8.12	11.9	11.9	50.0	48.0
Shivrani	18.9	16.7	9.21	9.63	9.16	8.38	12.2	12.1	49.3	48.2
Kevtari	20.0	18.4	8.73	7.96	8.96	8.39	11.9	10.6	49.6	44.3
Range	(18.0-20.1)	(15.7-19.3)	(8.73-10.4)	(7.96-9.63)	(8.96-9.24)	(8.12-8.39)	(10.3-12.2)	(10.3-12.1)	(49.2-50.0)	(44.3-48.2)
Mean	19.3	18.1	9.59	9.05	9.07	8.30	11.7	11.4	49.5	46.7
SD	0.75	1.24	0.61	0.64	0.12	0.10	0.69	0.77	0.30	1.53
Variance	0.56	1.53	0.37	0.41	0.01	0.01	0.48	0.60	0.09	2.36

Fig.1 Location of Majhwa block of Mirzapur district in Uttar Pradesh



The maximum Fe (15.2 mg kg^{-1}) and Zn (3.11 mg kg^{-1}) content in surface soil was found in Mitai, while the highest content of Mn (16.2 mg kg^{-1}) and Cu (2.63 mg kg^{-1}) was recorded in Kachhawa and Baraini, respectively. In subsurface soil (20-40 cm) the DTPA extractable Fe, Mn, Cu and Zn content ranged between 9.30 to 13.1, 2.6 to 5.1, 1.23 to 1.62 and 0.98 to 1.44 mg kg^{-1} , respectively. The study demonstrated that DTPA extractable Fe, Mn, Zn and Cu content in subsurface soils was sufficient having a mean of 11.5, 3.62, 1.37 and 1.26 mg kg^{-1} , respectively. The available B content in surface and subsurface soil ranged between 1.23 to 1.47 and 0.96 to 1.11 mg kg^{-1} , with a mean of 1.35 and 1.02 mg kg^{-1} , respectively. The maximum available B content in surface (1.47 mg kg^{-1}) and sub-surface soils (1.11 mg kg^{-1}) was found in Shivrani and Bajaha village. The surface soil had higher content of available Fe, Mn, Cu, Zn and B compared to subsurface soil. The DTPA extractable Zn content in surface soil (0-20 cm) had positive and highly significant correlation ($r = 0.93^{**}$) with available B. Critical limits recommended by Lindsay and Norvell (1978) for DTPA extractable, Fe, Mn, Zn and Cu are 4.5, 2.0,

0.6 and 0.2 mg kg^{-1} , respectively. The sufficient amount of micronutrients in soils of vegetables and pulse growing areas of Mirzapur were also reported by Singh and Kumar (2012). Singh and Singh (2016) studied the nutrient status of red soils of Vindhyan region, they also found that the DTPA extractable Fe, Mn, Cu and Zn content was above critical limits for its deficiency as per given by Lindsay and Norvell (1978).

Water soluble cations

The water soluble Ca, Mg, Na and K content in surface soils ranged from 18.0 to 20.1, 8.73 to 10.4, 8.96 to 9.24 and 10.3 to 12.2 with a mean of 19.3, 9.59, 9.07 and 11.7 m eq L^{-1} , respectively (Table 5). The maximum water soluble Ca, Mg, Na and K content in surface soil was recorded in Baraini, Mitai, Kachhawa and Shivrani, respectively. In subsurface soil (20-40 cm) the water soluble Ca, Mg, Na and K content ranged between 15.7 to 19.3, 7.96 to 9.63, 8.12 to 8.39 and 10.3 to 12.1 m eq L^{-1} , respectively. The data showed that water soluble cation content in both surface and subsurface soil varied in following order $\text{Ca} > \text{K} > \text{Mg} > \text{Na}$. The mean

water soluble Ca, Mg, Na and K content of subsurface soil was 18.1, 9.05, 8.30 and 11.4 m eq L⁻¹, respectively. The total cationic content in surface and subsurface soil ranged between 49.2 to 50.0 and 44.3 to 48.2 m eq L⁻¹, with a mean of 49.5 and 46.7 m eq L⁻¹, respectively. The maximum total cationic concentration in surface (50.0 m eq L⁻¹) and sub-surface soils (48.2 m eq L⁻¹) was found in Mitai and Shivrani village. The soils of the study regions are affected due to frequent flood occurring in the Ganga River. The water soluble cations in study sites are higher because of accumulated clay of Ganga River which is rich in water soluble cations. The samples were collected in the month of May, when rate of evaporation is higher and salts accumulate on the soil surface with evaporating water. Thus the study sites showed higher content of water soluble cations.

The soils of Mjhawa Block of Mirzapur district had a pH of 7.5 to 8.2 in surface soils and 7.8 to 8.4 in subsurface soils. It contained medium to high organic carbon in surface soils, medium status of available N, P and K and low status of available S. The highest available N, P and K content was in Bajaha village, while highest S was found in Kachhawa. The DTPA extractable Fe, Mn, Zn, Cu and B content in surface as well as subsurface soils was under sufficient category. The highest DTPA extractable Fe, Mn, Zn, Cu and B content in surface soils was found in Mitai, Kachhawa, Baraini, Mitai and Shivrani village, respectively. The soils were low in available S hence the application of organic matter and gypsum may be recommended for application in fields.

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