



Original Article

POTASSIUM-DRIVEN GROWTH REGULATION AND NUTRIENT DYNAMICS IN
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ABSTRACT

Potassium (K) is an indispensable macronutrient that is critical for plant growth, water regulation, and nutrient uptake. This study designed to scrutinize the impact of diverse concentrations of potassium on the development, biomass and mineral uptake in carrot (*Daucus carota* L.). A precise pot experiment was conducted at the University of Agriculture DI Khan during the 2024–2025 growing season. Carrot plants were treated with four potassium concentrations 0 ppm (control) to 150 ppm with 50 ppm difference in concentration. The results exposed that potassium treatment expressively boosted plant height, root length, and overall biomass paralleled to the control. The 100 ppm potassium treatment indicated the chief improvements in plant growth and biomass, with values of 29.5 cm for plant height, 30.2 cm for root length and 17.3 g for total biomass. Additionally, mineral uptake of N, P & K was significantly increased in the 100 ppm treatment. These findings suggest that judicious potassium concentrations can increase carrot productivity and nutrient absorption, offering a prospective strategy for improving crop performance in horticultural systems..

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the supremely grown root vegetables globally, famous for its high nutritional value, chiefly in terms of vitamins, minerals and antioxidants. It is essential in human diets and is cultivated comprehensively for its edible root. In order to exploit crop productivity and dietary content, proper nutrient management is necessary. Among the macro-nutrients mandatory for plant growth, potassium (K) plays a decisive role in diversified physiological processes, including enzyme activation, water regulation, photosynthesis, and stress tolerance ¹.

Potassium is indispensable for maintaining cellular functions i.e. protein synthesis and the transportation of sugars, amino acids, and other crucial nutrients. It also plays a dynamic role in stomatal regulation that impacts water uptake and transpiration efficiency ². Potassium deficiency in plants is often associated to abridged growth, diminished photosynthesis, and poorer resistance to diseases and abiotic stresses ³. Consequently, augmenting potassium availability is critical for improving plant health and productivity.

In carrots, the role of potassium in cultivating growth and yield has been documented, but its effects on mineral uptake and biomass production entail further investigation. While nitrogen (N) and phosphorus (P) are often the focus of exploration on soil fertility, potassium remains equally energetic for enhancing overall plant performance ⁴. Few studies have specifically addressed the impact of different potassium concentrations on carrot growth, making this investigation valuable for understanding the dynamics of nutrient uptake in this crop ^{5,6,7}.

The primary objective of this study was to evaluate the effects of various potassium

concentrations on carrot growth, biomass accumulation, and nutrient uptake. It was hypothesized that potassium treatments would improve growth parameters and increase the absorption of nitrogen, phosphorus, and potassium in carrots, leading to higher productivity and better nutritional quality.

Materials and Methods

A pot experiment was conducted at the University of Agriculture DI Khan during the 2024–2025 growing season. The experimental design was a completely randomized design (CRD) with four treatments and four replications. Uniform carrot seeds (variety Kesar) were sown in pots containing a loamy soil mixture. The soil was characterized by a pH of 7.3, organic matter content of 1.2%, and available nitrogen, phosphorus, and potassium levels of 0.08%, 7.6 mg/kg, and 135 mg/kg, respectively.

Experimental Treatments

The treatments consisted of different potassium concentrations applied as potassium nitrate (KNO₃) solutions:

- T₀: Control (0 ppm K)
- T₁: 50 ppm K
- T₂: 100 ppm K
- T₃: 150 ppm K

Foliar application of the potassium treatments was carried out twice during the growing season, at 30 and 45 days after transplantation (DAT). The solution was applied at a rate of 200 mL per plant, ensuring uniform coverage of the leaves.

Data Collection Parameters

- **Growth Parameters:** Plant height (cm), root length (cm), and number of leaves per plant.

- **Biomass Parameters:** Fresh leaf weight (g), dry leaf weight (g), and total biomass (g plant^{-1}).
- **Mineral Uptake:** Nitrogen, phosphorus, and potassium content in dry matter (%) was determined using standard methods.

Statistical Analysis

Data were subjected to one-way analysis of variance (ANOVA), and means were compared using the least significant difference (LSD) test at a 5% significance level. Statistical analysis was performed using SPSS software (version 25.0).

Results and Discussion

Table 1: Effect of Potassium Concentrations on Growth Parameters in Carrot

Treatment	Plant Height (cm)	Root Length (cm)	Number of Leaves
T ₀ (Control)	22.1 ± 0.8c	22.5 ± 0.7c	12.4 ± 0.5c
T ₁ (50 ppm K)	24.6 ± 1.0b	25.4 ± 0.9b	14.3 ± 0.6b
T ₂ (100 ppm K)	29.5 ± 1.3a	30.2 ± 1.2a	16.7 ± 0.8a
T ₃ (150 ppm K)	28.7 ± 1.1ab	28.1 ± 1.0ab	15.3 ± 0.7ab

Biomass Production

Biomass production, as indicated by fresh and dry leaf weights, was significantly higher in the potassium-treated plants. The 100 ppm treatment resulted in the highest total biomass ($17.3 \pm 0.8 \text{ g}$), followed by 150 ppm ($16.4 \pm 0.7 \text{ g}$). In contrast, the control plants had the lowest total biomass

Growth Parameters

Potassium application significantly improved the growth parameters in carrot plants (Table 1). Plant height was highest in the 100 ppm treatment ($29.5 \pm 1.3 \text{ cm}$), followed by the 150 ppm treatment ($28.7 \pm 1.1 \text{ cm}$). The control plants had the lowest height ($22.1 \pm 0.8 \text{ cm}$). Similar trends were observed in root length, with the 100 ppm treatment showing the longest roots ($30.2 \pm 1.2 \text{ cm}$) compared to the control ($22.5 \pm 0.7 \text{ cm}$). These results indicate that potassium enhances both root and shoot development, likely by improving cellular processes involved in cell elongation and division, which are essential for plant growth^{8,9,10}.

($12.1 \pm 0.6 \text{ g}$) (Table 2). These results suggest that potassium plays a key role in stimulating vegetative growth, leading to an increase in overall biomass accumulation. The increased biomass could be attributed to improved photosynthesis and nutrient translocation, processes that potassium is known to enhance^{11,12}.

Table 2: Effect of Potassium Concentrations on Biomass Production in Carrot

Treatment	Fresh Leaf Weight (g)	Dry Leaf Weight (g)	Total Biomass (g plant^{-1})
T ₀ (Control)	5.2 ± 0.3c	1.4 ± 0.1c	12.1 ± 0.6c
T ₁ (50 ppm K)	6.3 ± 0.4b	1.8 ± 0.1b	14.5 ± 0.7b
T ₂ (100 ppm K)	7.8 ± 0.5a	2.2 ± 0.1a	17.3 ± 0.8a
T ₃ (150 ppm K)	7.2 ± 0.4ab	2.0 ± 0.1ab	16.4 ± 0.7ab

Mineral Uptake

Potassium treatments also had a significant effect on the mineral uptake of nitrogen, phosphorus, and potassium (Table 3). The 100 ppm treatment resulted in the highest nitrogen uptake ($2.65 \pm 0.09\%$), followed by the 150 ppm treatment ($2.42 \pm 0.07\%$). Similarly, phosphorus uptake was highest in the 100 ppm treatment ($0.38 \pm 0.01\%$),

and potassium uptake was also significantly improved in the 100 ppm treatment ($3.23 \pm 0.12\%$). The control plants had the lowest mineral content for all three nutrients. These findings highlight the importance of potassium in enhancing nutrient uptake, which could be due to its role in improving root function and increasing the efficiency of nutrient transport^{8,12,13}.

Table 3: Effect of Potassium Concentrations on Mineral Uptake in Carrot

Treatment	Nitrogen Uptake (%)	Phosphorus Uptake (%)	Potassium Uptake (%)
T ₀ (Control)	$1.98 \pm 0.08c$	$0.33 \pm 0.01c$	$2.65 \pm 0.12c$
T ₁ (50 ppm K)	$2.22 \pm 0.07b$	$0.35 \pm 0.01b$	$2.90 \pm 0.10b$
T ₂ (100 ppm K)	$2.65 \pm 0.09a$	$0.38 \pm 0.01a$	$3.23 \pm 0.12a$
T ₃ (150 ppm K)	$2.42 \pm 0.07ab$	$0.36 \pm 0.01ab$	$3.05 \pm 0.11ab$

Bottom of Form

Conclusion

The results of this study demonstrate that potassium significantly enhances the growth, biomass production, and mineral uptake of carrots. Among the different concentrations tested, the 100 ppm potassium treatment was the most effective in improving plant height, root length, biomass accumulation, and mineral uptake. These findings suggest that optimal potassium application can improve carrot productivity and nutrient assimilation, providing valuable insights for nutrient management practices in horticultural systems.

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