EFFECT OF FERTILIZER GRADIENTS AND SOIL DEPTH ON PHYSICO-CHEMICAL PROPERTIES OF SOILS IN WHEAT

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ABSTRACT

The field experiment was conducted on wheat at the Central Research Farm (CRF), Gayeshpur encompassing the new alluvial zone of West Bengal, to evaluate "effect of fertilizer gradients and soil depth on physico-chemical properties of soil in wheat". The experiment was laid out in factorial RBD with three treatments [T_1: 100:50:50, T_2: 120:60:60, T_3: 150:75:75 :: N:P:K kg/ha], eight sampling dates and three depth of sampling with three replications. Soil pH has been observed to increase significantly with increasing soil moisture and can govern 32.2 - 42.4 per cent of total variations. Increasing application of N, P and K were found to reduce soil pH significantly across different dates and depth of sampling. The Soil OC recoveries were observed to increase significantly and progressively with advancement of crop period and the changes in moisture can govern 86.7 per cent of total variations in soil OC. The recoveries of available macronutrients in the soil were within the range of 111.40-178.53 for N, 38.91-86.74 for P and 120.74-178.40 for K. The changes in available macronutrients in the soil with respect to changes in soil moisture were same as in soil pH and organic carbon (OC). The changes in recoveries of available macronutrients (63 % for soil N, 83 % for soil P and 77% for soil K variations) under different simulated situations were largely dictated by variations in soil moisture (SM).

KEY WORDS: Fertilizer, Physico-chemical properties, Wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the main staple food of nearly 35 per cent of the world population (Singh, 1999). It accounts for 30 per cent of all cereal food worldwide and provides about 20 per cent of the total dietary calories and proteins worldwide. Wheat is the second most important cereal crop next to rice in India. It is grown in an area of 29.9 million hectares (M ha) with production of 93.9 million tonnes (M t) and productivity of 3140 kg/ha (2011-2012).

Water content is an important property of soils, influencing soil solution chemistry and nutrient uptake by plants. Under field conditions, soil moisture fluctuations could regulate the availability of nutrients and the field distribution of plant species. Phosphorus uptake by plants is greatly influenced by soil moisture, being largely controlled by diffusion rates and P depletion in the rhizosphere (Gahoonia *et al*., 1994). Increase in concentration of K, Mg, P and Mn in soil solution, with increased soil moisture indicated that high soil moisture changes the availability of these nutrients (Misra and Tyler, 1999).

By changing soil solution chemistry, moisture could regulate plant competition not only for available water but also for nutrients. Increases in soil moisture content led to change in the ion distribution, free hydrated metal concentrations and complexation (Fotovat *et al.,* 1997). Soil chemical properties may exert a profound influence on growth and performance of plants (Grime and Curtis, 1976). By influencing root hair growth of plant, nutrient uptake efficiency may also be affected (Mackay and Barber, 1985). Increase of pH in soil solutions may play an important role in availability of those nutrients, which are pH dependent.

MATERIALS AND METHODS

The field investigation was conducted on wheat during the *rabi* 2013 at the Central Research Farm (CRF), Gayeshpur, Nadia, Bidhan Chandra Krishi Viswavidyalaya, encompassing the New Alluvial Zone of West Bengal. The available N, P and K were 122.3, 14.8 and 131.5 kg/ha, respectively. Wheat (*Triticum aestivum* L) var. PBW 363 was used for the field experimentation. The experiment was laid out in factorial RBD with three treatments [T_1: 100:50:50, T_2: 120:60:60 and T_3: 150:75:75 :: N:P:K kg/ha], eight sampling dates (22, 42, 60, 68, 76, 83, 92 DAS and at harvest) and three depth of sampling (0-15, 15-30, 30-45 cm) with three replications. Source of N, P, K, were Urea, SSP, MOP, respectively. Soil samples were collected in pre determined intervals and analyzed for soil pH, oxidisable organic carbon and available primary nutrients. Soil pH was determined from soil-water suspension in 1:2.5 ratios with the help of pH meter as described by Jackson (1973). Organic carbon of soil was estimated by wet digestion method of Walkley and Black (1934) as outlined by Jackson (1973). Available nitrogen content of soil was determined by using hot alkaline potassium permanganate method as proposed by Subbiah and Asija (1956). Available phosphorus was determined as per Olsen's method (Olsen *et al.,* 1954), Available potassium of soil was extracted with neutral 1 N ammonium acetate estimated using flame photometer as outlined by Jackson (1973). Soil moisture percentage was computed gravimetrically at a depth of 15, 30 and 45 cm in the field. Moisture percentage of the samples was determined using the formula suggested by Gardner (1965).

RESULT AND DISCUSSION

The changes in soil pH, organic carbon, N, P and K across the advancing growth of wheat and increasing depth of sampling and varying fertilizer applications are recorded in Table 1 to 3.

Soil pH

The soil pH was observed to change significantly with dates of sampling, depth of sampling and fertilizer applications while the interactions among these factors also brought significant changes in soil pH. The soil pH has been found to reduce significantly with increase in dosage of fertilizer applications and to increase significantly with increase in depth of sampling. The changes in soil pH with advancement of days after wheat sowing were significant and did not follow any definite trend.

The relationship between changing soil moisture and soil pH has been elucidated in Figure1 and 2. Soil pH has been observed to increase significantly with increasing soil moisture, possibly due to dilution of soil solution with increasing moisture and in the present investigation, the changes in moisture can govern 32.2 - 42.4 per cent of total variations observed in soil pH. Findings of Misra and Tyler (1999) were quite in good agreement with our observations that pH in the soil solution increased with soil moisture from 30±90% WHC.

Increasing administration of urea, SSP and MOP were found to reduce soil pH significantly which remained true across different dates of sampling and increasing depth of sampling as well. The application of chemical fertilizer tends to acidify agricultural soils. The application of nitrogen fertilizer causes the acidification of arable land by means of nitrification was reported earlier (Black, 1992; Juo *et al*., 1996).

Oxydizable organic carbon (OC)

The soil OC was observed to change significantly with dates of sampling, depth of sampling and fertilizer applications, while the interactions among these factors also brought significant changes in soil OC. The recoveries (g/kg) of soil OC were found the highest (6.25) at 30 cm soil depth on Day 1 (68 DAS) under T_2 (N:P:K :: 120:60:60) and the lowest (2.20) at 15 cm soil depth on day 6 (83 DAS) date from T_1 (N:P:K::120:60:60).

The relationship between changing soil moisture and soil OC has been elucidated in Figure 3. Soil OC has been observed to increase significantly with increasing soil moisture and in the present investigation, the changes in moisture can govern 86.7 per cent of total variations observed in soil OC. In general, under comparable conditions, the nitrogen and organic matter content increase as the effective moisture becomes greater (Rusco *et al*., 2001). Wang *et al*. (2002) found a positive correlation between soil organic carbon (SOC) and soil moisture (SM) where spatially structured variance accounted for a large proportion of the variance in SOC due to variations in SM (44%).

The soil OC has been found to increase significantly with increase in dosage of fertilizer applications and to reduce significantly with increase in depth of sampling (Figure 4). The Soil OC recoveries were observed to increase significantly and progressively with advancement of wheat growth except on day 7 (83 DAS) where soil OC remained to be higher.

Available primary nutrients in Soil

The soil available N, P and K was observed to change significantly with dates of sampling, depth of sampling and fertilizer applications, while the interactions among these factors also brought significant changes in soil available N, P and K.

The recoveries of plant available N, P and K from the experimental soil under wheat were observed to increase significantly with increasing doses of fertilizers and reduce with increasing depth of sampling (Figure 6). The variations in such recoveries with progressing growth of wheat did not follow any definite trend (Figure 5).

The recoveries (kg/ha) of available macronutrients in the experimental soils were observed to remain in the ranges of 111.40-178.53 for N, 38.91-86.74 for P and 120.74-178.40 for K.

The changes in available macronutrients in the experimental soils can be explained by similar changes in soil moisture (SM), pH and oxidizable organic carbon (OC). The lower recoveries of the available macronutrients across increasing depths of soil profile can be largely complemented by significant correlations with changes in SM and OC.

Pearson's correlation @ 15 cm depth			
	Soil N	**Soil P**	**Soil K**
Moisture	.807**	.918**	.884**
pH	.432*	.653**	.578**
OC	.663**	.849**	.803**

Pearson's correlation @ 15 cm depth			
	Soil N	**Soil P**	**Soil K**
Moisture	-.438**	-.467**	-.382**
OC	.482**	.431**	.401**

****Significant at the 0.05 level (2-tailed)*** ***** Significant at the 0.01 level (2-tailed)***

The effect of enriched organic fractions in improving the availabilities of N, P and K has been well elucidated by several earlier workers. Such increase in available macronutrients with more soil OC may be facilitated through presence of easily replaceable cations, N, P and K being held in organic forms and release of elements from minerals through acid humus (Brady, 1988). The pH of the experimental soil under various simulated situations varied from 6.5-7.0 and the mobility of nutrients in the soil being largely depended on soil pH, are optimally available to plants at pH ranges between 6.5 to 7.5 (Brady and Weil, 2002). In the present investigation also, the changes in recoveries of available macronutrients under different simulated situations have been observed to be largely dictated (63% for soil N, 83 % for soil P and 77% for soil K variations) by variations in soil moisture (SM) under similar situations, as reflected through the following regression relationships.

Relationships drawn between observations obtained at 15 cm soil depth

Relationship	R^2	R^2_{adj}	SE_{est}
Soil available N= 2.75 SM** + 94.36	0.651	0.635	8.840
Soil available P= 3.22 SM** + 3.22	0.842	0.835	6.101
Soil available K= 3.94 SM** + 84.14	0.782	0.772	9.117

Significant at $P_{0.05}$; *****Significant at $P_{0.01}$;***

CONCLUSION

Soil pH has been observed to increase significantly with increasing soil moisture, possibly due to dilution of soil solution with increasing moisture and the changes in moisture can govern 32.2 - 42.4 per cent of total variations observed in soil pH. Increasing dose of fertilizer found to reduce soil pH significantly across different dates and depth of sampling. The application of chemical fertilizer tends to acidify agricultural soils. Organic carbon increase significantly with increase in dosage of fertilizer applications and to reduce significantly with increase in depth of sampling. It increase significantly with increasing soil moisture and the changes in moisture can govern 86.7 per cent of total variations in soil OC. The recoveries of available macronutrients in the soil were within the range of 111.40-178.53 for N, 38.91-86.74 for P and 120.74-178.40 for K. The changes in available macronutrients in the soil with respect to changes in soil moisture were same as in soil pH and oxidizable organic carbon (OC).

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Table 1: Interaction effects of date (Dt) and depth (D) of sampling under wheat on important soil properties

Treatment	pH	Organic C (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Dt_1D_1	6.87	4.48	159.73	67.48	150.67
Dt_1D_2	6.85	4.40	157.49	64.58	148.93
Dt_1D_3	6.93	3.80	138.60	62.48	141.06
Dt_2D_1	6.66	4.77	154.27	79.94	132.68
Dt_2D_2	6.83	3.67	148.76	66.68	132.92
Dt_2D_3	6.90	3.39	143.73	64.08	130.28
Dt_3D_1	6.62	4.63	140.82	84.14	128.77
Dt_3D_2	6.88	3.49	135.62	80.85	123.38
Dt_3D_3	6.84	3.42	123.20	58.84	122.60
Dt_4D_1	6.55	4.85	135.22	78.07	145.00
Dt_4D_2	6.90	3.33	129.87	68.70	140.73
Dt_4D_3	6.83	3.27	114.46	54.62	127.50
Dt_5D_1	6.74	4.70	128.16	84.45	163.17
Dt_5D_2	6.87	3.67	124.85	56.73	156.00
Dt_5D_3	6.86	3.62	116.16	47.97	131.87
Dt_6D_1	6.84	4.55	141.67	68.70	161.14
Dt_6D_2	6.88	3.62	129.80	53.47	155.07
Dt_6D_3	6.85	2.82	119.13	50.60	128.71
Dt_7D_1	6.82	5.37	147.91	72.50	168.28
Dt_7D_2	6.88	4.93	142.62	61.36	163.21
Dt_7D_3	6.86	3.32	120.71	53.30	148.37
Dt_8D_1	6.86	4.20	144.18	68.84	163.66
Dt_8D_2	6.81	3.85	134.58	56.59	161.09
Dt_8D_3	6.85	3.65	123.13	48.42	151.96
SEm (±)	0.011	0.069	2.736	1.320	1.489
CD (P=0.05)	0.031	0.193	7.649	3.690	4.163

Table 2: Interaction effects of date (Dt) of sampling and fertilizer treatment (T) under wheat on important soil properties

Treatment	pH	Organic C (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Dt_1T_1	6.95	4.12	140.58	56.59	139.54
Dt_1T_2	6.92	3.37	151.53	67.19	148.71
Dt_1T_3	6.78	5.20	163.71	70.76	152.40
Dt_2T_1	6.88	3.52	148.62	65.08	128.81
Dt_2T_2	6.79	4.48	150.64	72.28	133.54
Dt_2T_3	6.72	3.82	147.49	73.34	133.54
Dt_3T_1	6.85	3.84	118.07	70.36	122.34
Dt_3T_2	6.79	3.77	137.91	74.62	124.28
Dt_3T_3	6.71	3.93	143.67	78.84	128.13
Dt_4T_1	6.80	3.93	119.69	73.67	133.84
Dt_4T_2	6.76	3.87	127.82	67.49	140.87
Dt_4T_3	6.72	3.65	132.04	60.24	138.52
Dt_5T_1	6.90	4.12	118.89	60.18	155.44
Dt_5T_2	6.81	3.57	123.63	64.87	145.35
Dt_5T_3	6.76	4.30	126.64	64.11	150.24
Dt_6T_1	6.91	3.70	122.98	51.83	140.71
Dt_6T_2	6.86	3.33	128.56	59.10	149.78
Dt_6T_3	6.80	3.95	139.07	61.85	154.43
Dt_7T_1	6.91	4.49	130.56	60.37	147.14
Dt_7T_2	6.86	4.93	137.49	66.13	160.05
Dt_7T_3	6.80	4.20	143.20	60.66	172.67
Dt_8T_1	6.89	3.43	123.60	52.98	154.45
Dt_8T_2	6.83	4.10	138.80	60.42	159.89
Dt_8T_3	6.79	4.16	139.49	60.45	162.36
SEm (±)	0.011	0.069	2.736	1.320	1.489
CD (P=0.05)	0.031	0.193	7.649	3.690	4.163

Table 3: Interaction effects of depth (D) of sampling and fertilizer treatment (T) under wheat on important soil properties

Treatment	pH	Organic C (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
D_1T_1	6.82	4.67	135.56	68.17	143.18
D_1T_2	6.75	4.64	141.33	79.21	152.09
D_1T_3	6.67	4.77	155.09	79.17	159.74
D_2T_1	6.94	3.56	126.07	61.43	144.54
D_2T_2	6.87	3.78	147.24	66.06	147.20
D_2T_3	6.78	4.27	140.54	63.37	151.25
D_3T_1	6.90	3.45	121.99	54.54	133.13
D_3T_2	6.86	3.36	122.58	54.27	136.64
D_3T_3	6.83	3.42	130.11	56.31	136.12
SEm (±)	0.007	0.042	1.675	0.808	0.912
CD (P=0.05)	0.020	0.117	4.683	2.259	2.550

Different sampling dates:

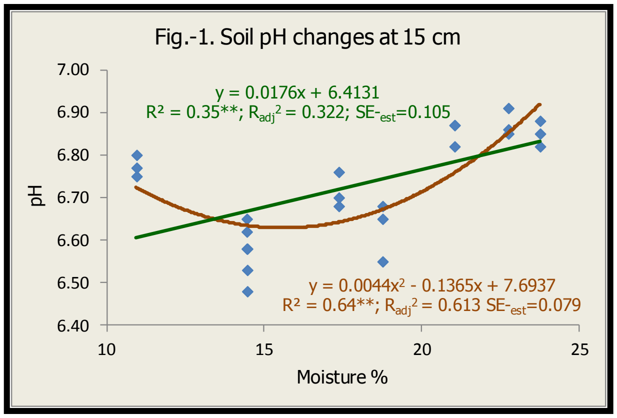
Dt_1= 25th Jan, 2013 (22 DAS), Dt_2= 14th Feb, 2013 (42 DAS),
Dt_3= 04th March,2013 (60 DAS), Dt_4= 12th March, 2013 (68 DAS),
Dt_5= 20th March, 2013 (76 DAS), Dt_6= 27th March, 2013 (83 DAS),
Dt_7=5th April, 2013 (92 DAS), Dt_8= 22nd April,2013 (At harvest);

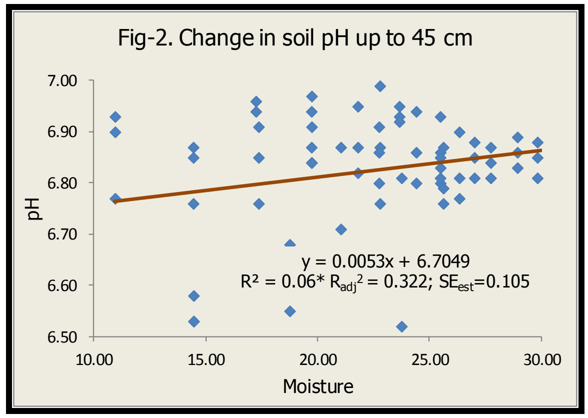
Fertilizer Treatments:

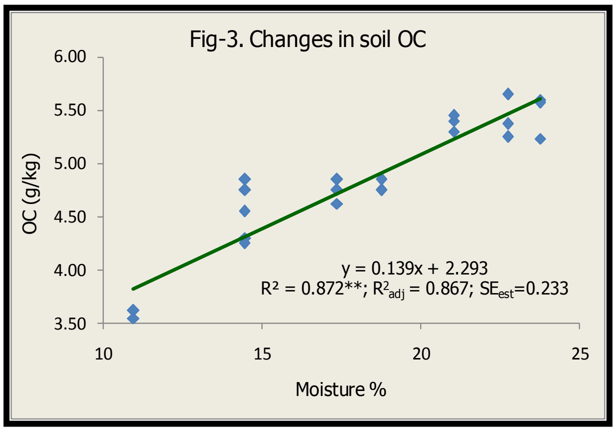
T_1= NPK @ 100:50:50 kg ha^{-1},
T_2= NPK @ 120:60:60 kgha^{-1} and
T_3= NPK @ 150:75:75 kg ha^{-1};

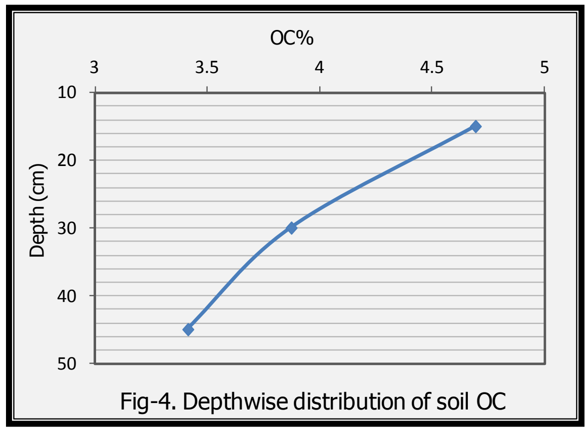
Soil Depth:

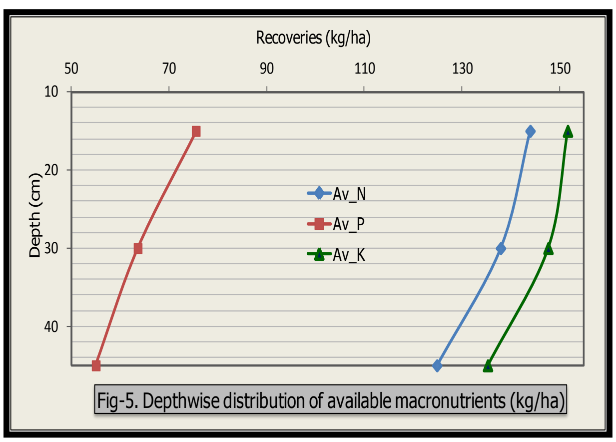
D_1= 0- 15 cm, D_2= 15- 30 cm, D_3= 30- 45 cm

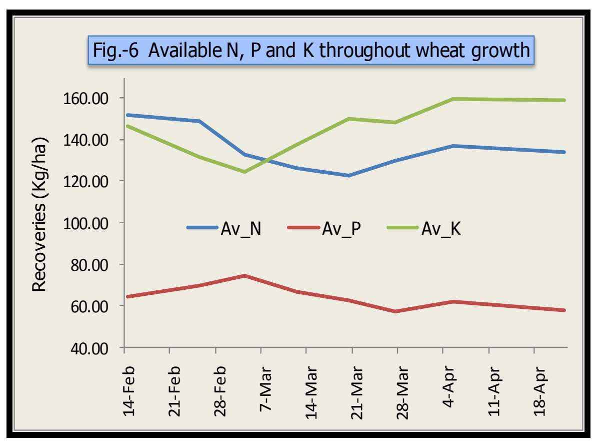












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