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Vertical Distribution of Soil Nutrients in Pulse-Growing Black Soils of Sohaon Block in Ballia District, Uttar Pradesh

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In general, the distribution of soil nutrients is governed by soil-forming factors and processes, crops grown and external supply. The continuous mining of the nutrients under intensive cropping system is of serious concern. The large tract of Eastern Uttar Pradesh is witnessing the deficiency of most of the nutrients and Ballia district is not an exception (Singh *et al.* 2017; Gupta *et al.* 2019). Singh *et al.* (2020) have characterised some of the rice-growing soils of Eastern Uttar Pradesh and reported depth-wise distribution of some fertility parameters. Research studies on the horizon-wise distribution of nutrients in the shrink-swell soils of other parts of the country have been reported (Prasad and Gajbhiye 1999; Karthikeyan *et al.* 2014). However, this type of study is lacking for Eastern Uttar Pradesh, particularly for pulse-growing black soils of Ballia district..

Ballia district (25°23" to 26°11" N; 83°38" to 84°39" E) is situated in the central part of the Ganges basin at an elevation 59 m above MSL. The mean annual rainfall ranges from 950 to 1150 mm. Two soil profiles one in Daulatpur village (P_1) and one in Narahi village (P_2) of Sohaon block, were studied. Soil samples (19 nos.) were collected from different layers and processed for the analysis. Pigeon pea is dominant *kharif* crop whereas lentil and chickpea are grown in *rabi* on residual moisture or under protective irrigation. If pigeon pea is grown in *kharif,* then farmers opt for a non-pulse crop in *rabi.*

The soil samples were analyses for pH (1:2.5 soil water suspension) using a glass electrode. Electrical conductivity (EC) was determined in 1:2.5 soil-water extract using Conductivity Bridge (Jackson 1973). Calcium carbonate ($CaCO_3$) was determined by rapid titration method (Puri 1930). Organic carbon (OC) was determined by rapid titration method (Walkley and Black 1934).The available nitrogen (N), was determined by alkaline Potassium permanganate method (Subbaih and Asija 1956), available phosphorus (P) and available potassium (K) were analysed by Olsen method (Olsen *et al*. 1954) and N neutral ammonium acetate extract method (Muhr *et al.* 1965), respectively. Available sulphur (S) was analysed by the procedure outlined by Williams and Steinberg (1959). Micronutrient cations were determined by the method proposed by Lindsay and Norvell (1978).

pH, EC, Organic Carbon and $CaCO_3$

The soils of Daulatpur profile (P_1) had an irregular distribution of pH with depth (Table 1) due to different cycles of fluvial deposition. However, the soils of P_2 had an increasing trend of pH with depth (Table 2). EC of soil samples ranged from 1.005 to 1.007 dS m^{-1}. Gupta *et al.* (2019) also reported a similar distribution of EC in some soils of Bairia block of Ballia. Soil organic carbon at different depth of two profile ranged from 0.17 to 0.52 (Table 1 and 2) and decreased with depth. The surface soil of P_1 had higher organic carbon than the

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Table 1. pH, EC, O.C., $CaCO_3$, available nutrients at different depths of Daulatpur soil profile (P_1)

Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	O.C. (%)	$CaCO_3$ (%)	N ($kgha^{-1}$)	P ($kgha^{-1}$)	K ($kgha^{-1}$)	S	Fe	Cu	Zn	Mn
								($mgkg^{-1}$)				
0-15	8.3	1.007	0.52	1.221	205.0	16.72	425	8.75	3.80	2.89	0.9	12.10
15-30	8.4	1.008	0.67	1.25	189.0	16.04	336	7.15	2.25	1.44	0.3	9.66
30-45	7.7	1.006	0.30	0.521	173.8	14.18	336	7.06	2.18	0.77	0.23	6.96
45-60	7.7	1.006	0.30	0.321	158.0	9.04	302	6.87	1.76	1.55	0.23	6.76
60-75	7.8	1.007	0.39	0.40	126.0	6.72	358	5.67	1.55	0.92	0.23	5.45
75-90	8.2	1.005	0.43	0.25	126.0	6.04	358	5.32	1.48	1.34	0.2	5.20
90-120	7.8	1.006	0.40	0.30	118.0	6.72	358	4.88	1.06	1.13	0.18	4.15
120-135	8.3	1.006	0.36	0.25	110.0	6.72	336	4.03	1.06	1.27	0.18	3.98
135-142	7.9	1.006	0.19	0.25	106.0	6.72	347	3.75	2.18	1.69	0.18	2.17
142-157	8.3	1.006	0.17	1.40	94.0	4.61	235	2.50	1.06	3.24	0.15	1.71

Table 2. pH, EC, WHC, O.C., $CaCO_3$, N, P, K and S of soil at different depths of N**arahi** soil profile (P_2)

Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	B.D. (Mgm^{-3})	W.H. (%)	O.C. (%)	$CaCO_3$ (%)	N ($kgha^{-1}$)	P ($kgha^{-1}$)	K ($kgha^{-1}$)	S	Fe	Cu	Zn	Mn
										(mg kg^{-1})				
0-15	7.1	1.005	1.58	37.30	0.37	1.65	158.8	16.72	403	10.6	2.89	7.19	0.32	4.96
15-30	7.1	1.006	1.11	41.34	0.22	1.52	142.2	16.04	313	8.73	1.69	6.88	0.28	4.74
30-45	7.1	1.005	1.10	36.01	0.3	1.30	126.2	13.04	313	8.73	1.55	6.23	0.18	4.04
45-60	7.5	1.006	1.08	40.28	0.13	0.25	120.0	13.18	336	7.54	1.34	4.64	0.16	2.99
60-75	7.6	1.005	1.13	43.05	0.24	0.40	114.0	10.18	347	6.87	1.27	3.91	0.15	2.79
75-90	7.8	1.006	1.20	39.17	0.37	0.50	109.0	10.0	347	5.25	1.13	3.91	0.14	2.70
95-105	8.0	1.006	1.15	35.08	0.40	0.62	100.0	6.72	380	4.26	0.92	3.33	0.10	2.06
105-135	8.4	1.005	1.10	34.80	0.22	0.60	94.8	7.61	403	3.17	0.77	1.96	0.10	2.06
135-150	8.5	1.007	1.08	37.90	0.22	0.42	56.8	6.72	380	1.62	0.21	1.67	0.09	1.71

corresponding layer of P_2. The calcium carbonate in soil matrix of P_1 ranged from 0.25 to 1.40% and decreased with depth barring last layer (1.40%). The surface layer of P_2 had 2.65% $CaCO_3$ in the surface layer but decreased with depth.

Available N, P, K and S

Available nitrogen content in soil of two profiles ranged from 56.8 to 205 kg ha^{-1} with the highest values in the surface layers, and it decreased with depth. In general, soil-N seems to depend on organic carbon and inversely proportional to pH throughout the depth. Available phosphorus (Tables 1 and 2) ranged from 6.04 (75-70 cm of P_1) to 16.72 kg ha^{-1} (surface layer of P_1 and P_2). In general, the layers of P_2 had higher available P than the corresponding layers of P_1 (Table 2). The available P was closely related to pH of the soil. The available K content in the two soil profiles varies from 235 to 425 kg ha^{-1} and in general, it decreased with the depth. Similar finding was also reported by Singh *et al.* (2019). The available sulphur varied from 2.50 to 8.75 mg kg^{-1} in the soils of of P_1 wheres in the soils of P_2 it varied from 1.62 mg kg^{-1} to 10.63 mg kg^{-1} (Tables 1 and 2). The higher amount of available sulphur was found to be in the surface soil than in sub-surface soil owing recycling over the years by plant and organic matter accumulation (Bhatnagar *et al.* 2003). Gupta *et al.* (2019) opined that soil organic matter regulates the sulphate-S content in the alluvial soil.

Micronutrients

The available DTPA-Fe in the soils ranged from 0.28 to 3.80 mg kg^{-1} with the highest value found to be in the surface layer of P_1 (Daulatpur profile) that retained more than 1mg kg^{-1} DTPA-Fe throughout the depth, but the soils of P_2 could not maintain it beyond the soil depth of 90 cm. The available DTPA-Cu were found above the critical limit and it ranged from 0.77 to 7.19 mg kg^{-1} in different layers of soil profiles (Table 1 and 2).

The available Zn ranged from 0.09 to 0.9 mg kg^{-1}. Except the surface layer of P_1, all the layers had Zn content below the critical limit (0.6 mg kg^{-1}). Similar finding have also been reported by Gupta *et al.* (2019) for soils of Bairia block in Ballia district, Uttar Pradesh. The DTPA-Mn decreased with depth in both the soil profiles. The highest DTPA-Mn of 12.10 mg kg^{-1} was observed in surface layer whereas the lowest value of 1.71 mg kg^{-1} was found in the last layer of P_1. Similarly, DTPA-Mn was maximun (4.96 mg kg^{-1}) in surface layer of P_2 while it was minimum(1.71 mg kg^{-1}) in the lower most layers. The content of DTPA-Mn of both the soil profiles was above the critical limit proposed by Lindsay and Norvell (1978).

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