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Changes in Plant Availability and Uptake of NPK Along with Soil Moisture

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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, India. The experiment was laid out in factorial RBD with three treatments [T_1: 100:50:50 :: N:P:K kg/ha, T_2: 120:60:60 :: N:P:K kg/ha, T_3: 150:75:75 :: N:P:K kg/ha], eight sampling dates and three depth of sampling with three replications. The recoveries of plant nutrients (mg/kg) were 11.78 - 32.69 for N, 1.63 - 3.27 for P and 11.11 - 25.48 for K. The variations in soil moisture significantly governed variations in accumulations of N, P and K in wheat, to the tune of 46.8% in N, 79.9% in P and 78.6% variations in K accumulation. NPK uptake by wheat at harvest is significantly increased with increasing application of N, P and K fertilizers.

Key words: *Nutrient recovery, Accumulation, Soil moisture*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the main staple food of nearly 35 per cent of the world population[1] . To increase the yield of crops nutrition is most important which includes nutrient availability in soil, plant accumulation. India achieved remarkable progress in wheat production during the last four decades and is the second largest wheat producer in the world with the production touching a record level of 93.90 mt an area of around 28.40 m ha during 2011-12 [2,3].

Availability of plant nutrients depends on many factors in which soil moisture content, soil physico-chemical properties like pH, organic carbon, etc. are most important. The availability of water in the soil affects plant growth and especially the capability to absorb nutrients needed for plant growth and development. Although nutrients in the upper soil layers represent important resources for plants[4,5], these are the layers that undergo the largest fluctuations in moisture[5]. Soil chemical properties may exert a profound influence on growth and performance of plants[6]. By influencing root hair growth of plant, nutrient uptake efficiency may also be affected[7]. Purpose of this article is to show the relation between soil moisture content, nutrient availability and plant accumulation.

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MATERIAL AND METHOD

The field investigation was conducted on wheat during the *rabi* season of 2013 at the Central Research Farm (CRF), Gayeshpur, Nadia, Bidhan Chandra Krishi Viswavidyalaya, encompassing the New Alluvial Zone of West Bengal. The experimental site is Gangetic alluvium with good drainage and water holding capacity. The available N, P and K were 122.3, 14.8 and 131.5 kg ha^{-1}, 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 :: N:P:K kg/ha, T_2: 120:60:60 :: N:P:K kg/ha, 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 analysed for available primary nutrients. Available nitrogen content of soil was determined by using hot alkaline potassium permanganate method as proposed by Subbiah and Asija[8]. Available phosphorus in Olsen's method[9], Available potassium of soil was extracted with neutral 1 N ammonium acetate estimated using flame photometer as outlined by Jackson[10]. Collected plant samples at pre determined interval were analysed for NPK. Plant N was estimated by digesting with concentrated H_2SO_4[10], plant P and K were estimated by digesting in triacid (HNO_3 : H_2SO_4 : $HClO_4$ :: 9:1:4) mixture[10]
Soil moisture percentages were calculated by gravimetric method[11].

RESULT AND DISCUSSION

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 (Table 1) .The variations in such recoveries with progressing growth of wheat did not follow any definite trend, but an increase in recoveries at the end of growth period may be due to decomposing root and fallen leaves.

The recoveries (kg/ha) of available primary nutrients 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 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 beyond 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)

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[12]. Increase in concentration of K, Mg, P and Mn in soil solution, with increased soil moisture, indicate that high soil moisture changes the availability of these nutrients[13].

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 regression relationships shown in table 2.

The accumulation of N, P and K in wheat dry matter throughout the advancing growth periods and varying fertilizer applications were recorded in tables 3 to 5. The N, P and K recoveries from wheat dry matter were observed to decrease significantly and progressively with advancement of crop growth and to increase significantly with increasing administration of fertilizers. The rate of increase in dry matter production was enhanced rapidly between 30 to 90 DAS[14].

The recoveries of plant nutrients from wheat dry matter (mg/kg) were observed to remain in the ranges of 11.78 - 32.69 for N, 1.63 - 3.27 for P and 11.11 - 25.48 for K, where the highest recoveries were always associated with samples drawn in 22 DAS from plots receiving 150:75:75 kg/ha NPK and the lowest recoveries with samples drawn at harvest form plots receiving 100:50:50 kg/ha NPK.

Such changes in NPK accumulation were observed to remain in quite good agreement with the changes of NPK availabilities in experimental soils observed in similar situations (Figures 1 to 3).

The relationship between soil moisture status and accumulation of plant nutrients in wheat dry matter has been largely governed by the changes observed in the availabilities of the nutrients (N, P and K) in the experimental soil under different simulated situations as has been also observed by Misra and Tyler[13].

Water content is an important property of soils, influencing soil solution chemistry and nutrient uptake by plants. Morphology and other specific properties of the root, nutrient concentration in the soil solution, the mobility of nutrients in the soil, and supply from solid phases, affect nutrient uptake[15]. Bozkurt and Mansuroglu[16], Acharya *et al.*,[17] who were of the opinion that excess water causes nitrogen losses due to deep percolation and volatilization and limited water restricts the growth and development of plant.

Optimum soil moisture facilitates nutrient accumulation in crop which has been envisaged in the present investigation through the relationship drawn between accumulation of N, P and K in wheat dry matter and changing soil moisture (SM) status (Tables 6) where variations in SM significantly governed variations in accumulations of N, P and K in wheat, to the tune of 46.8% (variations in N accumulation), 79.9% (variations in P accumulation) and 78.6% (variations in K accumulation).

Table 1: Effect of different fertilizer levels, date and depth of sampling under wheat on important soil properties

Treatment	pH	Organic C (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Date of sampling (Dt)					
Dt_1	6.88	4.23	151.94	64.85	146.89
Dt_2	6.80	3.94	148.92	70.23	131.96
Dt_3	6.78	3.85	133.22	74.61	124.92
Dt_4	6.76	3.82	126.52	67.13	137.75
Dt_5	6.82	3.99	123.05	63.05	150.34
Dt_6	6.86	3.66	130.20	57.59	148.31
Dt_7	6.86	4.54	137.08	62.39	159.95
Dt_8	6.84	3.90	133.96	57.95	158.90
SEm (±)	0.006	0.040	1.579	0.762	0.859
CD (P=0.05)	0.017	0.112	4.414	2.130	2.401
Depth of sampling (D)					
D_1	6.75	4.69	143.99	75.52	151.67
D_2	6.86	3.87	137.95	63.62	147.67
D_3	6.87	3.41	124.89	55.04	135.29
SEm (±)	0.004	0.024	0.967	0.467	0.526
CD (P=0.05)	0.011	0.067	2.703	1.306	1.471
Fertilizer treatment (T)					
T_1	6.89	3.89	127.87	61.38	140.28
T_2	6.83	3.93	137.05	66.51	145.31
T_3	6.76	4.15	141.91	66.28	149.04
SEm (±)	0.004	0.024	0.967	0.467	0.526
CD (P=0.05)	0.011	0.067	2.703	1.306	1.471

Different sampling dates: Dt_1=22 DAS, Dt_2=42 DAS, Dt_3=60 DAS, Dt_4=68 DAS, Dt_5=76 DAS, Dt_6=83 DAS, Dt_7=92 DAS, Dt_8= At harvest; Fertilizer Treatments: T_1= NPK @ 100:50:50 kg ha^{-1}, T_2= NPK @ 120:60:60 kg ha^{-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

Table 2: Regression relation between available NPK and soil moisture

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 $P_{0.01}$; Relationships drawn between observations obtained at 15 cm soil depth

Table 3: N accumulation (g kg^{-1}) in wheat dry matter at different growth stages under varying fertilizer levels (dry wt. recoveries)

Treatment (T) / Date (D)	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	Mean
T_1	25.69	23.45	14.77	14.28	16.38	11.25	9.59	11.78	15.90
T_2	28.21	21.07	16.66	11.41	11.97	11.57	10.50	12.10	15.44
T_3	32.69	24.29	21.49	15.96	13.09	12.27	10.94	12.44	17.90
Mean	28.86	22.94	17.64	13.88	13.81	11.70	10.34	12.11	
		Date (D)			Treatment (T)			D × T	
SEm (±)		0.194			0.119			0.335	
CD (P=0.05)		0.598			0.367			1.032	

Table 4: P accumulations (g kg^{-1}) in wheat dry matter at different growth stages under varying fertilizer levels (dry wt. recoveries)

Treatment (T) / Date (D)	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	Mean
T_1	3.15	2.48	2.05	2.15	1.82	1.81	2.21	1.63	2.16
T_2	3.22	2.41	2.03	2.37	1.89	2.03	1.58	2.18	2.21
T_3	3.27	2.52	2.32	2.43	2.13	1.83	2.53	1.68	2.34
Mean	3.21	2.47	2.13	2.32	1.95	1.89	2.11	1.83	
		Date (D)			Treatment (T)			D × T	
SEm (±)		0.038			0.023			0.066	
CD (P=0.05)		0.117			0.071			0.203	

Table 5: K accumulation (g kg^{-1}) in wheat dry matter at different growth stages under varying fertilizer levels (dry wt. recoveries)

Treatment (T) / Date (D)	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	Mean
T_1	21.39	15.95	15.72	10.73	11.99	11.51	11.31	11.11	13.71
T_2	21.41	16.11	17.11	14.03	12.01	11.65	12.21	12.57	14.87
T_3	25.48	16.34	15.83	15.08	12.70	13.25	11.55	12.82	15.15
Mean	22.76	16.13	16.22	13.28	12.23	12.14	11.69	12.16	
		Date (D)			Treatment (T)			D × T	
SEm (±)		0.312			0.119			0.540	
CD (P=0.05)		0.961			0.367			1.664	

Table 6: Relationship between accumulation of nutrients in wheat dry matter and soil moisture status

Relationship (** *Sig at* $P_{0.01}$)	R^2	R^2_{adj}	SE_{est}
Plant N= 0.92 SM** + 9.552	0.482	0.468	4.173
Plant P= 0.12 SM** + 0.117	0.808	0.799	0.266
Plant K= 1.43 SM** + 7.738	0.796	0.786	3.812

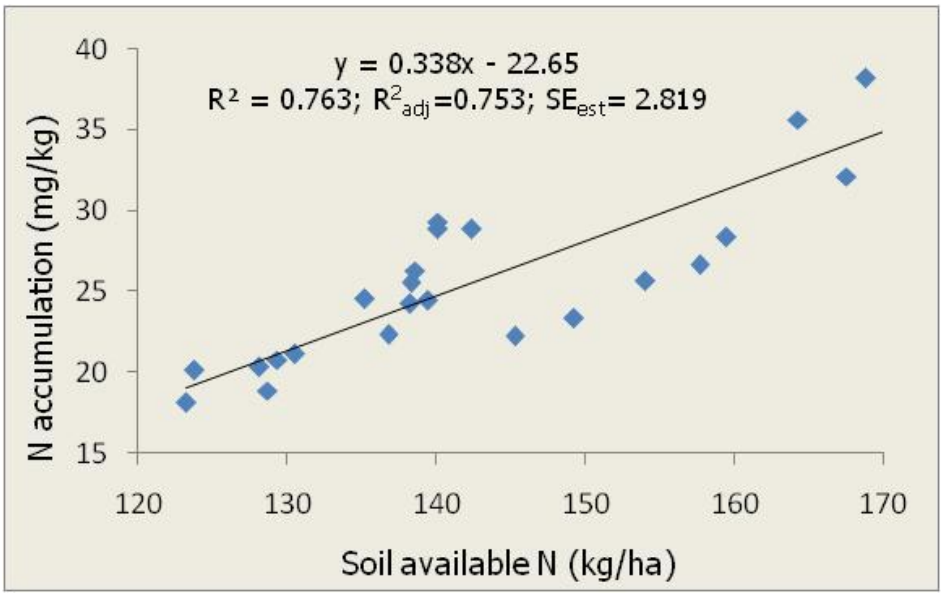

Fig. 1: N accumulation in wheat dry matter in relation to soil available N

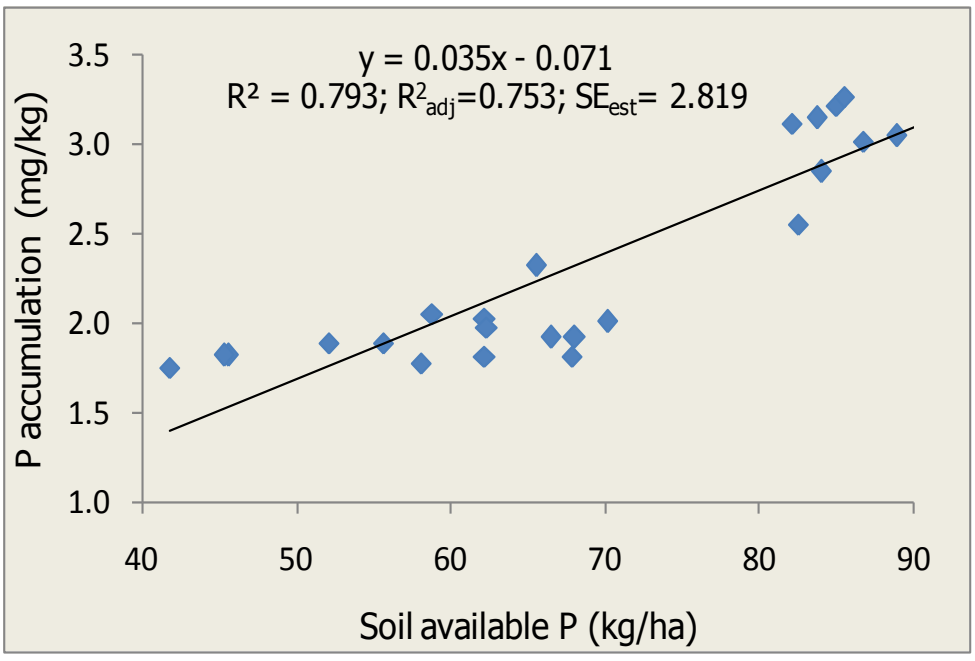

Fig. 2: P accumulation in wheat dry matter in relation to soil available P

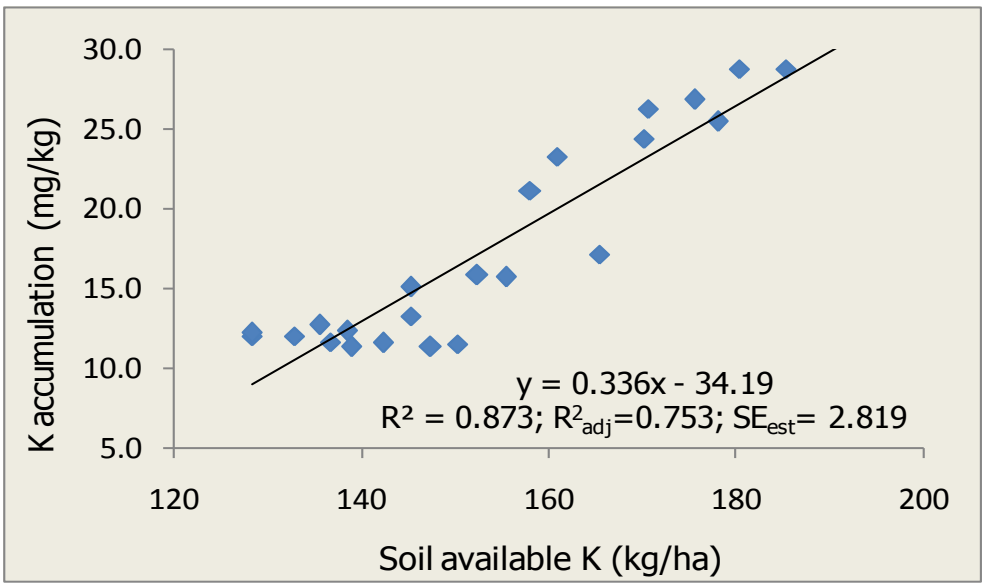

Fig. 3: K accumulation in wheat dry matter in relation to soil available K

REFERENCES

1. Singh, S. Growth, yield and phenological response of wheat cultivars to delayed sowing. *Indian Journal of Plant Physiology*, **8 (3):** pp 277-286 (1999).
2. Anonymous. Economic Survey of India & Company Affairs, Govt. of India, New Delhi (2012).
3. Meena, V.S., Maurya, B.R., Verma, R., Meena, R., Meena, R.S., Jatav, G.K., and Singh, D.K. Influence of Growth and Yield Attributes of Wheat (*Triticum AestivumL.*) by Organic and Inorganic Sources of Nutrients with Re
4. sidual Effect Under Different Fertility Levels, *The Bioscan*, **8**(3): 811-815 (2013).Robinson, D. The responses of plants to non-uniform supplies of nutrients. New Phytologist, **127**: pp 635-674.
5. Cui, M. and Caldwell, M.M. A large ephemeral release of nitrogen upon wetting of dry soil and corresponding root response in the field. *Plant and Soil*, **191**: pp 291-299 (1997).
6. Grime, J.P. and Curtis, A.V. The interaction of drought and mineral nutrient stress in calcareous grassland. *Journal of Ecology*, **64**: pp 975-988 (1976).
7. Mackay, A.D. and Barber, S.A. Effect of soil moisture and phosphate level on root hair growth of corn roots. *Plant and Soil*, **86**: pp 321-331 (1985).
8. Subbiah, B.V. and Asija, V.N. A rapid procedure for determination of available nitrogen in soils. *Current Science*, **31**(5): pp 196-198 (1956).
9. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. Estimation of available phosphorus extractable. Nature, **213**: pp 418-419 (1954).
10. Jackson, M.L.Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi (1973).
11. Gardener, W.H. Water content. In: Methods of soil analysis. American Society of Agronomy, **9**: pp 128-129 (1965).
12. Gahoonia, D.S., Raza, S. and Nielsen, N.E. Phosphorus depletion in the rhizosphere as influenced by soil moisture. *Plant and Soil*, **159**: pp 213-218 (1994).
13. Misra, A. and Tyler, G. Influence of Soil Moisture on Soil Solution Chemistry and Concentrations of Minerals in the CalcicolesPhleumphleoidesand Veronica spicataGrown on a Limestone Soil. *Annals of Botany* **84**: 401- 410 (1999).

14. Barber, S.A. Soil Nutrient Bioavailability: A mechanical approach, 414 pp. 2nd Ed. John Wiley & sons, New York, NY (1995).
15. Bozkurt, S. and Mansuroglu, G.S. Effect of drip line depths and irrigation levels on yield, quality and water use characteristics of lettuce under greenhouse condition. *African Journal of Biotechnology*. **10**(17): 3370-3379 (2011b).
16. Acharya, S.K., Shukla, Y.R. and Khatik, P.C. Effect Of Water Regime On Growth And Yield of Lettuce (*Lactuca Sativa* L.), *The Bioscan*, **8(1):** 201-206 (2013).