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Research Paper

Site specific NPK recommendation in wheat (*Triticum aestivum*) for sustained crop and soil productivity in *mollisols* of *Tarai* region

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ABSTRACT

Field experiment was conducted in three consecutive *rabi* seasons of 2006–07 to 2008–09 at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India to study the effect of 'site specific NPK recommendation' in wheat {*Triticum aestivum* (L.) emend. Fiori & Paol} for sustained crop and soil productivity in mollisols of *Tarai* region. The experiment consisted of eight fertilizer combinations comprising of N, P_2O_5, and K_2O. Treatments were T_1- 170: 60: 120, T_2- 170: 30: 120, T_3- 170: 0: 120, T_4- 170: 30: 80, T_5- 170: 30: 40, T_6- 170: 30: 0, T_7- 150: 60: 40 and T_8- 120: 40: 0, which were laid out in RBD with four replications. Experimental findings revealed that application of N, P_2O_5 and K_2O @ 170: 60: 120 kg/ha produced maximum grain yield, which increased by 7.1% and 16.5 % over recommended NPK (150N: 60 P_2O_5: 40 K_2O kg/ha) and farmer practice (120 N: 40 P_2O_5: 0 K_2O kg/ha), respectively. Application of nitrogen @ 120 kg N/ha and phosphorus @ 40 kg P_2O_5/ha as farmer fertilizer practice produced lowest grain yield. Increasing fertilizer nitrogen up to 170 kg N along with 30 kg P_2O_5 and 80 kg K_2O increased the crop growth, yield contributing characters and yield of wheat significantly. Significant response of P was observed up to 30 kg P_2O_5/ha and in case of K up to 80 kg K_2O/ha over no application, whereas further increase in P and K doses had non–significant response . However, fertility status of soil after harvest of three cycles of crop increased with increased application of N, P and K upto 170 kg N, 60 kg P_2O_5 and 120 kg K_2O/ha. Thus, the results suggests that application of N, P_2O_5 and K_2O @ 170, 30 and 80 kg/ha to wheat crop is required for achieving higher productivity on sustainable basis besides maintenance of soil fertility in *Tarai* region of north India.

Key words : Agronomic use efficiency, Grain yield, Site specific NPK management, Soil fertility, Wheat

Wheat is second important food crop of India after rice. Wheat is grown predominantly in rice–wheat cropping system, and this system is considered back bone of food security in India, which is followed in 10.5 million hectare area (Yadav *et al.*, 2005). With introduction of high–yielding varieties of rice and wheat, there has been a significant change in the cropping patterns in north India, wherein most of the rice area is normally rotated with wheat. Both these crops are heavy nutrient feeders and their intensive cropping leads to large withdrawal of plant nutrients from soil, thereby accentuating the problem of nutrient disorders and affecting crop yields. Therefore, soil–fertility management is of utmost importance. Nambiar and Abrol (1989) and Gupta *et al*., (2000) also reported that under continuous and high intensive farming, the nutrient supplying power of most of the soils has been found to be decline particularly when rice based cropping systems are followed. Due to decline in soil fertility, farmers have to use more and more fertilizer year after year to obtain optimum yield (Hobbs *et al.*, 1990). The excessive and imbalance use of inorganic fertilizer was reported to be the major constraint of declining productivity of rice–wheat cropping system (Hobbs, 1994). When these crops are grown under good management conditions, they remove large quantities of nutrients. Hedge and Pandey (1989) estimated that a system yielding 6.95 t/ha rice and 3.86 t/ha wheat removed 316 kg N, 28 kg P and 342 kg K/ha. Such large drain may impoverish the soil in due course of time, adversely affecting physical, chemical and biological properties of soil. Thus, balance application of NPK for maintenance and enhancement of soil productivity in rice–wheat system is a challenging issue.

Blanket application of nitrogen, phosphorus and potassium is being used by most of the farmers, which not only waste the fertilizer resources but failed to increase productivity substantially as the recommendations are either over estimated or under estimated due to diverse heterogeneous

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nature of soil. Farmers are using 80–200 kg N, 10–30 kg P and 0–20 kg K/ha, making it imbalanced, which resulted in low fertilizer use efficiency and reduced yield (Hobbs *et al*., 1990). Heavy doses of fertilizers applied in multiple cropping systems lead to the accumulation of large amount of phosphorus in soil, and in certain soils possibly of potassium also. The magnitude of accumulation, however, depends on the type of soil, nature and intensity of cropping and the amount of fertilizer added (Mc Collum, 1991). On the other hand, the depletion of available P and K might take place if intensive cropping is practiced without the external supply of these nutrients to the soil. Hence, sustainable management of plant nutrients is required for obtaining higher yields on sustainable basis. Farmer are harvesting yield of around 3.0–4.0 t/ ha which could be increased up to 5.5–6.0 t/ha on sustainable basis through the balance use of NPK in rice–wheat cropping system. Keeping in view, an experiment was conducted to find out site specific NPK recommendation in wheat for sustained crop and soil productivity in mollisols of *Tarai* region.

MATERIALS AND METHODS

The field experiment was conducted during 2006–07 to 2008–09 at Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, located in the *Tarai* belt of shivalik range of the Himalayas at 29^0 N latitude, 79.29^0 E longitude and at the altitude of 243.8 m above mean sea level. The soil was silty clay loam in texture, neutral to slightly alkaline in reaction (pH 7.9), rich in organic matter (1.75%), low in available nitrogen (240 kg N/ha), medium in available phosphorus (13 kg P/ha) and low in available potassium (207 kg K/ha) at the beginning of the experiment (2006–07) in 0–15 cm soil layer. The total average rainfall recorded during crop growth period was 37.05 mm, average minimum and maximum temperature ranged from 2.8 to 15.2 and 19.2 to 32.5, respectively and relative humidity between 60–94%.

Wheat crop was sown during *rabi* season in rice–wheat cropping system and during *kharif* season rice was taken as commercial crop. Eight treatments were executed in wheat crop consisting of different combination of N, P_2O_5, and K_2O. Treatments were T_1- 170: 60: 120, T_2- 170: 30: 120, T_3- 170: 0: 120, T_4- 170: 30: 80, T_5- 170: 30: 40, T_6- 170: 30: 0, T_7- 150: 60: 40, T_8- 120: 40: 0, which were laid out in randomized block design with four replications. Half of the total nitrogen along with full amount phosphorus and potassium were applied to crop as basal through urea, single super phosphate and muriate of potash, broadcasted and incorporated into top 20 cm soil with the help of spade in different plots. Rest half nitrogen was top dressed in two splits at tillering (30 DAS) and flowering stage (60 DAS) of crop growth. Wheat 'PBW-343' was sown @ 100 kg seed per hectare. The seeds were sown manually in furrows opened by tractor mounted furrow opener at 23 cm inter row spacing. All improved packages of practices were followed to raise the crop. The soil and plant analysis were done by using standard methods. The soil was analyzed after harvesting the crop to find out the change in available nutrient (N, P and K) status. Since data obtained over the years done at same experimental site followed the homogeneity test, pooling was done over the seasons and mean data are given. The data obtained were statistically analyzed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributes

Wheat is well responsive to increased doses of fertilizers particularly NPK, resulting in good growth performance and higher productivity (Abrol *et al*., 1997). Similarly, the outcome of the present investigation revealed that growth parameters such as plant height, number of shoots/m^2 and dry matter accumulation were significantly higher with application of 170, 60 and 120 kg N, P_2O_5 and K_2O/ha respectively over farmer practice (T8) and recommended NPK (T7) (Table 1). At 90 DAS, NPK application @ 170N, 60 P_2O_5, 120 K_2O kg/ha recorded the highest value of growth parameters. The magnitude of increase in plant height was 12.4 and 18.8%, number of shoots/m^2 was 17.8 and 18.4% and dry matter accumulation was 15.98 and 18.04% over farmer fertilizer practice (N_{120}+P_{40}+K_0) and recommended practice (N_{150}+P_{60}+K_{40}), respectively. Plant height, number of shoots/m^2 and dry matter accumulation was superior under higher dose of NPK due to better nutrient availability and reduced interplant competition in the community. More supply of nitrogen, phosphorus and potassium is favorable for increasing growth of wheat plants (Pandey and Sinha, 2006). Increasing rate of N application from 150 to 170 kg/ha along with other nutrients significantly enhanced the growth parameters *viz.*, plant height, number of shoots and dry matter accumulation. Nutrient particularly nitrogen is a very important for plant growth because of constituent of major cell parts and protein production (Prasad *et al.*, 1982). Increased dose of nitrogen has led to more shoot growth (Grant, 1998), because it promotes cell division and increase the synthesis of chlorophyll content in leaves hence; it is helpful to improve the CO_2 buildup in plants through increased photosynthesis; ultimately increasing plant height and tillers (Shangguan *et al.*,2000). Results indicate that increased application of phosphorus from 0 to 30 kg P_2O_5/ha had significant increase in plant height, number of shoots/m^2 and dry matter accumulation but further increment of phosphorus doses up to 60 kg P_2O_5/ha showed non–significant increase. Increasing the level of potassium from 0 to 80 and further to 120 kg K_2O/ha significantly increased the plant height, number of shoots/m^2 and dry matter accumulation over no potassium application. Phosphorus helped in increased plant height and higher root to shoot ratio resulting in vigorous root system which increased uptake of other essential nutrient ions. Similarly, Siddique *et al*. (1990) also confirmed that higher root: shoot ratio under increased phosphorus nutrition, resulted in better growth of wheat plants. Similarly, potassium imparts resistance to pest and disease and helps to escape the plants from other abiotic stresses (Perrenoud, 1990), ultimately resulting in vigorous growth of plants to attain greater plant height. A similar result was also reported by Maliwal *et al.* (1991). As we discussed above points more crop growth at higher level of nutrients resulted in accumulation of more dry matter through increased photosynthetic activity. This could be probably because of increase in plant height and number of shoots/ m^2 due to balanced NPK nutrition. Such inferences have also been recorded by Dev (1992).

Yield attributes

Experimental results revealed that different fertility levels brought significant improvement in yield attributes and yield of wheat crop. Significant increase in number of spikes per m^2 and filled spikelets per spike were noticed when application of N increased from 150 to 170 kg N/ha while, increased application of phosphorus from 0 to 30 kg P_2O_5/ha or to 60 kg P_2O_5/ha and potassium from 0 to 80 kg K_2O/ha or to 120 kg K_2O/ha increased only the number of spikes (Table 1). However, non significant increase in filled spikelets per spike was recorded when application of phosphorus was increased from 0 to 30 kg P_2O_5/ha or to 60 kg P_2O_5/ha and potassium from 0 to 80 kg K_2O/ha or to 120 kg K_2O/ha. The highest number of spikes/m^2 and filled spikelets per spike (360 and 14.3, respectively) was recorded with application of 170: 60: 120 kg NPK/ha while, lowest number of spikes/m^2 (295.5), filled spikelets per spike (10.45) were observed with application of 120: 40: 0 kg NPK/ha as farmers practice. It might be attributed to the fact that balanced and judicious application of fertilizer ensures synergetic reaction among nutrients and reduction in number of unfilled spikelets per spike and sterility per cent mainly due to the induced translocation of photosynthates from source to sink. This finding is also conformity with the findings of Dev (1992).

Grain and straw yields

Results on wheat productivity revealed that among the different treatment applied to enhance the yield; significantly more grain yield was recorded with treatment N_{170}+P_{60}+K_{120} (T_1) which was significantly higher than the farmer fertilizer practice (N_{120}+P_{40}+K_0) and recommended fertilizer level (N_{150}+P_{60}+K_{40}) (Table 1). Application of NPK @ 170:30:80 kg N, P_2O_5 -and K_2O/ha produced 13.96 and 4.7% more grain yield than farmers practices and recommended fertilizer, respectively. However, further increasing fertilizer doses had non–significant increase in yield. It is because of the appropriate dose of NPK could make better combination for completion of prominent process like chlorophyll synthesis, promotion of healthy root growth, translocation of photosynthates, enzymes activation for biochemical reaction within plant tissue, wherein the plant get good opportunity for nutrient uptake which results in higher plant growth and development as well as yield. Similar results were also reported by Pandey and Sinha (2006).

The minimum grain yield (4.9 t/ha) was recorded in farmers practice and increased nitrogen application to 170

Table 1. Growth, yield attributes, harvest index, 1,000-grain weight and partial factor productivity as influenced by treatments (Pooled data of three years).

Treatment	Growth attributes (90 DAS)			Yield attributes		1,000–grain weight (g)	Yield (t/ha)		HI (%)
	Plant height (cm)	Shoots/ m^2	Dry matter (g/m^2)	Spikes/ m^2	Filled spikelets/ spike		Grain	Straw	
N_{170} + P_{60} + K_{120}	81.0	370	299	360	14.3	43.9	5.7	8.8	39.3
N_{170} + P_{30} + K_{120}	77.4	355	291	342	13.3	42.8	5.6	8.7	39.2
N_{170} + P_0 + K_{120}	70.6	336	275	319	12.1	42.6	5.2	7.6	40.0
N_{170} + P_{30} + K_{80}	77.7	371	292	344	12.6	43.4	5.6	8.3	40.1
N_{170} + P_{30} + K_{40}	75.2	355	283	333	12.3	42.6	5.5	8.1	40.2
N_{170} + P_{30} + K_0	70.5	346	279	325	11.6	43.6	5.2	7.8	39.8
N_{150} + P_{60} + K_{40}	72.0	316	258	303	11.3	42.6	5.3	8.0	39.9
N_{120} + P_{40} + K_0	68.2	315	254	296	10.5	42.7	4.9	7.3	40.2
SEm±	2.1	6	3	6	0.3	0.5	0.1	0.2	0.6
CD (P=0.0 5)	6.2	16	9	17	0.8	1.4	0.3	0.5	NS

kg N/ha along with other nutrients (P and K) increased the grain yield significantly over recommended fertilizer practice to the tune of 14.9%. Increased application of phosphorus from 0 to 30 kg P_2O_5/ha had significant increase (8.2%) in grain yield. Further increasing the phosphorus fertilizer from 30 to 60 kg P_2O_5/ha had non-significant effect on grain yield (Table 1). Similar trends were observed in case of potassium and yield increased with increasing application of potassium up to 120 kg/ha. Increment in successive level of potassium up to 80 kg/ha has resulted increased yield of wheat over 40 kg/ha but both were at par. Further increase in potassium level up to 120 kg/ha gave significant increase in grain yield of wheat over no application (Table 1). Wheat yield increased 7.7 and 8.5% with the application of 80 and 120 kg K/ha over no K application. Similar, increase in grain yield of wheat 'Mexi Pak-65' and 'Khushal' were obtained by balanced application of NPK over blanket application (Amanullah *et al*., 1985).

The results indicate that different fertility levels significantly influence straw yield and maximum straw yield (8.8 t/ha) was recorded with application of 170 N: 60 P_2O_5: 120 K_2O kg NPK/ha while, the minimum (7.1 t/ ha) with application of 120N: 40 P_2O_5: 0 K_2O kg NPK/ha (Table 1). Increased application of N from 120 to 150 and/or 170 kg/ha, increased the straw yield. Similar trends were recorded in P from 0 to 30 or 60 kg P_2O_5/ha and potassium from 0 to 40 kg/ha and 40 to 80 kg/ha, which increased the straw yield significantly. It might be due to higher shoot density and increased rate of dry matter because nutritional requirement of wheat plant could be met from these treatments and plant remains competition free for nutritional demand. Thus, maximum energy of wheat plant was involved in yield process. On the contrary, imbalanced application of nutrients continuously in wheat crop led to a loss of productivity which arises from continuous exhaustion of essential nutrients from the soil. Such inference was explicitly drawn from present investigation where farmer fertilizer practice produced minimum yields.

Agronomic use efficiency of P and K

Agronomic efficiency of phosphorus (AEP) and potassium (AEK) were significantly influenced by different levels of nutrients. Based on yield, significantly higher agronomic efficiency of phosphorus (14.0 kg grain/kg of P_2O_5 applied) and potassium (7.5 kg grain/kg K_2O applied) were recorded with the application of 30 kg P_2O_5 and 40 kg K_2O over no application, respectively. With each increment in P and K levels, AEP and AEK declined and lowest value of AEP (2.7 kg grain/kg of P_2O_5 applied) and AEK (1.3 kg grain/kg K_2O applied) were recorded in P 60 over P30 and K 120 over 80, respectively (Fig 1 and 2). It might be due to incremental grain yield at each successive levels of P and K declined. Mangel and Kirkby (1978) also described that as the growth factor is increased to improve yield, the yield increments become smaller.

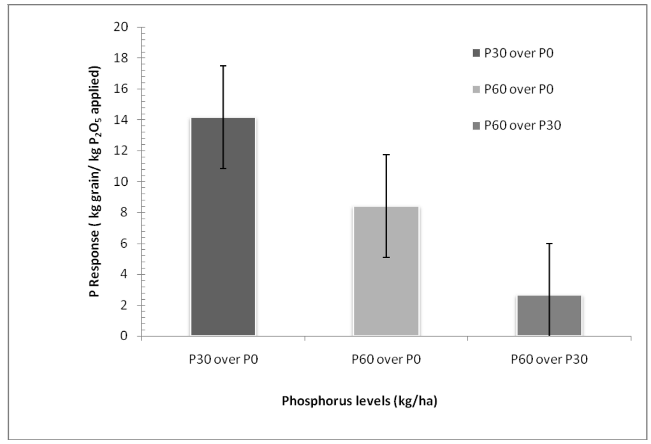

Fig. 1. Agronomic efficiency of phosphorus (kg grain/ kg P_2O_5 applied) under different levels of phosphorus.

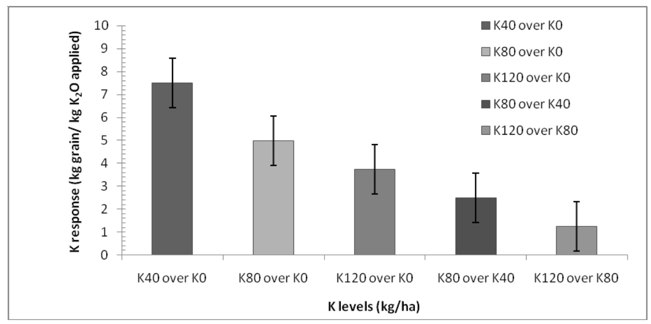

Fig. 2. Agronomic efficiency of potassium (kg grain/ kg K_2O applied) under different levels of potassium.

Nutrient uptake

Application of NPK @ 170, 60 and 120 kg N, P_2O_5 - and K_2O/ha resulted in more uptake of N, P and K. This may be attributed to increased grain and straw yield of crop and their respective nutrient contents owing to increased availability of nutrients to the crop as a result of improved soil fertility. The results are in close conformity with the finding of Mubarak and Singh (2011). This explicitly brings out the importance of balanced fertilizer application to wheat crop. Considering the nitrogen content in plants, increase in nitrogen concentration due to higher nitrogen application was quite obvious. The difference due to nitrogen application comes through higher availability of such nutrients in soil (Table 3). Yadav *et al.*, (2003) also observed that N uptake by wheat increased with increasing rate of nitrogen. Our results revealed that greatest value of nitrogen uptake by wheat were recorded in treatment receiving 170 kg N/ ha. Higher dose of phosphorus also increased the nitrogen content in grain and straw and uptake by wheat crop as phosphorus promote development of healthy and vigorous root for more uptake of other nutrients. However, application of potassium along with constant rate of nitrogen and phosphorus decreased the nitrogen content in grain but total uptake did not follow same trend (Table 2). It might be due to the fact that ion balance becomes a problem by luxury consumption of potassium while total uptake depends upon total biomass production. Increased phosphorus level from 0 to 30 kg/ha increased total phosphorus uptake and concentration while further increment in phosphorus dose did not significantly influence total uptake by wheat crop. Application of potassium from 0 to 80 and 120 kg/ha increased phosphorus uptake by grain and straw. Recommended fertilizer practice recorded higher total K uptake as compared to farmer fertilizer practice (Table 2). Increased phosphorus application up to 60 kg P_2O_5/ha had resulted in to significantly higher total potassium uptake by wheat crop over no application but the difference was non significant beyond 30 kg P_2O_5/ha. Higher total potassium uptake by wheat crop was observed up to 120 kg K_2O/ ha but it was significant up to 80 kg K_2O application. Siddique *et al*. (1990) also reported higher P and K uptake by grain and straw under balanced supply of plant nutrients particularly N, P and K. It might be due to active root system in optimum nutrition, which efficiently helps in better absorption of nutrients from the soil producing higher biomass and nutrient concentration resulting in higher nutrient uptake.

Soil fertility

The measured soil parameters *viz*., soil pH, organic matter (%), available nitrogen, available phosphorus, and available potassium content after harvest of crop were significantly influenced by different treatments except soil pH, and organic matter (%). The low soil pH value was recorded with farmer fertilizer practice and recommended fertilizer practice. The value of soil pH decreased from initial status (7.9) to 7.6 in T_6 (N_{170}+P_{30}+K_0), 7.69 in Rec-

Table 2. Uptake of nitrogen, phosphorus and potassium as influenced by different treatment (Pooled data of three years)

Treatment	Nutrient uptake (kg/ha)								
	Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
$N_{170}+P_{60}+K_{120}$	105.6	40.4	146.0	19.2	7.9	27.1	62.5	160.6	223.1
$N_{170}+P_{30}+K_{120}$	99.8	37.0	136.8	18.7	7.3	26.0	60.5	156.6	217.1
$N_{170}+P_{0}+K_{120}$	92.2	32.3	124.4	17.0	6.0	23.0	53.8	140.8	194.6
$N_{170}+P_{30}+K_{80}$	100.6	36.6	137.2	18.3	6.7	25.0	60.0	149.4	209.3
$N_{170}+P_{30}+K_{40}$	100.0	36.5	136.5	17.9	6.4	24.3	55.9	140.6	196.4
$N_{170}+P_{30}+K_{0}$	94.3	35.0	129.2	16.1	6.1	22.2	49.2	130.7	179.8
$N_{150}+P_{60}+K_{40}$	87.5	34.3	121.8	17.8	6.5	24.3	56.2	138.4	194.6
$N_{120}+P_{40}+K_{0}$	77.4	29.4	106.8	16.2	5.7	21.9	50.7	123.2	173.9
SEm±	2.4	1.1	2.8	0.4	0.12	0.5	1.6	3.2	4.0
CD (P=0.05)	6.8	3.1	8.3	1.1	0.6	1.9	4.6	9.3	11.5

Table 3. Economics and post harvest soil nutrient status after three years as influenced by different treatment (Pooled data of 3 years)

Treatment	Cost of cultivation (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	B:C ratio	Soil properties				
				pH	Organic matter (%)	Soil available nutrients (kg/ha)		
						N	P	K
Initial*	–	–	–	7.90	1.75	240.0	14.0	207.0
$N_{170}+P_{60}+K_{120}$	17.6	69.1	3.93	7.84	1.80	245.9	17.1	215.3
$N_{170}+P_{30}+K_{120}$	16.9	69.2	4.09	7.78	1.77	244.0	15.9	211.6
$N_{170}+P_{0}+K_{120}$	16.2	63.2	3.90	7.80	1.72	242.7	13.4	209.2
$N_{170}+P_{30}+K_{80}$	16.6	67.9	4.10	7.86	1.76	241.8	15.3	204.3
$N_{170}+P_{30}+K_{40}$	16.3	66.7	4.09	7.82	1.76	241.5	15.4	204.0
$N_{170}+P_{30}+K_{0}$	16.0	63.0	3.94	7.79	1.75	238.1	14.6	195.4
$N_{150}+P_{60}+K_{40}$	16.7	64.8	3.86	7.69	1.74	235.8	16.6	197.9
$N_{120}+P_{40}+K_{0}$	15.7	59.3	3.78	7.69	1.71	228.1	14.3	192.5
SEm±	–	–		0.08	0.09	1.3	0.8	2.0
CD (P=0.05)	–	–		NS	NS	3.7	2.3	5.9

*Initial values were taken before starting of wheat crop (2006–07) ommended fertilizer practice and farmer fertilizer practice and 7.84 with N_{170}+P_{60}+K_{120} (Table 3). This is might be due to continuous use of inorganic fertilizer. Similar observation was recorded by Basumantary and Talukdar, (1998). The role of soil organic carbon in maintaining soil fertility and productivity is well recognized since time immemorial. Therefore, its maintenance in the soil is of great concern under intensive cropping. Nand Ram (1995) reported that loss of soil organic matter found to be associated with its rapid mineralization as a result of intensive farming and attainment of stable equilibrium with changing soil crop environment. It has been found from present study that treatment had non–significant effect on soil organic matter content however; it increased slightly with increasing application rate of inorganic fertilizers. It might be due decomposition of higher and active root biomass and greater release of organic root exudates after harvest of crop in optimized fertilizer treatment. However, Bhandari *et al.* (1992) observed that continuous application of inorganic fertilizer decreased the organic matter content in soil. The value of available nitrogen, phosphorus and potassium content in soil after harvest were significantly influenced by the different treatments after three years of crop cycle. Results revealed that the available nitrogen, phosphorus and potassium content increased in soil after harvest of wheat with increasing application of nutrients (NPK) through inorganic fertilizers (Table 3). Prasad *et al.* (1983) reported that nutrient status of soil increased with the application of 150 per cent of recommended NPK. Similar observations were also reported by Bhardwaj *et al.* (1994) and Yadav (1998). Increasing nitrogen, phosphorus and potassium fertilization resulted in buildup of nutrient status of soil, depletion of potassium was checked and its build up took place with NPK application (Pathak and Tiwari, 1989).

Economics

The cost of cultivation was recorded to be highest (₹17,565) with N_{170} + P_{60} + K_{120} while, net return was highest (69,177.49) in N_{170} + P_{30} + K_{120}. The minimum net return was observed with farmer fertilizer practice (Table 3). Doberman *et al.*, (2002) observed that site–specific nutrient management recorded higher profit over current farmer fertilizer practice. Similar results were also reported by Pachauri *et al.*, (2004). However, the benefit cost ratio studied was noticed to be highest with treatment N_{170} + P_{30} + K_{80} followed by N_{170} + P_{30} + K_{120} and N_{170} + P_{30} + K_{40} (Table 4). The less fertilizer application under these treatment compared to N_{170} + P_{60} + K_{120} reduced the cost of cultivation, which coupled with higher yields resulted in higher benefit cost ratio.

It may be concluded from present investigation that nitrogen @170 kg N/ha along with phosphorus @ 30 kg P_2O_5/ha and potassium @ 80 kg K_2O/ha might be beneficial under *Tarai* region of north India for achieving higher productivity and profitability of wheat besides maintaining soil fertility under rice–wheat cropping system.

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