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## Research Article

# Effect of potassium ($K^+$) on growth, yield components and macronutrient accumulation in Wheat crop

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**Abstract**

Plant growth, nutrient uptake and yield can be sustained by the application of potassium fertilization. A pot experiment was conducted to study the effect of macronutrients accumulation of wheat about different potassium rates.The results revealed that the effect of different potassium levels on the growth and grain yield of wheat was significant. The application of potassium at 100% increased the most of the growth, yield components and accumulation of nutrients in wheat crop from 20−50% as compared to (control) the plots receiving no potassium application. In comparison to control, potassium application at 75% also significantly increased growth and yield components from 8−40%, however, potassium application of 50 and 25% increased the growth and yield components by 4−20%. As compared to plots receiving no potassium, application of potassium resulted 3−6% higher nitrogen content in grain and 2−11% higher nitrogen content in straw. While, potassium application increased the potassium contents by 50−154% in grain and 70-140% contents of potassium in straw as compared to control plots. However, in comparison to plots without potassium nutrition, application of potassium fertilization improved phosphorus contents by 2−10% in grain and 3-50% in straw of wheat crop. Among potassium levels of 25%, 50%, 75% and 100% were significant indicating that potassium at the rate of 100% was an optimum level for obtaining maximum grain yields in wheat crop. This study concluded that application of potassium nutrition increased the all growth, yield comonents and accumumation of nitrogen, phosphorus and potassium contents in grain and straw of wheat crop.

**Keywords**: Macronutrients; Potassium; Wheat

## Introduction

Wheat (*Triticum aestivum* L.) is a staple food of billions of people in the world which provides the main energy requirement of the human diet over all the world. The world would require approximately 840 million tons of wheat by 2050 from its current production level of 642 million tones which is supplying 68% of the calories and protein in the diet [1].Among wheat producing countries Pakistan is included in top ten of the world [2].Among nutrients applied in wheat, Potassium is most important element for growth of plant and plays a vital role in photosynthesis enzyme action, production of protein, carbohydrates and enabling to resist against pest and diseases [3]. Our country's soils obtain most and relatively large amount of total $K^+$as component of insoluble minerals, however only a small portion is available to plants[4].Applying of inadequate amount of Potassium fertilizer dose on sandy loam and silt soils for several years may lead to Potassium lack and yield loss [6].$K^+$ deficiency restricts sustainable crop production, especially wheat crop. Hence, the information about $K^+$ requirement of wheat through balanced fertilization is very necessary which in-turn based upon determining the $K^+$status of soils. Potassium plays a vital role in the plants especially in cell metabolism, activate enzyme activity and enhanced the plant growth and crop quality [7-9].

**Materials and methods**

A pot experiment was conducted to assess the result of various rates of potassium on macronutrient accumulation in wheat crop. The experiment was conducted at Department of Soil Science, Sindh Agriculture University, and Tandojam. The details of experiment are given as under.

**Experimental description**

**Variety**: TD-1 The experimental design was randomized complete block design (RCBD) with four replication and soil filling capacity of each pot was 12 kg Treatments K rates kg $K_2O$ $ha^{-1}$

**Treatments five** $T_1$ =Control, $T_2$ = 25 kg $K_2O$ $ha^{-1}$**,** $T_3$ = 50 kg $K_2O$ $ha^{-1}$**,** $T_4$ = 75 kg $K_2O$ $ha^{-1}$**,** $T_5$ =100 kg $K_2O$ $ha^{-1}$.

**Fertilizer application:** Potassium was applied as Sulphate of potash (SOP) according to designed treatments. All the plots received recommended rate of nitrogen as urea and phosphorus as single super phosphate (SSP). Full dose of Phosphorus and Potassium was added at the sowing time, while Nitrogen was applied in two equal splits.

**Soil analysis:** Soil texture, soil pH, EC (dS $m^{-1}$), organic matter (%), lime content (%), total nitrogen (%), available Phosphorus (mg $kg^{-1}$), AB-DTPA extractable Potassium (mg $kg^{-1}$).

**Plant analysis:** Grain and straw samples were used to analyze nitrogen content (%), phosphorus content (%), and potassium content (%).

**Harvesting:** Crop was harvested at maturity. All the growth and biomass parameters were recorded.

**Statistical analysis:** The soiland plant data were statisticallyanalyzedusing appropriate statistical procedures. Mean separations were done by CV, SE and LSD by using Statistics version 8.1.

**Results**

**Plant height (cm)**

The effect of potassium levels on plant height of the wheat crop was assessed,and the results are presented in (Table 1).The highest results plant height (60.57 cm) was found in plots fertilized with 100% potassium, closely 75% potassium which resulted in average plant height of 53.22 cm.The plant height reduced to 48.17 cm, and 43.87 cm when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$**.** However, the lowest plant height of 41.22 cm was found in control, without fertilizer. Moreover, the addition of potassium showed beneficial effects on plant height. The LSD test suggested that statistically, the

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differences in plant height between potassium levels of 25,50,75,100 were significant (P<0.05).

**Spike length (cm)**

The effect of potassium levels on spike length of the wheat crop was assessed,and the results are presented in (Table 1).The highest results spike length (9.05 cm) was observed in plots fertilized with 100 kg $K_2O$ $ha^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average spike length of 8.35 cm. The spike length reduced to 8.05 cm, and 7.72 cm when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$,. However, the lowest spike length of 7.45 cm was oberved in control, without fertilizer. Moreover, the addition of potassium showed beneficial effects on spike length. The LSD test suggested that statistically, the differences in spike length between potassium levels of 25,50,75,100 were significant (P<0.05)

**Spikelet's spikeper plant**

The effect of potassium levels on spikelet's spikeper plant of the wheat crop was assessed,and the results are presented in (Table 1).The highest results spikelet's spikeper plant (11.97) were noted in plots fertilized with 100 kg $K_2O$ $ha^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average spikelet's spikeper plant of 10.95. The spikelet's spikeper plant reduced to 10.45, and 9.95 when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$. However, the lowest spikelet's spikeper plant of 9.42was found in control, without fertilizer. Moreover, the addition of potassium showed beneficial effects on spikelet's spikeper plant. The LSD test suggested that statistically the differences in spikelet's spikeper plant between potassium levels of 25,50,75,100 were significant P<0.05).

**Grains spike plant**

The effect of potassium levels on grains spikeper plant of the wheat crop was assessed,and the results are presented in (Table 1). The highest results grains per spike (32.47) was found in plots fertilized with 100 kg $K_2O$ $ha^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average grains spikeper plant of 29.50. The grains per spike reduced to 27.45, and 25.55 when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$. However, the lowest grains spikeha$^{-1}$of 23.65was recorded in observed, where no fertilizer was applied. Moreover, the addition of potassium showed beneficial effects on grains per spike. The LSD test suggested that statistically, the differences in grains spike$^{-1}$ between potassium levels of 25,50,75,100 were significant (P<0.05).

**Seed Index (1000 grain weight in g)**

The effect of potassium levels on seed index (1000 grain weight in g) of the wheat crop was assessed,and the results are presented in (Table 1). The highest results seed index (32.20 g) was observed in plots fertilized with 100 kg $K_2O$ha$^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average seed index of 29.13 g. The seed index reduced to 25.38 g, and 24.02 g when potassiumwas used at the rate of 50% and 25 kg $K_2O$ $ha^{-1}$. However, the lowest seed index of 23.00 gwas noted in control, without fertilizer. Moreover, the addition of potassium showed beneficial effects on seed index. The LSD test suggested that statistically the differences in seed index (1000 grain weight in g) between potassium levels of 25,50,75,100 were significant (P<0.05).

**Grain yield/ plant (g)**

The effect of potassium levels on grain yield plant$^{-1}$ (g) of the wheat crop was assessed,and the results are presented in (Table 1). The highest results grain yield per plant (11.25 g) was found in plots fertilized with 100 kg $K_2O$ $ha^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average grain yield per plant of 10.65 g, respectively. The grain yield per plant reduced to 10.02 g, and 9.25 g when potassiumwas used at the rate of 50 kg $K_2O$ ha$^{-1}$and 25 kg $K_2O$ ha$^{-1}$. However, the lowest grain yield per plant of 8.55 gwas observed incontrol, without fertilizer. Moreover, the addition of potassium showed beneficial effects on grain yield per plant. The LSD test suggested that statistically, the differences in grain yield per plant (g) between potassium levels of 25,50,75,100 were significant ($P<0.05$).

**Straw yield/ plant (g)**

The effect of potassium levels on straw yield per plant (g) of the wheat crop was assessed,and the results are presented in (Table 1). The highest results straw yield per plant (12.42 g) was observed in plots fertilized with 100 kg $K_2O$ ha$^{-1}$potassium, closely 75 kg $K_2O$ ha$^{-1}$potassium which resulted in average straw yield per plant of 11.42 g. The straw yield per plantreduced to 11.05 g, and 10.42 g when potassiumwas used at the rate of 50 kg $K_2O$ ha$^{-1}$and 25 kg $K_2O$ per ha$^{-1}$. However, the lowest straw yield per plant of 9.95 gwas noted in control, without fertilizer. Moreover, the addition of potassium showed beneficial effects on straw yield per plant. The LSD test suggested that statistically, the differences in straw yield per plant (g) between potassium levels of 25, 50, 75, 100 were significant ($P<0.05$).

**Table 1. Effect of potassium levels on agro-traits of wheat crop**

| Treatments | Plant height (cm) | Spike length (cm) | Spikelets spike$^{-1}$ | Grain spike$^{-1}$ | Seed Index (g) | Grain yield plant$^{-1}$ (g) | Straw yield plant$^{1}$ (g) |
|---|---|---|---|---|---|---|---|
| K0 | 41.22 E | 7.45 E | 9.42 E | 23.65 E | 23.00 E | 8.55 E | 9.95 E |
| K25 | 43.87 D | 7.72 D | 9.95 D | 25.55 D | 24.02 D | 9.25 D | 10.42 D |
| K50 | 48.17 C | 8.05 C | 10.45 C | 27.45 C | 25.38 C | 10.02 C | 11.05 C |
| K75 | 53.22 B | 8.35 B | 10.95 B | 29.50 B | 29.13 B | 10.65 B | 11.42 B |
| K100 | 60.57 A | 9.05 A | 11.97 A | 32.47 A | 32.20 A | 11.25 A | 12.42 A |
| CV | 0.59 | 1.50 | 1.33 | 0.63 | 0.63 | 0.43 | 1.06 |
| SE | 0.2062 | 0.0861 | 0.0990 | 0.1238 | 0.1200 | 0.0303 | 0.0829 |
| LSD (0.05) | 0.4492 | 0.1876 | 0.2156 | 0.2698 | 0.2615 | 0.0660 | 0.1807 |

**Nitrogen content in grain (%)**

The nitrogen content in grain of wheat crop was assessed,and the results are presented in (Table 2).The highest results of nitrogen content in grain (2.03%) was found in plots fertilized with 100 kg $K_2O$ ha$^{-1}$potassium, closely 75 kg $K_2O$ha$^{-1}$potassium which resulted in average nitrogen content in grain of 2.02%. The nitrogen content in grain reduced to 1.99%, and 1.95% when potassiumwas used at the rate of 50 kg $K_2O$ ha$^{-1}$and 25 kg $K_2O$ ha$^{-1}$. However, the lowest nitrogen content in grain of 1.91%was recorded in control, without fertilizer.

**Nitrogen content in straw (%)**

The nitrogen content in the straw of wheat crop was assessed,and the results are presented in Table-2.The highest results of nitrogen content in straw (0.68%) was noted in plots fertilized with 100 kg $K_2O$ ha$^{-1}$potassium, closely 75 kg $K_2O$ ha$^{-1}$potassium which resulted in average nitrogen content in the straw of 0.67%. The nitrogen content in straw reduced to 0.65%, and 0.62% when potassiumwas used at the rate of 50 kg $K_2O$ha$^{-1}$and 25 kg $K_2O$ ha$^{-1}$. However, the lowest nitrogen content in the straw of 0.61%was observed in control, without fertilizer.

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**Table 2. Effect of potassium levels on different ions concentration of wheat crop**

| Treatments | Nitrogen content in grain (%) | Nitrogen content in straw (%) | Potassium content in grain (%) | Potassium content in straw (%) | Phosphorus content in grain (%) | Phosphorus content in straw (%) |
|---|---|---|---|---|---|---|
| K0 | 1.91 D | 0.61 C | 0.24 C | 1.02 D | 0.40 C | 0.02 B |
| K25 | 1.95 C | 0.62 C | 0.37 B | 1.94 C | 0.41 BC | 0.02 B |
| K50 | 1.99 B | 0.65 B | 0.39 B | 2.07 BC | 0.41 BC | 0.02 B |
| K75 | 2.02 A | 0.67 A | 0.53 A | 2.23 AB | 0.42 AB | 0.03 B |
| K100 | 2.03 A | 0.68 A | 0.54 A | 2.43 A | 0.44 A | 0.04 A |
| CV | 0.73 | 2.01 | 8.01 | 7.15 | 2.60 | 25.22 |
| SE | 0.0103 | 9.22003 | 0.0236 | 0.0982 | 7.69203 | 5.43903 |
| LSD (0.05) | 0.0224 | 0.0201 | 0.0515 | 0.2139 | 0.0168 | 0.0119 |

**Potassium content in grain (%)**

The potassium content in grain of wheat crop was assessed,and the results are presented in Table-2.The highest results of potassium content in grain (0.54%) was recorded in plots fertilized with 100 kg $K_2O$ $ha^{-1}$potassium, closely 75 kg $K_2O$ $ha^{-1}$potassium which resulted in average potassium content in grain of 0.53%.The potassium content in grain reduced to 0.39%, and 0.37% when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$. However, the lowest potassium content in grain of 0.24%was found in control, without fertilizer.

**Potassium content in straw (%)**

The phosphorus content in the straw of wheat crop was assessed,and the results are presented in Table-2.The highest results of phosphorus content in straw (2.43%) was found in plots fertilized with 100 kg $K_2O$ $ha^{-1}$phosphorus, closely followed by 75 kg $K_2O$ $ha^{-1}$phosphorus which resulted in average phosphorus content in the straw of 2.23%. The phosphorus content in straw reduced to 2.07%, and 1.94% when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2O$ $ha^{-1}$. However, the lowest phosphorus content in the straw of 1.02%was recorded in control, without fertilizer.

**Phosphorus content in grain (%)**

The phosphorus content in grain of wheat crop was assessed,and the results are presented in Table-2.The highest results of phosphorus content in grain (0.44%) was noted in plots fertilized with 100 kg $K_2O$ $ha^{-1}$phosphorus, closely 75 kg $K_2O$ $ha^{-1}$phosphorus which resulted in average phosphorus content in grain of 0.42%. The phosphorus content in grain reduced to 0.41%, and 0.41% when potassiumwas used at the rate of 50 kg $K_2O$ $ha^{-1}$and 25 kg $K_2Oha^{-1}$. However, the lowest phosphorus content in grain of 0.40%was found in control, without fertilizer.

**Phosphorus content in straw (%)**

The phosphorus content in the straw of wheat crop was assessed,and the results are presented in Table-2.The highest results of phosphorus content in straw (0.04%) was recorded in plots fertilized with 100 kg $K_2Oha^{-1}$phosphorus, closely 75 kg $K_2O$ $ha^{-1}$phosphorus which resulted in average phosphorus content in the straw of 0.03%. The phosphorus content in straw reduced to 0.02%, and 0.02% when potassium was applied at the rate of 50 kg $K_2Oha^{-1}$and 25 kg $K_2O$ $ha^{-1}$. However, the lowest phosphorus content in the straw of 0.02%was found in control, without fertilizer**.**

**Characteristics of expérimental soil**

In (Table 3), it is indicated that the soil of experiment was silty clay in texture with silt (51.1 %), clay (48.4 %), and (0.5 %) sand, silt and clay, respectively and EC were 1.37 dS $m^{-1}$, pH 7.5, organic matter (0.86 %), AB-DTPA Phosphorous (4.2 mg $kg^{-1)}$ and AB-DTPA Potassium 93 mg $kg^{-1}$.

**Table 3. Characteristics of expérimental soil**

| Characteristics | Values |
|---|---|
| **a. Mechanical properties** | |
| Textural class | Silty clay |
| Sand (%) | 0.5 |
| Silt (%) | 51.1 |
| Clay (%) | 48.4 |
| **b. Physico-chemical properties** | |
| EC (dS $m^{-1}$) (1:2.5 soil water extract) | 1.37 |
| pH (1:2.5 soil water suspension) | 7.5 |
| Organic matter (%) | 0.86 |
| Phosphorus – ABDTPA (mg $kg^{-1}$) | 4.2 |
| Potassium – ABDTPA (mg $kg^{-1}$) | 93 |



## Discussion

Potassium is one of the nutrients essentially required for plant growth and grain development in wheat. Potassium depletion is reported in agricultural soils of Pakistan and low levels of potassium showing negative effects on the crop yields. Generally, sulfate of potassium and muriate of potassium are the forms of potassium fertilizers [10].

The results that effect of different potassium levels on the growth and grain yield of wheat was significant (P<0.05). The highest potassium level of 100%resulted in60.57 cm plant height, 9.05 cm spike length, 11.97spikelets spikeper plant 32.47 grains spikeper plant, 32.20 g seed index (1000 grain weight, g), 11.25 g grain yield per plant, 12.42 g straw yield per plant, 2.03% nitrogen content in grain, 0.68% nitrogen content in straw, 0.54% potassium content in grain, 2.43% phosphorus content in straw, 0.44% phosphorus content in grain and 0.04% phosphorus content in grain. The application of potassium at the rate of 75% resulted in53.22 cm plant height, 8.35 cm spike lengthper plant , 10.95 spikelets spike per plant ,29.50 grains spike per plant ,29.13 g seed index (1000 grain weight, g), 10.65 g grain yield plant per plant ,11.42 g straw yield plant per plant,2.02% nitrogen content in grain, 0.67 % nitrogen content in straw, 0.53% potassium content in grain, 2.23% phosphorus content in straw, 0.42% phosphorus content in grain and 0.03% phosphorus content in grain. Potassium fertilizers when applied at the rate of 50% resulted 48.17 cm plant height, 8.05 cm spike length, 10.45 spikelets spike per plant ,27.45 grains spike per plant ,25.38 g seed index (1000 grain weight, g), 10.02 g grain yield plant per plant ,11.05 g straw yield plant per plant,1.99% nitrogen content in grain, 0.65% nitrogen content in straw, 0.39% potassium content in grain, 2.07% phosphorus content in straw, 0.41% phosphorus content in grain and 0.02% phosphorus content in grain. The potassium fertilizer when applied at the rate of 25% produced 43.87 cm plant height, 7.72 cm spike length, 9.95 spikelets spike per plant , 25.55 grains spike per plant ,24.02 g seed index (1000 grain weight, g), 9.25 g grain yield plant per plant,10.42 g straw yield plant per plant ,1.95% nitrogen content in grain, 0.62% nitrogen content in straw, 0.37% potassium content in grain, 1.94% phosphorus content in straw, 0.41% phosphorus content in grain and 0.02% phosphorus content in grain. The plots having no potassium application (control) produced 41.22 cm plant height,7.45 cm spike length, 9.42 spikelets spike$^{-}$ per plant,23.65 grains spike per plant,23.00 g seed index (1000 grain weight, g), 8.55 g grain yield plant per plant,9.95 g straw yield plant per plant , 1.91% nitrogen content in grain, 0.61% nitrogen content in straw, 0.24% potassium content in grain, 1.02% phosphorus content in straw, 0.40% phosphorus content in grain and 0.02% phosphorus content in grain. The values for all the increase and grain yield components of wheat were markedly increased with application of potassium. Among potassium levels of 0%, 25%, 50%, 75% and 100% were significant ($P<0.05$) indicating that the potassium at the rate of 100% was an most effective level for acquiring economically higher grain yields plant per plant in wheat crop **[11]**. A researcher suggested 40 kg K per $ha^{-1}$for wheat, while recommended 50 kg $K^{+}$per$ha^{-1}$for optimizing the plant height regardless of varieties **[12]**. The tillering capacity under 100 kg $ha^{-1}$ potassium level was even lower than the value under control treatment, which reflects an adverse effect of higher amounts of $K^{+}$ on the crop **[12]**. The results also suggest that K application beyond 75 kg $ha^{-1}$was excessive and experimental soils reacted negatively and resulted in a considerable decrease in the tillering capacity **[13]**. **[14]** Suggested that tillering capacity improved by K application but excessive K use results in adverse effects on tillering capacity. One report suggested that 100 kg $ha^{-1}$ K application for increased more grains in spikes in wheat **[15]**. Similarly, one study recommended 75 kg $K_2O$ per hector for achieving desired results for grain weight spike per plant **[16]**. While **[17, 18]** concluded beneficial impacts of K application on growth and grain yield contributing traits of wheat. **[19]** Reported that K application at higher rates produced bolder and heavier grains; while **[20]** reported that there was significant increase 1000 grains weight of wheat under higher K application rates. **[21]** Suggested 80 kg $ha^{-1}$ K for achieving desired grain yield; while **[22]** found that growth and grain yield attributes of wheat improved significantly due to Potassium application in addition to Nitrogen and Phosphorous.**[13, 14]** emphasized the Potassium application in addition to Nitrogen and Phosphorous for achieving higher yields in wheat.

## Conclusions

The values for all the growth and grain yield components of wheat markedly increased with the application of potassium. Maximum Potassium rate of 100 kg $K_2O$ per $ha^{-1}$produced higher yields and increased the content of Nitrogen, Phosphorous and Potassiumin grain and straw of wheat.

## Authors' contributions

Conceived and designed the experiments: KH Talpur & MN Kandhro, Performed the experiments: GM Kubar, Analyzed the data: GM Kubar, KA Kubar & MS Kubar, Contributed materials/ analysis/ tools: GM Kubar, S Khashkhali & MM Nizamani, Wrote the paper: AA Kubar.

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