

IMPROVING WHEAT GROWTH AND PHYSIOLOGICAL EFFICIENCY WITH FOLIAR AUGMENTATION OF POTASH

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Abstract

Potassium (K) is an indispensable macronutrient that regulates plant growth, improves stress tolerance and boosts crop yield. A pot culture research was conducted at the Agriculture Research Institute, Dera Ismail Khan, during the 2022–2023 growing season to estimate the special effects of foliar-applied potash (K_2O) on wheat growth and yield. Treatments comprised 0 (control), 1%, 2%, 3%, and 4% K_2O applied at the tillering and booting stages. Results showed that 3% K_2O significantly enhanced plant height (85.3 ± 2.1 cm), tiller count (4.5 ± 0.3 plant⁻¹), LAI (3.4 ± 0.2), chlorophyll content (46.7 ± 1.5 SPAD), photosynthetic rate (16.2 ± 0.5 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), transpiration rate (4.5 ± 0.2 $\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$), stomatal conductance (0.35 ± 0.02 $\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$), biomass accumulation (36.5 ± 1.8 g plant⁻¹), and grain yield (14.8 ± 0.9 g plant⁻¹). However, at 4% K_2O , insignificant reductions were experiential in some parameters, signifying that excessive potassium application may have antagonistic effects. The results indicate that 3% K_2O is the optimal concentration for improving wheat productivity under controlled conditions.

Keywords: “Wheat”, “Potash”, “Foliar Application”, “Growth”, “Yield”, “Photosynthesis”, “Stomatal Conductance”, “Biomass Accumulation”, “Pot Experiment”.

INTRODUCTION

Potassium (K) is a vital macro-nutrient required for several physiological and metabolic functions in plants, counting enzyme activation, photosynthesis, osmotic regulation and stress tolerance (Gu X,). It plays a very crucial role in enhancing crop productivity by augmenting nutrient uptake efficiency, increasing drought stress resistance and stimulating grain filling (Gul H,). Wheat (*Triticum aestivum* L.) is a principal food crop, and optimizing its nutrient management is essential for sustainable agricultural production.

Foliar application of potash (K_2O) has gained attention as an effective strategy for addressing potassium deficiencies, particularly in dry regions where soil potassium availability is often limited (Khan MZ,). Unlike soil-applied fertilizers, foliar potassium application ensures direct absorption by plant tissues, leading to a rapid physiological response and improved nutrient use efficiency (Sakara HM,) (Ishfaq M,).

Several studies have reported the positive impact of foliar-applied K on cereal crops. For instance, Zareian et al. (Zareian A,) demonstrated that moderate foliar K_2O application improved wheat biomass and grain yield. However, excessive potassium application can lead to ion toxicity, nutrient imbalances, and reduced efficiency of other essential elements such as calcium and magnesium (Sharma S,) (Rahman A,).

This study aims to evaluate the optimal foliar K_2O concentration for maximizing wheat growth and yield under controlled pot conditions. It is hypothesized that an appropriate dose of K_2O will enhance biomass production, chlorophyll content, photosynthetic efficiency, and grain yield, while excessive application may have diminishing effects.

MATERIALS AND METHODS

Experimental Site and Design

A pot experiment was conducted at the Arid Zone Research Center, Dera Ismail Khan, during the 2022–2023 wheat growing season. The experiment followed a completely randomized design (CRD) with five treatments and four replications. Each pot contained 10 kg of loamy soil, and wheat seeds (cv. Faisalabad-2008) were sown at a density of 5 plants per pot.

Treatment Plan

The experiment included the following foliar potash (K_2O) treatments, applied at the tillering and booting stages:

- T₀: Control (no K_2O application)
- T₁: 1% K_2O solution
- T₂: 2% K_2O solution
- T₃: 3% K_2O solution
- T₄: 4% K_2O solution

Each treatment was prepared using water-soluble potassium fertilizer (K_2SO_4 , 50% K_2O), and a uniform spray volume (100 mL per pot) was applied using a hand sprayer. The plants were regularly irrigated and monitored for growth performance.

Results and Discussion

Plant Growth Parameters

Foliar application of K_2O significantly influenced wheat growth parameters (Table 1).

Plant Height

Foliar application of K_2O significantly influenced wheat plant height (Table 1). T₃ (3% K_2O) resulted in the tallest plants (85.3 ± 2.1 cm), which was significantly higher than the control (72.8 ± 2.0 cm).

T₄ (4% K₂O) exhibited a slight decrease (83.0 ± 1.7 cm) compared to T₃, suggesting that excessive potassium application may lead to nutrient toxicity or osmotic stress.

Tiller Count

Tiller production per plant was significantly enhanced by K₂O application. T₃ recorded the highest tiller count (4.5 ± 0.3 plant⁻¹), which was 50% greater than the control (3.0 ± 0.2 plant⁻¹). T₂ and T₄ exhibited similar values (4.1 ± 0.2 and 4.2 ± 0.2 plant⁻¹, respectively),

indicating an optimum range between 2% and 4% K₂O.

Leaf Area Index (LAI)

The leaf area index (LAI) increased with K₂O application up to 3% concentration. T₃ had the highest LAI (3.4 ± 0.2), which was significantly higher than the control (2.0 ± 0.1). T₄ (3.2 ± 0.1) showed a slight decline, reinforcing the potential negative impact of excessive potassium application.

Table 1: Effect of different foliar concentrations of potash on growth parameters

Treatment	Plant Height (cm)	Tillers per Plant	LAI
T ₀ (Control)	$72.8 \pm 2.0d$	$3.0 \pm 0.2c$	$2.0 \pm 0.1d$
T ₁ (1% K ₂ O)	$77.5 \pm 1.8c$	$3.6 \pm 0.2b$	$2.5 \pm 0.1c$
T ₂ (2% K ₂ O)	$81.6 \pm 1.5b$	$4.1 \pm 0.2a$	$3.0 \pm 0.1b$
T ₃ (3% K ₂ O)	$85.3 \pm 2.1a$	$4.5 \pm 0.3a$	$3.4 \pm 0.2a$
T ₄ (4% K ₂ O)	$83.0 \pm 1.7ab$	$4.2 \pm 0.2a$	$3.2 \pm 0.1ab$

Physiological Parameters

Potassium application significantly improved chlorophyll content, photosynthetic rate, transpiration rate, and stomatal conductance (Table 2).

Chlorophyll Content

Chlorophyll content increased with increasing K₂O levels, with T₃ recording the highest SPAD value (46.7 ± 1.5), which was 16.4% greater than the control (40.1 ± 1.2). However, T₄ (45.5 ± 1.3) showed a slight reduction, possibly due to stress from excessive foliar K₂O application.

Photosynthesis Rate

Photosynthetic activity followed a similar pattern, with T₃ achieving the highest rate (16.2 ± 0.5 μmol

$\text{CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), whereas the control recorded the lowest (12.5 ± 0.4 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$). T₄ showed a slight reduction to 15.8 ± 0.4 , indicating that 3% K₂O is the optimal concentration for maximizing photosynthesis.

Transpiration Rate and Stomatal Conductance

Transpiration and stomatal conductance increased significantly with K₂O application. T₃ recorded the highest transpiration rate (4.5 ± 0.2 $\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$) and stomatal conductance (0.35 ± 0.02 $\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$), which were significantly greater than the control (3.2 ± 0.2 and 0.21 ± 0.01 , respectively). These results suggest that foliar K₂O enhances gas exchange and water regulation in wheat plants.

Table 2: Effect of different foliar concentrations of potash on physiological parameters

Treatment	Chlorophyll (SPAD)	Photosynthesis ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)	Transpiration ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)	Stomatal Conductance ($\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$)
T ₀	$40.1 \pm 1.2d$	$12.5 \pm 0.4d$	$3.2 \pm 0.2c$	$0.21 \pm 0.01d$
T ₁	$42.3 \pm 1.4c$	$13.8 \pm 0.3c$	$3.8 \pm 0.1b$	$0.27 \pm 0.02c$
T ₂	$44.8 \pm 1.1b$	$14.9 \pm 0.5b$	$4.2 \pm 0.2ab$	$0.30 \pm 0.02b$
T ₃	$46.7 \pm 1.5a$	$16.2 \pm 0.5a$	$4.5 \pm 0.2a$	$0.35 \pm 0.02a$

T₄	45.5 ± 1.3ab	15.8 ± 0.4ab	4.3 ± 0.2ab	0.33 ± 0.01ab
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Yield and Biomass Accumulation

Potash application significantly enhanced biomass accumulation and grain yield (Table 3).

Biomass Accumulation

Biomass accumulation was significantly improved by foliar K₂O application. T₃ exhibited the highest biomass accumulation (36.5 ± 1.8 g plant⁻¹), which was 29% greater than the control (28.3 ± 1.5 g plant⁻¹). The decline observed in T₄ (35.0 ± 1.7 g

plant⁻¹) suggests that excessive potassium application may reduce assimilate partitioning.

Grain Yield

The highest grain yield was recorded in T₃ (14.8 ± 0.9 g plant⁻¹), which was significantly higher than the control (9.8 ± 0.5 g plant⁻¹). Although T₄ (14.2 ± 0.8 g plant⁻¹) still performed well, the slight reduction indicates a threshold beyond which additional K₂O provides no further benefits.

Table 3: Effect of different foliar concentrations of potash on biomass and yield parameters

Treatment	Biomass Accumulation (g plant ⁻¹)	Grain Yield (g plant ⁻¹)
T₀	28.3 ± 1.5d	9.8 ± 0.5d
T₁	31.7 ± 1.3c	11.2 ± 0.6c
T₂	34.2 ± 1.6b	12.9 ± 0.7b
T₃	36.5 ± 1.8a	14.8 ± 0.9a
T₄	35.0 ± 1.7ab	14.2 ± 0.8ab

CONCLUSION

This study demonstrated that foliar application of 3% K₂O significantly improved wheat growth, physiological processes, and yield. The improvements in plant height, tiller count, LAI, chlorophyll content, photosynthetic rate, and biomass accumulation indicate that potassium plays a crucial role in plant development. However, increasing the concentration beyond 3% led to slight reductions in some parameters, suggesting a possible threshold for optimal performance. Future field trials are recommended to confirm these findings under varying soil and climatic conditions, ensuring that the benefits of foliar K₂O application can be effectively translated into large-scale wheat production.

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