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Original Research Article

Effect of Long-term Fertilizer Application on Growth and Yield Attributes of Wheat Preceding Rice Crop

Anuj Kumar, Alok Kumar, and Chandan Singh*

Department of Soil Science and Agriculture Chemistry N.D.U.A. & T. Kumarganj, Faizabad-224229, India
**Corresponding author*

A B S T R A C T

The present investigation was conducted with objective to know the effect of long term application of fertilizers on growth and yield attributes of wheat at CRS Masodha, Faizabad during rabi season of 2010-11. The study was conducted in the randomized block design with three replications. The experiment comprised ten treatments of in-organic fertilizers. The observations were recorded on growth attributes and yield attributes. The present study revealed that the maximum plant height (92.9 cm), number of spikes/m^2 (329/m^2), grains per spike (45), test weight (34.6 g) were recorded in $N_{120}P_{80}K_{40.}$ Maximum grain yield (32.75 q/ha) was obtained from recommended doses of NPK (N_{120} P_{80} K_{40}), which was significantly higher than imbalanced or suboptimal treatments. Application of phosphorus along with nitrogen or nitrogen and potassium both significantly increased the yield attributing characters. The positive effect of potassium application was noticed only with the nitrogen and phosphorus both.

Keywords

Grain yield,
Test weight,
Wheat-rice system

Introduction

In India, rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L.) rotation is a dominant cropping system across the Indo-Gangetic plains and in the Himalayan foot-hills. Approximately 10.5 million ha under this cropping system contributes about 25% of total food grain production (243 m tonnes). About 33% of India's rice and 42% of wheat is grown in this rotation. Nearly 65% of total fertilizer used in the country (27 m tonnes) is applied to rice and wheat crops alone.

The concept of balanced fertilization cannot be confined to N, P and K alone. Balanced fertilization includes application of all the plant nutrients essential for high agricultural productivity and health of the soil. Results generated from long-term fertilizer experiments on rice-wheat system suggested that under continuous cropping, decline in soil fertility and the resultant crop productivity are matters of 'nutrient imbalance' which has been recognized as one of the most important factors that limit crop yields (Nambiar and Ghosh, 1984). Even the application of optimum NPK fertilizers devoid of organics has not been able to sustain its productivity (Nambiar and Abrol, 1989). Both rice and wheat are exhaustive feeders of nutrients and remove about 258 kg N, 52 kg P and 323 kg K per hectare under best NPK management practices (Swarup and Singh, 1989).

Materials and Methods

A long-term fertility experiment was started during 1977-78 with a fixed rice-wheat cropping system at the permanent site, superimposing the same layout. Eighteen fertility combinations comprising three levels of nitrogen (40, 80, 120 kg N/ha), three levels of phosphorus (0, 40, 80 kg P_2O_5/ha), and two levels of potassium (0, 40 kg K_2O/ha), were implemented. Similar treatment combinations were given for rice and wheat both in four replications along with one control (N_0 P_0 K_0) in each replication. However, in the present study following ten treatments were selected and tested in a Randomized Block Design with four replications.

Results and Discussion

The perusal of Table-2 revealed that the highest grain yield of wheat (32.75 q/ha) was recorded in balanced nutrient (N_{120} P_{80} K_{40}) treatment which was significantly higher than other imbalanced or suboptimal nutrient treatments. The continuous application of N alone (N_{120}) and NK (N_{120} K_{40}) treatments provided 2.28 to 3.05 q/ha lower grain yield over control (unfertilized). The yield data of wheat clearly showed that nitrogen and potassium both failed to respond in the absence of phosphorus. The application of 40 kg P_2O_5 along with 120 kg N/ha and 40 kg K_2O/ha (N_{120} P_{40} K_{40}) increased the grain yield of wheat by 25.88 q/ha over N_{120} K_{40} treatment. Omitting of phosphatic fertilizers caused sharp decline in the grain yield of wheat.

The decline in the response of applied nitrogen may have been a result of changes in soil properties caused by repeatedly flooding and drying of rice-wheat fields. These changes reduce the nitrogen supplying capacity of soils by inhibiting the release of native soil N (Olk *et al*., 1996). It is well recognized fact that productivity would be adversely affected even if one factor is limiting. This limiting factor also limits the positive influence of all other growth factors. Therefore, application of N alone or with K failed to produce the potential yield in the absence of phosphorus. The decline in yield with imbalanced/suboptimal application of nutrients (NPK) is probably associated with a deficiency or imbalance in one or more soil nutrients.

Phosphorous was found to be the second most limiting nutrient. Application of 80kg phosphorus along with nitrogen and potash increased the grain yield of wheat by 31.22 and 30.45 q/ha over N_{120} and N_{120} K_{40}, respectively. The responses of P_{40} and P_{80} over N_{120} K_{40} were found 64.7 and 38.06 kg grain per kg P_2O_5. Nambiar and Abrol (1989) also reported the similar trend in response of P application in the rice – wheat cropping system.

The regular application of phosphatic fertilizer @ 40 and 80 kg P_2O_5 /ha / crop raised the available soil P by approximately 2 and 3 times, respectively, of its initial value (10 kg P/ha) in a span of 34 years. While neglecting the use of phosphorus declined available soil P in control near to half (5.4 kg P/ha) of its initial level. The lowest available soil P (3.8 kg P/ha) was recorded in N alone (N_{120}) treatment. Verma *et al.*, (1987) also reported that depletion of P was more pronounced with 100% N dose than that in unfertilized control, possibly because of enhanced crop growth and more P removal by the crop. Maintenance or buildup of P level of soil should form one of the important aspect of P fertilizer use to ensure stability in crop production over a period of time (Mingxing *et al*., 2007).

It is an established fact that the amount of available P increases in P treated plots while it tends to decrease where P is not applied. Rana *et al*., (1983) reported that application of P fertilizer increased the available P and decreased the possible adverse effect of high doses of nitrogenous fertilizers alone.

After N and P, the K nutrient was found to be beneficial. Thus, NPK combination gave higher yields of crops because of better fertility status as a result of supply of these nutrients. Such observations have been recorded in several long-term experiments conducted in all over India (Biswas and Benbi, 1989; Nambiar and Abrol, 1989; Hegde and Dwivedi, 1992).

In the 34th years of cropping the addition of 40 kg K_2O/ha over 120 kg N and 80 kg P_2O_5/ha (N_{120} P_{80}) increased the grain yield of wheat by 7.07 q/ha. Incremental yield response to K fertilizer was found 17.7 kg grain per kg applied K_2O during 34th year. Kumar *et al.* (2006) also reported that responses to K fertilizer were lower than phosphorus and nitrogen. The lower responses were due to illitic clay minerals, which release the adequate amount of K from its non-exchangeable pool to meet the K demand of the crop (Kumar *et al*., 2007).

Fertility treatments also showed some variations in harvest index values. Higher values of harvest index were recorded in the treatments received all nutrients (NPK) as compared to control and N alone and N K treatments. In imbalance nutrients treatments, the grain shrinks which reduced grain yield with respect to total biological yield. Other fertility treatments having NP and NPK did not show much variation in the values of harvest index.

The grain yield is a function of its different yield attributing characters (Table-2) such as the number of spikes per unit area, number of grains per spike and 1000-grain weight (Tanka *et al.,* 1964 and Laghari *et al*., 2010). The growth and developmental studies made during these phases helped in explaining the variations in yield.

Table.1 Details of treatment

Treatment Symbol used	Fertilizer nutrient doses (kg/ha/crop)		
	N	P_2O_5	K_2O
Control	0	0	0
$N_{40}P_{40}K_{40}$	40	40	40
$N_{40}P_{80}K_{40}$	40	80	40
$N_{80}P_{40}K_{40}$	80	40	40
$N_{80}P_{80}K_{40}$	80	80	40
N_{120}	120	0	0
$N_{120}K_{40}$	120	0	40
$N_{120}P_{40}K_{40}$	120	40	40
$N_{120}P_{80}$	120	80	0
$N_{120}P_{80}K_{40}$	120	80	40

Table.2 Effect of various fertilizer treatments on grain yield, straw yield and harvest index of wheat after 33 cycles of rice-wheat

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Control	4.58	6.13	42
N_{40} $P_{40}K_{40}$	19.75	26.48	42.7
N_{40} P_{80} K_{40}	24.31	29.10	45.5
N_{80} P_{40} K_{40}	20.93	25.53	45
N_{80} P_{80} K_{40}	26.89	32.62	45.1
N_{120}	1.53	1.97	43.7
N_{120} K_{40}	2.30	2.85	44.6
N_{120} P_{40} K_{40}	28.18	35.25	44.40
N_{120} P_{80}	25.68	31.37	45
N_{120} P_{80} K_{40}	32.75	40.75	44.5
SEm+	**0.72**	**1.30**	-
CD at 5%	**2.10**	**3.90**	-

Table.3 Effect of various fertilizer treatments on plant height, number of spikes/m^2, number of grains/spike and 1000 grain weight of wheat after 33 cycles of rice-wheat

Treatment	Plant height (cm)	Number of spikes/ m^2	Number of grain/ spike	1000 grain weight(g)
Control	62.1	155	20	22.3
N_{40} $P_{40}K_{40}$	85.6	251	34	27.8
N_{40} P_{80} K_{40}	86.8	295	40	28.6
N_{80} P_{40} K_{40}	88.4	268	36	30.2
N_{80} P_{80} K_{40}	89.8	308	43	32.3
N_{120}	58.7	128	16	17.8
N_{120} K_{40}	60.4	141	18	18.6
N_{120} P_{40} K_{40}	87.3	314	42	33.1
N_{120} P_{80}	89.6	305	41	31.4
N_{120} P_{80} K_{40}	92.9	329	45	34.60
SEm+	**2.1**	**11**	**1.7**	**0.6**
CD at 5%	**6.3**	**33**	**5.1**	**1.8**

The application of N alone (N_{120}) and N K (N_{120} K_{40}) produced minimum number of spikes (128-141 m^2) which were lower to unfertilized (Control). The maximum number of spikes (329/m^2) was recorded with the balanced nutrients (N_{120} P_{80} K_{40}) treatment (Table -3). The number of grains per spikes varied from 16 in N_{120} to 45 in N_{120} P_{80} K_{40}. The control plots had 20 grains per spike. Similarly, 1000-grain weight increased from 17.8 g in N_{120} to 34.6 g in N_{120} P_{80} K_{40}. The minimum values of all these characters in N_{120} (N alone) and N_{120} K_{40} treatments resulted in the minimum grain yield of wheat.

The improvement in all these yield attributing characters with application of full dose of nutrients (N_{120} P_{80} K_{40}) provided maximum grain and straw yields. Recommended doses of nitrogen application along with phosphorus (N_{120} P_{80}) increased the plant height, yield attributing characters and grain yield over imbalanced (N_{120}, N_{120} K_{40}) or suboptimal doses of NPK fertilizers (Table 1). It is due to the diverse collective physiological role, played by N, P and K in various metabolic activities of wheat plant. Nambiar and Abrol (1989) also reported that the crop yield improved considerably with the application of P fertilizer over N which

further improved with balanced use of N, P and K fertilizers.

The overall yield data clearly indicated that the balanced use of NPK (N_{120} P_{80} K_{40}) produced the highest yield. The yield decreased significantly with suboptimal of imbalance doses of NPK fertilizers. The long-term application of nitrogenous fertilizers alone or with potassic fertilizers (without phosphorus) failed to respond over a span of 34 years. The yield responses of fertilizer N declined in wheat, whereas, responses to P and K increase over the years.

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