Research Article

Yield response of wheat to nitrogen and potassium fertilization

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Abstract

A field study was carried out to evaluate the impact of various nitrogen (N) and potassium (K) combinations on yield of wheat crop during winter 2012-2013. Two factorial randomized complete block design (RCBD) was used for the experiment. There were three levels of nitrogen (90, 120, 150 kg N ha⁻¹) and five levels of potassium (0, 30, 60, 90, 120 kg K₂O ha⁻¹). Nitrogen used at the rate of 150 kg ha⁻¹ significantly improved plant height, grains spike⁻¹, 1000 grain weight, biological and grain yields of wheat. Similarly, K application at 90 kg K₂O ha⁻¹ significantly enhanced plant height by 8%, grain spike⁻¹ by 11%, thousand grain weight by 18%, biological yield by 42% and grain yield by 27% over control however, further increase in K level to 120 kg K₂O ha⁻¹ did not significantly improve these parameters. It was concluded that N application at the rate of 150 kg ha⁻¹ in combination with 90 kg K₂O ha⁻¹ were optimum for achieving higher yield of wheat.

Keywords: Wheat; Nitrogen; Potassium; Yield; Fertilization

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important food grain crop grown worldwide. It ranks first in the world cereal crops accounting for 30% of all cereal food worldwide and is a staple food for over 10 billion people in as many as 43 countries of the world. It provides about 20% of the total food calories for the human race [1]. Farming systems have improved over the

years by increasing crop yields through the use of improved varieties and increased fertilizer inputs. Several authors claim that at least 30 to 50% of yield growth is attributable to commercial fertilizers [2]. However, fertilizer inputs are increased due to increasing world inhabitants and the growth of agriculture into less fruitful areas. It also enlarged fertilizers cost and reduced fertilizer effectiveness. Such as the

efficiency of nitrogen in grains production (maize, barley, wheat, rice, sorghum, millet, oats and rye) is about 33%, with 67% losses producing a 15.9 billion US\$ annual losses [3].

Nitrogen (N) occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein of which nitrogen is an essential constituent. Consequently to get more crop production in nitrogen deficient soils its application is essential [4]. Similarly, potassium (K) is the third important macro nutrient after nitrogen (N) and phosphorus (P) required by crop because it has an important osmotic role in plants efficiency, enzyme activation, carbohydrate and proteins syntheses [5] energy relations and assimilates translocation [6]. Shorter internodes, weaker straw, increased lodging and slower growth are the resulted symptoms of K deficiency.

N and P fertilization have played a major role in increasing wheat yield. However, wheat production sometimes is limited because farmers give little attention to K application. Due to the limited potash resources in Pakistan and increasing fertilizer cost, efficient application of K along with N is very important. Most of Pakistani soils are deficient in available N and K and it must be supplemented through fertilizers for the better growth and productivity.

Keeping in view the importance of N and K fertilizer application for improved wheat yield and quality, this experiment was initiated to study the response of qualitative and quantitative parameters of wheat to different N and K levels in an alkaline calcareous soil.

Materials and methods

An experiment was conducted in two factors factorial RCB design with three replications to evaluate the impact of three different nitrogen (90, 120, 150 kg N ha⁻¹) and five

potassium (0, 30, 60, 90, 120 kg K₂O ha⁻¹) levels on yield and yield components of wheat at Agronomy Research Farm, the University of Agriculture, Peshawar during winter 2013-14. The field was properly prepared and divided into plots of an area 3m x 5m. At the time of sowing whole K and half of N as per proposed treatment were applied while half N was applied at tillering stage. Basal dose of P at the rate of 90 kg P₂O₅ was also applied to all experimental units. Urea, SSP and SOP were used as fertilizer sources for N, P and K, respectively. Wheat variety (Siren) at the rate of 120 kg seed ha⁻¹ was planted in 30 cm apart rows. Normal cultural practices were followed throughout the growing season. Data were recorded on days to anthesis, plant height, grains spike⁻¹, 1000 grain weight, biological and grain yield. For composite soil sample, pH and EC were determined in 1:5 soils: water suspension by the method of [7, 8], respectively. Hydrometer method was used to find soil texture as per procedure described by [9]. [10] method was used to find soil organic matter content. Soil lime content was found by acid neutralization method of US salinity staff (1954). Kjeldahl method of [11] was used to find soil total N. AB-DTPA extractable P in soil samples was determined by [12].

A composite soil samples at the depth of 0-30 cm was taken before treatment application into the plots and analyzed. The soil of experimental site was silt loam in texture, alkaline in reaction, highly calcareous and non-saline, poor in organic matter, inadequate in total N and AB-DTPA extractable P contents (Table 1.)

For the statistical analysis of collected data procedure of [13] was used while using Statistix 8.1 package and for any significant difference among the treatments least significant difference (LSD) test was used.

Table 1. Physico chemical characteristics of experimental site

Property	Concentration	Units
Textural class	Silt loam	-
EC _e	2.75	d Sm ⁻¹
pH	7.58	-
Organic matter	0.74	%
Lime	18.6	%
P (AB-DTPA extractable)	2.24	mg kg ⁻¹
Total N content	0.09	%

Results and discussion

Days to Anthesis

Days to anthesis increased gradually with increasing levels of nitrogen. Maximum numbers of 138.33 days were taken to anthesis with the application of N at 150 kg ha⁻¹. Nitrogen applied at of 90 or 120 kg ha⁻¹ showed 134 days to anthesis indicating that N fertilizer prolong period to anthesis (Table 2). However, potash fertilizer did not significantly affect days to anthesis in wheat (Table 2). The results of [14] are in line with our findings, who reported that days to anthesis of wheat increased with the increase application of nitrogen.

The interactive effect of N and K on days to anthesis in wheat was found significant. The maximum number of 139.4 days were taken to anthesis with the combined application of at 150 kg N ha⁻¹ without K application. This was however statistically at par with that (139, 138, 138.4 and 137 days taken to anthesis) with combined application of N at 150 kg along with K at 30, 60, 90 or 120 kg ha⁻¹, respectively. The minimum number of 131 days were taken to anthesis with the combine application of 90 kg N and 60 kg K ha⁻¹. Similarly [15] also reported significant differences among different N and K rates for days to anthesis.

Table 2. Days to Anthesis as affected by combined application of N and K

Potassium (kg ha ⁻¹)	Nitrogen (kg ha ⁻¹)			Mean
	90	120	150	
	Days to anthesis			
0	133.0 efg	134.7 cdef	139.4 a	135.6
30	132.0 fg	131.0 g	139.0 a	134.0
60	131.4 fg	133.7 defg	138.0 ab	134.4
90	135.0 cde	132.0 fg	138.4 ab	135.2
120	132.4 efg	136.0 bcd	137.0 abc	135.2
Mean	132.8 b	133.5 b	138.4 a	

LSD (5%) for N = 1.26, K = NS, N*K = 1.3

Plant height

Results regarding plant height are presented in Table 3. Both nitrogen and potassium showed significant effects on plant height of wheat. The plant height increased gradually with increasing levels of nitrogen and potassium. On average, among the N treatments, maximum plant height of 88 cm

was obtained with the application of N at 150 kg ha⁻¹ which was statistically similar to 86.4 cm produced with 120 kg N ha⁻¹, but significantly higher than 84.6 cm observed at 90 kg N ha⁻¹. With respect to the response of plant height to potassium, maximum plant height of 89.2 cm was obtained with 120 kg K₂O ha⁻¹ which was statically at par with

that obtained with 90, 60 and 30 kg $\text{K}_2\text{O ha}^{-1}$ but significantly greater than control. It was evident from these results that application of potassium even at the lowest level of 30 kg $\text{K}_2\text{O ha}^{-1}$ significantly increased plant height of wheat over the control treatment. Similar results have also been reported by [16] where nitrogen and K_2O application had positive effects on plant height of which crop?

The interactive effect of N and K on plant height of wheat was significant. The taller

plants (91.3 cm) were recorded with the combined application of NK at 90: 90 kg ha^{-1} , it was statistically similar to plant height produced at all NK combination except those which received no potassium. The lowest plant height (70.8 cm) was obtained at 90 kg N used without K application. Similar results were also reported by [17] where higher and equal proportion of N and K significantly increased plant height, grain yield and biological yield of wheat crop.

Table 3. Plant height affected by combined application of N and K

Potassium (Kg ha ⁻¹)	Nitrogen (Kg ha ⁻¹)			Mean	Increase By potassium
	90	120	150		
	Plant height (cm)				
0	70.8 d	80.2 c	84.3 bc	78.4 b	0%
30	86.3 ab	86.6 ab	89.9 a	87.6 a	8%
60	87.0 ab	86.9 ab	86.6 ab	86.9 a	6%
90	91.3 a	87.2 ab	89.8 a	89.4 a	8%
120	87.7 ab	91.0 a	89.0 ab	89.2 a	9%
Mean	84.6 b	85.8 b	88.5 a		

LSD (5%) for N = 2.29, K = 2.95 and N*K = 5.12

Grains spike⁻¹

Grain per spike increased significantly with the increase in nitrogen and potassium level (Table 4). On average, the maximum number of grains (45.4) were produce at 120 kg N ha^{-1} . N application at the rate of 150 kg ha^{-1} produced 44.8 grains per spike that was significantly greater than 90 kg N ha^{-1} . Similarly, on average the highest grain per spike (46.4) was observed at 120 kg $\text{K}_2\text{O ha}^{-1}$ and this was significantly greater than K_2O applied at the rate of 30 and 60 kg ha^{-1} , whereas lower number of grain per spike of 46.1 was recorded for control. It was evident that application of potassium even at the lowest level of 30 kg ha^{-1}

significantly increased number of grain per spike of wheat over the control treatment. The same results were also reported by [18]. They reported that number of grains per spike increased with the increase in NK levels

The interactive effect of N and K on number of grain per spike of wheat was significant. The higher number of grain per spike (50) was obtained with the combined application of 150 kg N and 120 kg $\text{K}_2\text{O ha}^{-1}$ while the lowest number of grain per spike (39.3) was obtained with the application of N at the rate of 90 kg N ha^{-1} alone. Similarly [19] also reported that grains per spike increase with the increase in application of NK levels.

Table 4. Grains spike⁻¹ as affected by combined application of N and K

Potassium (Kg ha ⁻¹)	Nitrogen (Kg ha ⁻¹)			Mean	% Increase By potassium
	90	120	150		
	Grains spike ⁻¹				
0	39.3 g	42.3 f	43.3 ef	41.6 d	0
30	43.6 def	42.6 f	42.6 f	43.0 c	4
60	43.6 def	45.6 bcd	45.0 cde	44.7 b	8
90	42.6 f	50.0 a	46.0 bc	46.2 a	11
120	45.4 bcde	46.4 bc	47.4 b	46.4 a	12
Mean	42.9 b	45.4 a	44.8 a		

LSD (5%) for N = 0.97, K= 1.26 & N*K = 2.18

1000- Grain weight

Data on 1000 grain weight as affected by different levels of N and K fertilizer are shown in Table 5. 1000 grain weight increase significantly with the increasing trend in nitrogen and potassium. On the average maximum 1000 grain weight (37.7 g) was obtained at 150 kg N ha⁻¹. The 1000 grain weight of 36.7 g were produced at 90 kg N ha⁻¹ that was significantly higher than 90 kg N ha⁻¹ and statistically similar to that of N applied at 150 kg ha⁻¹. These findings are in line with those of [17] who reported that higher N application had positive effect on 1000 grain weight. Furthermore, these findings suggested that different N and K levels influenced to 1000 grain weight. With respect to the response of 1000 grain weight to potassium on average, the maximum 1000 grain weight of 39.9 g were noted for 90 kg K₂O ha⁻¹ and this was statistically different from the rest of K₂O levels, however 1000 grain weight produced at 120 and 60 kg K₂O ha⁻¹ were statistically

similar. Minimum 1000 grain weight of 34 g was observed for control treatment that was statistically at par as K₂O applied at the rate of 30 kg ha⁻¹. It was evident from these results that K₂O applied 60 kg ha⁻¹ significantly increased 1000 grain weight.

The interactive effect of N and K was also significant. On the average maximum 1000 grain weight of 42.4g was recorded for application of 120kg N ha⁻¹ in combination with 90 kg K₂O ha⁻¹. Minimum 1000 grain weight was recorded for the N and K application at the rate of 90:0 kg ha⁻¹ however it was statistically similar to NK applied at the rate of 120:0, 90:30, 120:30 or 150:120 kg ha⁻¹. Our result match with the finding of [19] who also found that 1000 grain weight of wheat is significantly increased with the application of N and K fertilizers as compared to control and their findings showed maximum 1000 grain weight of 44.5 g for N and K applied at the rate of 120:90 kg ha⁻¹ respectively.

Table 5. 1000 grains weight as affected by combined application of N and K

Potassium (Kg ha ⁻¹)	Nitrogen (Kg ha ⁻¹)			Mean	% increase by Potassium
	90	120	150		
	1000 grain weight (g)				
0	32.7 f	34.1 ef	35.0 de	33.9 d	0
30	33.8 ef	35.2 def	35.8 de	34.9 cd	3
60	35.9 de	37.8 bcd	39.0 bc	37.5 b	11
90	37.2 cd	42.4 a	40.3 ab	39.9 a	18
120	36.6 cd	32.1 bc	33.5 ef	36.6 bc	10
Mean	35.4 b	36.7 a	37.7 a		

LSD (5%) for N = 1.3, K= 1.7 & N*K= 2.96

Biological yield

The result showed that biological yield of wheat improved with increasing levels of N fertilizer Table 6. This was somehow surprising as our soils are mostly deficient in N and positive response is obtained almost everywhere in Pakistan. [20] Who reported dry matter production increased with increase in level of nitrogen. On average, the maximum biological yield of 6398 kg ha⁻¹ was obtained with the application at 150 kg N ha⁻¹ and the lowest yield of 5893 kg ha⁻¹ was obtained with N at 90 kg N ha⁻¹. However the differences in biological yield for 120 and 150 kg N ha⁻¹ were non-significant. The biological yield however responded positively to the K levels. The biological yield of wheat increased gradually with the increase levels of K. On average, the maximum biological yield of 7067 kg ha⁻¹ was obtained with the application of potassium at 120 kg K₂O ha⁻¹ and this was statistically at par with that obtained with 90 kg K₂O ha⁻¹ but was significantly greater than those obtained with lower K levels (60 and 30 kg K₂O ha⁻¹). It was evident that application of

potassium even at the lowest level of 30 kg K₂O ha⁻¹ significantly increased the biological yield of wheat over the control treatment. The previous finding of [19] are in close proximity with our findings who reported that biological yield increased significantly with the increase in potassium levels. However, differences in biological yield obtained with 30 or 60 kg K₂O ha⁻¹ were statistically non-significant.

The interactive effect of N and K on biological yield of wheat was also significant. The greatest biological yield of 7678 kg ha⁻¹ was obtained with the combined application of N at 120 kg and K at 120 kg ha⁻¹. This was however, statistically at par with that (6600 kg ha⁻¹) obtained with combined application of N at 120 kg and K at 90 kg ha⁻¹. The lowest biological yield was obtained at 90 N kg alone but this was statistically at par with those obtained with N at 120 kg or 150 kg with no K or N at 90 kg and K at 30 kg ha⁻¹ or N at 120 kg and K at 30 kg ha⁻¹. Similarly [21-22] observed increase in dry matter yield of wheat due to combine application of N and K.

Table 6. Biological yield as affected by combined application of N and K

Potassium (Kg ha ⁻¹)	Nitrogen (Kg ha ⁻¹)			Mean	% Increase by potassium
	90	120	150		
	Biological yield (Kg ha ⁻¹)				
0	5022 ef	5044 def	4878 f	4981.4 d	0
30	6467 b	5522 cde	5611 cd	5866.6 c	18
60	6622 b	6633 b	6556 b	6603.7 b	33
90	6922 b	7678 a	6600 b	7066.8 a	42
120	6956 b	6789 b	5822 c	6522.4 b	31
Mean	5893.2 b	6333.4 a	6398.0 a		

LSD (5%) for N = 409.2, K = 486.5 & N*K = 626.3

Grain yield (kg ha⁻¹)

Both nitrogen and potassium significantly increased the grain yield of wheat Table 7. The yield increased gradually with increasing levels of nitrogen and potassium. On average, the maximum grain yield (2647

kg ha⁻¹) was obtained with the application of N at the rate of 150 kg ha⁻¹. The yield (2502 kg ha⁻¹) produced with 120 kg N ha⁻¹ was significantly greater than that produced (2361 kg ha⁻¹) with 90 kg N ha⁻¹ but was significantly lower than that produced with

150 kg N ha⁻¹. [23, 24] observed that nitrogen application increase grain yield of wheat when compared to control. Similarly the average maximum grain yield (2775 kg ha⁻¹) was obtained with the application of potassium at 120 kg K₂O ha⁻¹ and this was statistically at par with that obtained with 90 kg K₂O ha⁻¹ but was significantly greater than those obtained with lower K levels (60 or 30 kg K₂O ha⁻¹). It was evident that application of potassium even at the lowest level of 30 kg K₂O ha⁻¹ significantly increased the grain yield of wheat over the control treatment.

However differences in grain yield obtained with 30 or 60 kg K₂O ha⁻¹ were statistically non-significant. The same results were also obtained by [25, 26] they reported that

Table 7. Grain yield as affected by combined application of N and K

Potassium (Kg ha ⁻¹)	Nitrogen (Kg ha ⁻¹)			Mean	%Increase by potassium
	90	120	150		
	Grain yield (Kg ha ⁻¹)				
0	2094 f	2219f	2226 f	2180 c	0
30	2235 f	2285 ef	2692 c	2404 b	10
60	2554 cd	2692 c	2538 cde	2476 b	14
90	2746 bc	2977 ab	2746 bc	2686 a	27
120	2746 bc	2696 c	3035 a	2775 a	33
Mean	2361c	2502 b	2647 a		

LSD (5%) for N =119.9, K =154.8 & N*K= 268.1

Conclusions and recommendations

Wheat yield and yield components significantly improved with the applications of nitrogen and potassium. It is therefore recommended that nitrogen and potassium should be applied at the rate of 150: 90 kg ha⁻¹ for the optimum yield of wheat crop under prevailing soil and climatic conditions of Peshawar, Paksitan.

Authors' contributions

Conceived and designed the experiments: M Adnan, Z Shah, H Ullah & IU Rahman, Performed the experiments: GA khan, M Arshad & B khan, Contributed reagents/ materials/ analysis tools: IA Mian, Wrote the paper: A Basir, M Ali & WU khan.

application of potassium even at lowest level significantly increase grian yield of wheat.

The interactive effect of N and K on grain yield of wheat was also significant. The highest t grain yield of 3035 kg ha⁻¹ was obtained with the combined application of 150 kg N and 120 kg K₂O ha⁻¹. This was however statistically at par with that (2077 kg ha⁻¹) obtained with combined application of N at 120 kg and K at 90 kg ha⁻¹. The lowest grain yield of 2094 kg ha⁻¹ was obtained with the application of 90 kg N ha⁻¹ with control K but this was statistically at par with those obtained with N at 120 kg or 150 kg with no K or N at 90 kg and K at 30 kg ha⁻¹ or N at 120 kg and K at 30 kg ha⁻¹. [19] has reported that different levels of N and K affected grain yield significantly.

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