Growth and Yield Response of Chili (*Capsicum Annum* L.) Genotypes Under Soil Applied Potassium

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Abstract

An experiment was conducted during the year 2022 to study the effects of soil-applied potassium on the growth and yield of chili (*Capsicum annum* L.) genotypes. The experiment took place at Latif Farm, Sindh Agriculture University, Tandojam. The experimental design used was a randomized complete block design factorial (RCBD) with three replications. Two chili varieties, namely Ghotki and Longi, were transplanted, and potassium was applied in the form of sulfate of potash. The potassium treatments included K1: Control (0 g plot^{-1}), K2: (52.5 g plot^{-1}), K3: (105 g plot^{-1}), K4: (157.5 g plot^{-1}), and K5: (210 g plot^{-1}). Various parameters were recorded, including plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, days to flowering, flower production plant^{-1}, days to fruiting, yield plant^{-1} (kg), number of fruits plant^{-1}, weight of a single fruit (g), and yield ha^{-1} (tones). The growth and yield characteristics of the chili were found to be significantly influenced by both the varieties and potassium levels. However, the interaction between the varieties and potassium levels did not have a significant impact on the growth and yield-related characteristics of the chili. Among the varieties, the Ghotki variety exhibited the highest values for plant height (118.78 cm), number of branches plant^{-1} (18.06), number of leaves plant^{-1} (127.92), flower production plant^{-1} (56.21), yield plant^{-1} (1.06 kg), weight of a single fruit (2.05 g), and yield ha^{-1} (19.61 tones). On the other hand, the Longi variety recorded the minimum values for days to flowering (58.92), days to fruiting (89.24), and number of fruits per plant (26.86). The treatment with potassium applied at 100 kg ha^{-1} resulted in the highest values for plant height (120.45 cm), number of branches plant^{-1} (21.00), number of leaves plant^{-1} (129.18), flower production plant^{-1} (57.33), yield plant^{-1} (1.11 kg), number of fruits plant^{-1} (31.24), weight of a single fruit (2.45 g), and yield ha^{-1} (19.42 tones). Conversely, the treatment with no potassium application (0 kg ha^{-1}) resulted in the lowest values for plant height (117.06 cm), number of branches plant^{-1} (14.50), number of leaves plant^{-1} (121.37), flower production plant^{-1} (54.28), yield plant^{-1} (0.96 kg), number of fruits plant^{-1} (23.50), and weight of a single fruit (1.61 g). The application of potassium at a rate of 100 kg ha^{-1} showed favorable outcomes in terms of the growth and yield characteristics of chili.

Additionally, the Ghotki variety demonstrated better results compared to the Longi variety in terms of various growth and yield attributes.

Keywords: chilies, growth, yield, potassium.

Introduction

Chilies, scientifically known as *Capsicum annuum* L., are members of the Solanaceae family. They originated circa 7500 BC, in the tropical parts of South America, notably in New Mexico and Guatemala. Mexico is credited with giving rise to chilies. The Portuguese introduced fiery chilies from Brazil to the Indo-Pak subcontinent before 1585. Cultivated chilies originate from the Americas, and evidence of their existence has been found in pre-historic remains in Peru. Among the crops belonging to the Solanaceae family, chilies rank third in importance, following tomatoes and potatoes (Akbar et al., 2022: Dubey et al., 2020). Chilies hold significant economic value and are highly regarded as a cash crop in Pakistan. They are cultivated on a large scale and occupy a prominent position in terms of cultivated area, ranking just after onions and potatoes. In Pakistan, the total area dedicated to chili cultivation spans 73,800 hectares, resulting in a total production of 187,700 metric tons. Notably, Khyber Pakhtunkhwa contributed 749 metric tons from an area of 629 hectares during the year (Ali et al., 2023: Yadav et al., 2021). Chilies thrive in well-drained soil with a composition of silt or clay loam. The quantity of chillies produced relies heavily on the availability of essential nutrients (Iqbal et al., 2023: Kusumiyati et al., 2022).

Chilies hold significant importance in the commercial sector, particularly in the manufacturing of oleoresin and other industrial resources, cosmetics, and pharmaceutical sectors. Dry chili (powder) is the primary focus of cultivation, although green chilies are also harvested (Ahmed et al., 2023: Iqbal et al., 2022: Butt et al., 2021). The production of chilies offers numerous nutritional, medicinal, and economic benefits. Apart from being a crucial ingredient in various cuisines, chilies find use in culinary applications, imparting pungency and red color and contributing to the flavor of ginger ales. They contain an array of chemical compounds, including fatty oils, minerals, proteins, fibers, vitamins, carotenoids, capsaicinoids, and steam-volatile oils (Hussain, 2022: Ridzuan et al., 2019). Fresh green chili peppers are not only delicious but also a rich source of essential vitamins such as A, B, C, E, P, and C (340 mg per 100 grams). Remarkably, they have even higher levels of vitamin C than citrus fruits, but fresh red chili peppers surpass carrots in terms of vitamin A content (Syed et al., 2022: Vidya et al., 2018). These versatile peppers find their applications in the food industry, where they are used to prepare chili paste, curry powder, and various culinary delights.

Moreover, chilies play a crucial role in improving the texture and flavor of baked goods. To maximize chili yield and quality and maintain soil fertility, the use of fertilizers is highly recommended. Nitrogen, phosphorous, and potassium are the three primary nutrients that are crucial for achieving optimal yields and improving the quality of chilies (Tariq et al., 2022: Sayekti et al., 2021). Solanaceous crops, including chilies, have a high demand for potassium. When the fruit is harvested, a significant amount of potassium is removed from the soil. Therefore, it is necessary to supplement these crops with potassium fertilizers, as the amount naturally present in the soil is often insufficient. Potassium is classified as a major macronutrient and is responsible for approximately 6% of the plant's dry weight, making it a vital nutrient for overall plant health and quality (Kumar et al., 2022). Adequate potassium (K) nutrition has been linked to various beneficial effects in horticultural crops, including increased yields, larger fruit size, higher concentrations of increased fruit color, longer shelf life, soluble solids and ascorbic acid, and better shipping quality (Nasrullah et al., 2022: Talwar et al., 2018). Potassium, among other essential macronutrients, is crucial for the general health, growth, development, and production of plants. Additionally, it is essential to a plant's ability to survive in harsh environmental circumstances since these conditions can impair essential physiological functions including protein synthesis, photosynthetic activities, root and shoot elongation, enzyme activity, water and nutrient transport, and chlorophyll production (Chowdhury et al., 2023). Potassium is engaged in a variety of physiological and biochemical processes that are necessary for the best possible plant development, yield, quality, and resilience to stress.

Furthermore, research has demonstrated that potassium is instrumental in activating more than 60 enzyme systems in plants. Additionally, the excessive use of nitrogen-based fertilizers has been shown to increase the susceptibility of plants to diseases and pests. However, this susceptibility can be mitigated through the appropriate application of potassium nutrition (Saxena et al., 2016). The successful cultivation of chili peppers relies on a variety of agricultural practices, including the management of nutrients. Among the necessary nutrients, potassium (K) plays a pivotal role in the expansion, development, and overall yield of chili plants. It is crucial for activating enzymes, regulating osmosis, and maintaining the proper balance of ions within plant cells. Insufficient potassium levels can result in lower crop yields and diminished quality, highlighting the importance for chili growers to comprehend how soil-applied potassium affects the growth and yield of different chili genotypes. The significance of potassium fertilization and its impact on chili cultivation has been acknowledged by experts (Iqbal et al., 2017). A lack of potassium can lead to symptoms like decreased fruit production, smaller fruit size, and increased vulnerability to pests and diseases. Hence, it is vital to optimize potassium application in chili cultivation to achieve higher yields and better quality. Additionally, the genotype of chili peppers is a crucial factor that influences their growth and yield. Different chili varieties or genotypes exhibit varying responses to external factors, including the availability of nutrients (Arain et al., 2022). Understanding how different chili genotypes react to soil-applied potassium can provide valuable insights for crop management and breeding programs. While the importance of potassium in crop nutrition is widely recognized, it is crucial to acknowledge that chili genotypes display diverse responses to nutrient availability (Umair et al., 2020).

Materials and Methods

The field trial was completed at Sindh Agriculture University's Department of Horticulture Student's Latif Farm in Tandojam during autumn 2022 to assess the "growth and yield performance of chili (*Capsicum annum* L.) genotype under soil-applied potassium." Two chili varieties were evaluated by applying different potassium rates. The factorial experiment was laid out in a randomized complete block design (RCBD) factorial with three replicates. The experiment was comprised of two factors. V_1 = Ghotki, V_2 = Longi Potassium (K)-Five K rates (applied in the form of SOP Fertilizer) = 5, K_1 = 0 kg ha^{-1} (control), K2 = 25 kg k_2O ha^{-1} (52.5 g $plot^{-1}$), K_3 = 50 kg k_2O ha^{-1} (105 g $plot^{-1}$), K_4 = 75 kg k_2O ha^{-1} (157.5 g $plot^{-1}$), K_5 = 100 kg k_2O ha^{-1} (210 g plot-1) Five plants were chosen at maturity for each experimental plot using the units of measurement: net plot area, nursery raising, planting of chili seedlings, intercultural operations, irrigation, weeding, plant protection, harvesting, data collection, and observations to be recorded.

Statistical design

Plant data from the experiments is statistically processed using the Statistics software package (Ver. 8.1). Mean separation was performed using the LSD binary test proposed by Steel et al. (1997).

Results

There was a significant difference ($p<0.05$) in the results for chili plants grown with varying levels of potassium. Among the different treatments, the application of 100 kg ha1 of potassium developed the highest plant height, with a measurement of 118.78 cm recorded in the Ghotki variety. On the other hand, the Longi variety had the lowest plant height of 118.57 cm. The variation in plant height was mainly dependent on the specific variety. After reaching maturity, the Ghotki variety displayed a maximum plant height of 120.45 cm, while a minimum height of 117.06 cm was observed in the control treatment (K1 = control) and the treatment with 100 kg ha^{-1} of potassium (K5 = 100 kg ha^{-1}), respectively. It was noted that the average values for new plant growth height ranged from 116.73 cm to 120.30 cm in the Longi variety and from 117.40 cm to 120.60 cm in the Ghotki variety. The highest plant height of 120.60 cm was recorded in the Ghotki variety with the application of 100 kg ha^{-1} of potassium (K_5), followed by the Longi variety with the same treatment (120.30 cm). Conversely, the lowest plant height of 116.73 cm was observed in the Ghotki variety with the control treatment (K1 = 117.40).

Table 4.1 Effect of potassium rates and varieties on plant height (cm)

Treatments K_2O ha^{-1}	**Varieties**		**Mean ± S.E**
	Longi	**Ghotki**	
K_1= Control	116.73	117.40	117.06 ± 0.47 d
K_2= 25 kg ha^{-1}	117.83	118.00	117.91 ± 0.12 d
K_3= 50 kg ha^{-1}	118.57	118.47	118.52 ± 0.07 c
K_4= 75 kg ha^{-1}	119.43	119.43	119.43 ± 0.01 b
K_5= 100 kg ha^{-1}	120.30	120.60	120.45 ± 0.21 a
Mean ± S.E	118.57±1.38 b	118.78±1.25 a	

Number of branches plant^{-1}

In Ghotki, the number of branches per plant was found to be 18.06, while in Longi, it was recorded as 15.80. This variation mainly depends on the specific variety of the plant. After reaching maturity, the maximum number of branches in plant 1 (21.00) was observed at a rate of 100 kg ha1 (K5), while the least number of branches in plant

1 (14.50) was recorded in the control group (K1). It was noted that the average number of branches per plant ranged between 12.33 and 19.33 in the Longi variety and between 16.66 and 22.66 in Ghotki. The extreme value of branches plant-1 (22.66) was observed in Ghotki with the K5 treatment, followed by the same treatment in the Longi variety (19.33) at a rate of 100 kg ha-1 (K5). On the other hand, the lowest value of branch plant-1 (12.33) was observed in different varieties with the control group (K1) in Ghotki.

Table 4.2 Effect of potassium rates and varieties on number of branches plant^{-1}

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	**Ghotki**	
K_1= Control	12.33	16.66	14.50 ± 3.06 e
K_2= 25 kg ha^{-1}	13.33	16.00	14.67 ± 1.88 d
K_3= 50 kg ha^{-1}	16.00	17.33	16.67 ± 0.94 c
K_4= 75 kg ha^{-1}	18.00	17.66	17.83 ± 0.23 b
K_5= 100 kg ha^{-1}	19.33	22.66	21.00 ± 2.35 a
Mean ± S.E	15.80 ± 2.97 b	18.06 ± 2.65 a	

Number of leaves plant^{-1}

In Ghotki, plant^{-1} exhibited a recorded number of leaves amounting to 127.92, while in Longi, the minimum count was observed at 122.70. On the other hand, Ghotki recorded the maximum number of leaves per plant at 132.20, whereas Longi had the minimum count at 118.60 (K1 = control). Upon analysis, it was discovered that the average values of the number of branches in plant^{-1} ranged from 118.60 to 126.17 in Longi and from 124.13 to 132.20 in Ghotki. The highest value of branches per plant, amounting to 132.20 (K_5), was observed in Ghotki, followed by the same treatment at 126.17 in the Longi variety (K5 = 100 kg ha^{-1}). Conversely, the minimal value of leaf plant^{-1}, recorded at 118.60 (K1 = 124.13), was observed in Ghotki.

Table 4.3 Effect of potassium rates and varieties on number of leaves plant^{-1}

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	**Ghotki**	
K_1= Control	118.60	124.13	121.37 ± 3.91 e
K_2= 25 kg ha^{-1}	120.97	125.83	123.40 ± 3.43 d
K_3= 50 kg ha^{-1}	123.27	127.80	125.53 ± 3.20 c
K_4= 75 kg ha^{-1}	124.50	129.63	127.07 ± 3.62 b

K_5= 100 kg ha^{-1}	126.17	132.20	129.18 ± 4.26 a
Mean ± S.E	122.70±2.97 b	127.92±3.16 a	

Days to flowering

In Longi, the maximum duration for flowering was recorded at 58.92 days, while the minimum duration was 55.32 days in Ghotki. In terms of specific treatments, the highest duration of 60.60 days was observed in the control group (K_1), whereas the shortest duration of 52.23 days was recorded in the treatment with 100 kg ha1 (K_5). Interestingly, the average duration for flowering in Longi ranged from 60.60 to 57.03 days, while in Ghotki it ranged from 57.36 to 52.23 days. Longi exhibited the highest duration of flowering at 60.60 days in the control group (K_1), followed by 60.06 days in the longi variety with a treatment of 25 kg ha1 (K_2). On the other hand, Ghotki had the deepest duration of flowering at 52.23 days, which was observed in different varieties under the treatment of 100 kg ha^{-1} (K_5).

Table 4.4 Effect of potassium rates and varieties on days to flowering

Treatments K_2O ha^{-1}	**Varieties**		**Mean ± S.E**
	Longi	**Ghotki**	
K_1= Control	60.60	57.36	58.98 ± 2.29 a
K_2= 25 kg ha^{-1}	60.06	56.70	58.38 ± 2.37 b
K_3= 50 kg ha^{-1}	59.26	55.70	57.48 ± 2.51 c
K_4= 75 kg ha^{-1}	57.66	54.63	56.15 ± 2.14 d
K_5= 100 kg ha^{-1}	57.03	52.23	54.63 ± 3.39 e
Mean ± S.E	58.927±1.53 a	55.327± 2.01 b	

Flower production plant^{-1}

The flower production in Plant-1 reached its peak at 56.21 in Ghotki, while the lowest production of 55.42 was observed in Longi. Additionally, the maximum flower production in Plant^{-1} was recorded at 57.33 with a dosage of K_5 (100 kg ha-1), whereas the minimum production of 54.28 was observed with the control dosage, K_1. It can be noted that the average values of flower production in Plant^{-1} ranged from 53.93 to 56.90 in Longi and from 54.63 to 57.76 in Ghotki. The highest recorded value of 57.76 for flower production in Plant^{-1} was observed in Ghotki, followed by 57.06 in the Longi variety with a dosage of K_4 (75 kg ha^{-1}). On the contrary, the downcast value of 52.93 for flower production in Plant^{-1} was recorded in Longi with the control dosage of K_1, while it was slightly higher at 54.63 in Ghotki with a different variety and dosage of K_1.

Table 4.5 Effect of potassium rates and varieties on flower production plant^{-1}

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	Ghotki	
K_1= Control	53.93	54.63	54.28 ± 0.49 e
K_2= 25 kg ha^{-1}	54.50	55.43	54.96 ± 0.65 d
K_3= 50 kg ha^{-1}	55.50	56.16	55.83 ± 0.46 c
K_4= 75 kg ha^{-1}	56.26	57.06	56.66 ± 0.56 b
K_5= 100 kg ha^{-1}	56.90	57.76	57.33 ± 0.60 a
Mean ± S.E	55.42±1.22 b	56.21±1.24 a	

Days to fruiting

Longi recorded the maximum number of days to fruiting, with a duration of 89.24 days, while Ghotki had the minimum number of days to fruiting, with duration of 85.88 days. In terms of the different treatments, the control group (K_1) had the highest number of days to fruiting, with a duration of 90.03 days, while the treatment with 100 kg ha1 (K_5) had the shortest duration, with 85.66 days. The average values for the days to fruiting were observed to be between 91.96 and 87.06 days in Longi and between 88.10 and 84.26 days in Ghotki. Among the longi variety, the utmost number of days to fruiting, 91.96 days, was noted in the control group (K_1), followed by 90.16 days in the longi variety with a treatment of 50 kg ha^{-1} (K_3). On the other hand, Ghotki had the smallest number of days to fruiting, with 82.26 days recorded in the treatment with 100 kg ha^{-1} (K_5) and 85.13 days recorded in the different variety (K_4) in Ghotki.

Table 4.6 Effect of potassium rates and varieties on days to fruiting

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	Ghotki	
K_1= Control	91.96	88.10	90.03 ± 2.72 a
K_2= 25 kg ha^{-1}	89.20	86.56	87.88 ± 1.86 b

K_3= 50 kg ha^{-1}	90.16	85.36	87.76 ± 3.39 c
K_4= 75 kg ha^{-1}	87.83	85.13	86.48 ± 1.90 d
K_5= 100 kg ha^{-1}	87.06	84.26	85.66 ± 1.97 e
Mean ± S.E	89.247±1.93 a	85.887±1.48 b	

Yield plant^{-1} (kg)

In the district of Ghotki, the maximum yield plant^{-1} (1.06 kg) was achieved, while the minimum yield (0.99 kg) was also observed in Ghotki. In terms of specific conditions, the highest yield plant^{-1} (1.11 kg) was recorded at K_5 with a rate of 100 kg ha^{-1}, whereas the least yield plant^{-1} (0.96 kg) remained observed at K_1, which served as the control group. The average values of the yield plant^{-1} ranged from 0.96 kg to 1.07 kg in Longi, while in Ghotki, the range was between 0.96 kg and 1.15 kg. Among all the locations, the highest yield plant^{-1} (1.15 kg) was achieved in Longi at K_5, followed by 1.11 kg in the Longi variety at K4, with a rate of 75 kg ha^{-1}. Conversely, the low yield plant^{-1} (0.96 kg) was observed in both Longi and Ghotki at K_1, with Longi also showing a slightly higher yield (0.99 kg) in a different variety at K_2.

Table 4.7 Effect of potassium rates and varieties on yield plant^{-1} (kg)

Treatments K_2O ha^{-1}	**Varieties**		**Mean ± S.E**
	Longi	**Ghotki**	
K_1= Control	0.96	0.96	0.96 ± 0.01 e
K_2= 25 kg ha^{-1}	0.99	1.01	1.00 ± 001 d
K_3= 50 kg ha^{-1}	0.99	1.07	1.03 ± 0.05 c
K_4= 75 kg ha^{-1}	1.02	1.11	1.06 ± 0.06 b
K_5= 100 kg ha^{-1}	1.07	1.15	1.11 ± 0.05 a
Mean ± S.E	0.99±0.04 b	1.06±0.07 a	

Number of fruit plants: 1

In the Longi region, the maximum number of fruit plants (26.86) was observed, while the minimum (26.21) was also recorded. Furthermore, the extreme number of fruit plants (31.24) was documented at a treatment level of K5 = 100 kg ha^{-1}, whereas the lowest number (23.50) was recorded under control conditions (K1 = control). The usual values of fruit plant^{-1} ranged between (22.00–31.33) in longi and (25.00–31.66) in ghotki. Ghotki exhibited the highest value of fruit plant-1 (31.66) under the treatment level of K5,, followed by the longi variety (31.33) under the treatment level of K5 (100 kg ha^{-1}). Conversely, the minimum fruit $plant^{-1}$ value (22.00) was observed in longi under treatment level (K_1), while ghotki recorded a value of (25.00) under a different variety (K1 = 25.00).

Table 4.8 Effect of potassium rates and varieties on number of fruit $plant^{-1}$

Treatments K_2O ha^{-1}	**Varieties**		**Mean ± S.E**
	Longi	**Ghotki**	
K_1= Control	22.00	25.00	23.50 ± 2.12 e
K_2= 25 kg ha^{-1}	25.00	24.00	24.50 ± 0.70 d
K_3= 50 kg ha^{-1}	27.00	20.73	26.86 ± 4.43 c
K_4= 75 kg ha^{-1}	29.00	29.66	29.33 ± 0.46 b
K_5= 100 kg ha^{-1}	31.33	31.66	31.24 ± 0.23 a
Mean ± S.E	26.86±3.59 a	26.21±11.84 b	

Single fruit weight (g)

In the study, the weight of separate fruits was examined and noted in various locations. The highest weight of a single fruit, measuring 2.05 grams, was observed in the Ghotki region. On the other hand, the lowest weight, measuring 2.02 grams, was recorded in Longi. In terms of the maximum single fruit weight, a value of 2.45 grams was observed in the area where 100 kg ha-1 (K5) was applied as a treatment. Conversely, the minimum single fruit weight of 1.61 grams was recorded in the control group (K1). The average value of the single fruit weight fell within the range of 1.61 to 2.47 grams. Specifically, in Longi, the recorded weights ranged from 1.61 to 2.44 grams, while in Ghotki, the range was 1.61 to 2.47 grams. Among all the recorded weights, the highest value of 2.47 grams was observed in Longi, specifically in the treatment group where 100 kg ha-1 (K5) was applied. Additionally, the variety in Longi also exhibited a weight of 2.44 grams under the same treatment (K5 = 100 kg ha-1). On the contrary, the lowest weight of 1.61 grams was observed in both Longi and Ghotki under the control group (K1), while Ghotki showed a slightly higher weight of 1.73 grams in the same variety under treatment (K2).

Table 4.9 Effect of potassium rates and varieties on single fruit weight (g)

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	**Ghotki**	
K_1= Control	1.61	1.61	1.61± 0.01 e
K_2= 25 kg ha^{-1}	1.73	1.91	1.82 ± 0.12 d
K_3= 50 kg ha^{-1}	2.05	2.07	2.06 ± 0.01 c
K_4= 75 kg ha^{-1}	2.27	2.26	2.26± 0.07 b
K_5= 100 kg ha^{-1}	2.47	2.44	2.45 ± 0.02 a
Mean ± S.E	2.02±0.35 b	2.05±0.31 a	

Yield ha^{-1} (tons)

In Ghotki, the maximum yield ha^{-1} (19.61 tonnes) was achieved, while the minimum yield (16.19 tonnes) was recorded in Longi. The highest yield ha^{-1} (19.42 metric tons) was observed at a rate of 100 kg ha^{-1} (K_5), whereas the shortest yield ha^{-1} (14.88 metric tons) remained recorded at a rate of 25 kg ha^{-1} (K_2). The average values of the yield ha^{-1} ranged from 12.82 to 19.00 metric tons in Longi and from 19.00 to 19.84 metric tons in Ghotki. Ghotki had the highest yield ha^{-1} (19.84 metric tons) at a rate of 100 kg ha^{-1} (K_5), followed by the Longi variety with a yield of 19.00 metric tons at the same rate (K5 = 100 kg ha^{-1}). On the other hand, the last yield ha^{-1} (12.82 metric tons) in Longi was recorded at rate (K_1), while the second lowest yield (14.66 metric tons) was recorded in the same Longi variety at rate (K_2).

Table 4.10 Effect of potassium rates and varieties on yield per hectare (tonnes)

Treatments K_2O ha^{-1}	Varieties		Mean ± S.E
	Longi	**Ghotki**	
K_1= Control	12.82	25.00	18.91 ± 8.61c
K_2= 25 kg ha^{-1}	14.66	15.11	14.88 ± 0.31 e
K_3= 50 kg ha^{-1}	17.29	17.34	17.31 ± 0.03 d
K_4= 75 kg ha^{-1}	17.18	20.76	18.97 ± 2.53 b
K_5= 100 kg ha^{-1}	19.00	19.84	19.42± 0.59 a
Mean ± S.E	16.19±2.43 b	19.61±3.73 a	

Discussion

Chilli is widely cultivated in the Sindh province of Pakistan and is known to be one of the most extensively grown vegetables (Afzal et al., 2023: Indrabi et al., 2022). The success of its production and quality greatly relies on nutrient management and good agricultural practices, commonly referred to as GAP (Mardanluo et al., 2018: Abbas et al., 2022). The nutrient requirements of chili are crucial for achieving maximum yield (Tripodi et al., 2018). Among the various essential nutrients, potassium plays a crucial role in both the vegetative and reproductive growth of chili (Iqbal and Siddiqui, 2023: Castellanos et al., 2017). Potassium plays a vigorous role in the growth and development of plants (Bhutia et al., 2018). It activates various enzymes in young plants, thereby enhancing their vegetative growth (Islam et al., 2017). Moreover, potassium positively impacts the quality and quantity of fruit produced by plants, as the availability of K in the soil is closely associated with fruit intensity and yield per plant. The application of increased rates of potassium fertilizer has been found to promote plant growth and enhance yield (Sharmeen et al., 2022). Insufficient amounts of potassium in the soil can negatively impact the development and fruiting of chili plants. Therefore, it is necessary to supplement the soil with increased potassium rates to bridge the yield gap and improve the vegetative and fruiting performance of chilli plants (Farhan and Rehman 2023: Nandagopal et al., 2022). The main objective of the present research was to enhance the vegetative and fruiting performance of chili genotypes by applying higher rates of potassium. Several parameters were evaluated during this study to assess the growth and fruiting efficacy of chili plants under different potassium rates. These parameters included plant height (in centimeters), number of branches plant-1, number of leaves plant-1, days to flowering, days to fruiting, single fruit weight (in grams), fruit weight plant-1, fresh fruit yield plant-1, and fruit yield ha-1.

The results of the study demonstrated that growth attributes such as plant height, branch production, and leaf production gradually increased with higher potassium rates. Notably, there was a major impact of varying potassium readings on plant height (Table 1). This effect can be attributed to the maximum uptake of potassium, which facilitates sufficient food production and the proper functioning of other physiological activities such as photosynthesis and nutrient flow within the plants (Aslam et al., 2022). The maximum height of the plants, measuring 120.45 cm, was observed in plants that received an increased dose of 100 kg ha-1. Similar results for plant height were also informed by Wang et al. (2022), where the study showed that a higher rate of 90 kg K ha-1 resulted in an upper limit plant height of 122 cm. Plant height is closely related to photosynthesis, which has a positive impact on fruit production (Riaz et al., 2022: Karim et al., 2021). The number of leaves per plant was meaningfully changed by nitrogen levels, while the influence of potash levels or the interface between nitrogen and potash was not significant ($P \leq 0.05$). The highest level of potassium (100 kg K ha-1) led to the maximum number of leaves per plant, with a count of 129.18, compared to the minimum count of 121.37 in the control group (Table 1). Inorganic nutrients have a beneficial impact on the development of red chili peppers because potassium helps with protein synthesis and is a necessary part of chlorophyll. The increase in the number of leaves per plant might be explained by the adequate potassium supply, which gives the plants a perfect habitat and balanced nourishment. This, in turn, leads to an increase in the quantity of leaves. There is a clear correlation between the number of branches and the number of leaves on a plant; plants with more branches typically have more leaves, and vice versa.

These findings partially align with the outcomes of Rajametov et al. (2021), who further reported a higher number of leaves per plant with increasing potassium application. The number of branches in plant 1 was meaningfully assumed to be caused by potassium, while the interactive effect of both potassium and nitrogen was not significant. The highest number of branches per plant, with a count of 21.00, was recorded with the highest dose of potassium (100 kg ha-1). These results are consistent with those of Priyadi et al. (2022). Similarly, Wahocho et al. (2016) observed a direct correlation between nitrogen levels and the number of branches per plant in chili plants. Their findings indicate that as the potassium rate increases, the number of branches in plant 1 also increases. The range of branches in plant 1 varied from 15.800 to 18.067 across different varieties. Furthermore, the number of fruits per plant He additionally stated that potassium application had a major impact, as seen in Table 4.4 ($P \leq 0.05$). The mean analysis revealed that the highest number of fruits per plant (31.50) was recorded when a potassium rate of 100 kg ha1 was applied. These results align with the verdicts of Sarwar et al. (2020), who reported an increase in the number of fruits per plant with higher potassium application. Potassium had a significant impact on chili yield ($P \leq 0.05$), while its interaction with other factors was not significant. The greatest yield (18.97 tons ha1) remained when 100 kg K ha1 was applied. The yield per hectare did not significantly vary among different chili varieties. These findings are consistent with the research conducted by Channa et al. (2020), which demonstrated that increasing the dose of potassium application led to a substantial increase in both fruit yield and total yield.

Conclusion

The findings indicate that the growth of chili plants and the quantity of seeds produced were significantly altered ($p<0.05$) by varying levels of potassium compared to the control group without any fertilizer. The seed yield showed a consistent increase with higher levels of potassium. Notably, the plot treated with 100 kg of potassium ha-1 (equivalent to 19.84 tonnes) (referred to as K5) achieved the highest recorded yield in the Ghotki region, followed by 19.00 tonnes in the Longi variety (also treated with K5 = 100 kg ha-1). Therefore, it is recommended to provide chili plants with 100 kg of potassium per day to promote optimal growth and maximize yield.

References

Abbas, K., Turabi, T. H., Saeed, A., & Abdullah, M. A. (2022). Examining the growth potential and eco-physiological response of Conocarpus erectus and Morus alba to limestone dust and lead (Pb) pollution. *Global Forests*, *1*(01), 11-24.

Afzal, S., Gul, S., & Mehmood, H. M. Z. (2023). Conversion of land utilization, Chickpea to Eucalyptus on marginal lands for the betterment of countryside. *Global Forests*, *2*(01), 26-32.

Ahmed, J., Shivhare, U. S., & Raghavan, G. S. V. (2000). Rheological characteristics and kinetics of color degradation of green chilli puree. *Journal of Food Engineering*, *44*(4), 239-244.

Ahmed, S., Younas, M., Asif, M., Saqib, M., Saleem, M. F., Khan, H. Z., ... & Shahid, M. (2023). Enhanced Wheat Yield: Fulvic Acid Application's Impact on Yield Factors under Heat Stress. *Journal of Food and Agricultural Technology Research*, *2*(02), 145-157.

Akbar, M., Qadir, I., & Arif, A. (2022). Assessment of carbon sequestration rate in eucalyptus-based irrigated forest plantation Bahawalpur. *Global Forests*, *1*(01), 33-53.

Ali, M. A., Shah, Y. R., Din, S., & Saqib, M. (2023). Climatic Variability's Influence on Cereal Harvests in Punjab, Pakistan: A Comprehensive Analysis and Mitigation Strategies. *Journal of Food and Agricultural Technology Research*, *2*(01), 92-104.

Arain, S. M., & Sial, M. A. (2022). Association analysis of fruit yield and other related attributes in four chilli (*Capsicum annum*L.) genotypes grown in Sindh province, Pakistan. *Pakistan Journal of Botany*, *54*(3), 817.

Aslam, Z., Ahmad, A., Bashir, S., Hussain, S., Bellitürk, K., Ahmad, J. N., & Abbas, T. (2022). Effect of integrated nutrient management practices on physiological, morphological and yield parameters of chilli (*Capsicum annum* L.). *Pakistan Journal of Botany*, *54*(6), 2143-2150.

Bhutia, K., Khanna, V., Meetei, T., & Bhutia, N. (2018). Effects of climate change on growth and development of chilli. *Agrotechnology*, *7*(2), 1-4.

Butt, M., Sattar, A., Abbas, T., Hussain, R., Ijaz, M., Sher, A., & Zuan, A. T. K. (2021). Morpho-physiological and biochemical attributes of Chili (*Capsicum annum* L.) genotypes grown under varying salinity levels. *Plos one*, *16*(11), 257-893.

Castellanos, J. Z., Cano-Ríos, P., García-Carrillo, E. M., Olalde-Portugal, V., Preciado-Rangel, P., Ríos-Plaza, J. L., & García-Hernández, J. L. (2017). Hot pepper (*Capsicum annuum* L.) growth, fruit yield, and quality using organic sources of nutrients. *Compost Science & Utilization*, *25*(1), 70-77.

Channa, M. H., Sial, M., Dahri, G. N., Jamro, A. S., Solangi, T., Nasir, A., & Aamir, A. (2020). Measuring profitability of chilli pepper production in Sindh, Pakistan. *Journal of Economics and Sustainable Development*, *11*(8), 81-89.

Chowdhury, M. F. N., Rafii, M. Y., Ismail, S. I., Ramlee, S. I., Hosen, M., Karim, K. R., & Sahmat, S. S. (2023). Growth and yield performances, pathogenicity, heat tolerance, antioxidant activity, and pungency level of anthracnose resistant and heat tolerant inbreed lines and their F1 hybrids of chili (*Capsicum annuum* L.). *Scientia Horticulturae*, *309*, 111606.

Dubey, J. K., Patyal, S. K., Katna, S., Shandil, D., Devi, N., Singh, G., & Singh, G. (2020). Persistence and dissipation kinetics of tebuconazole in apple, tomato, chilli and onion crops of Himachal Pradesh, India. *Environmental Science and Pollution Research*, *27*, 11290-11302.

Farhan, M., & Rehman, M. U. (2023). The foliar application of salicylic acid improves the growth, physiological and biochemical attributes in three forest species under drought stress. *Global Forests*, *2*(01), 44-51.

Hussain, S. (2022). Impact of Cold and Heat Stress on Different Stages of Wheat: A Critical Review. *Journal of Food and Agricultural Technology Research*, *1*(01), 28-38.

Indrabi, S. A., Malik, A. A., Hussain, K., Malik, G., Narayan, S., Akhter, A., & Rashid, M. (2022). Evaluation of Chilli (*Capsicum annuum* L.) Genotypes for Growth and Yield Attributing Traits. *Journal of Community Mobilization and Sustainable Development*, *17*(2), 1-8.

Iqbal, A., Zulfiqar, U., Ehsan, G. M., & Khan, R. (2022). Application of urea significantly enhanced the growth and biomass production in Terminalia arjuna seedlings. *Global Forests*, *1*(01), 25-32.

Iqbal, M., Hussain, D., Javed, M. Y., Ellahi, F., Asim, M., Adeel, M., ... & Baqir, M. (2023). In Vitro Efficacy Evaluation of Agrochemical Fungicides in the Mitigation of Colletotrichum Capsici Infection. *Journal of Food and Agricultural Technology Research*, *2*(02), 128-135.

Iqbal, S., Inam, A., Inam, A., Ashfaque, F., & Sahay, S. (2017). Potassium and wastewater interaction in the regulation of photosynthetic capacity, ascorbic acid and capsaicin in chilli plants. *Journal of Agricultural Water Management*, *184*, 201-210.

Iqbal, W., & Siddiqui, T. (2023). Phytotoxic impact of leaf extracts of Bombax ceiba L.(Bombax ceiba) and Populus deltoides L.(Poplar) on the growth of Triticum aestivum (Wheat). *Global Forests*, *2*(01), 33-43.

Islam, M. M., Islam, M. K., Proshad, R., Islam, M. S., Islam, M. S., Kormoker, T., & Billah, K. M. M. M. (2017). Effect of inorganic and organic fertilizers on soil properties with vegetative growth and yield quality of sweet pepper (*Capsicum annuum* L.) in Bangladesh. *International Journal of Agronomy and Agricultural Research*, *11*(5), 37-46.

Karim, K. R., Rafii, M. Y., Misran, A. B., Ismail, M. F. B., Harun, A. R., Khan, M. M. H., & Chowdhury, M. F. N. (2021). Current and prospective strategies in the varietal improvement of chilli (*Capsicum annuum* L.) especially heterosis breeding. *Agronomy*, *11*(11), 2217.

Kumar, R., & Deepandhu, S. D. (2022). Evaluation trial on hybrid chilli genotype under Prayagraj agro-climatic conditions (*Capsicum annuum* L.). *The Pharma Innovation Journal*, *11*(9), 2756-2760.

Kusumiyati, K., Syifa, R. J., & Farida, F. (2022). Effect of various varieties and dosage of potassium fertilizer on growth, yield, and quality of red chili (*Capsicum annuum* L.). *Open Agriculture*, *7*(1), 948-961.

Mardanluo, S., Souri, M. K., & Ahmadi, M. (2018). Plant growth and fruit quality of two pepper cultivars under different potassium levels of nutrient solutions. *Journal of plant nutrition*, *41*(12), 1604-1614.

Nandagopal, J. G. T., Harinarayanan, U. N. D., Raghavan, S., & Girija, S. (2022). Foliar selenium application mitigates low-temperature stress in chilli (*Capsicum annuum* L.) seedlings. *Energy Nexus*, *6*, 100-079.

Nasrullah, F., Naz, M., Khan, U. A., Kashif, A., & Hussain, S. (2022). Weeds Dynamics as Influenced by Seeding Rates and Row Spacing in Winter Wheat. *Journal of Food and Agricultural Technology Research*, *1*(01), 39-50.

Priyadi, R., Juhaeni, A. H., Meylani, V., & Fudholi, A. (2022). The Development of Inorganic Fertilizer and Bio-Fertilizer Combination and the Effectiveness of Application on the Growth and Production of Red Chili. *International Journal of Design & Nature and Ecodynamics*, *17*(1), 87-93.

Rajametov, S. N., Lee, K., Jeong, H. B., Cho, M. C., Nam, C. W., & Yang, E. Y. (2021). The effect of night low temperature on agronomical traits of thirty-nine pepper accessions (*Capsicum annuum* L.). *Agronomy*, *11*(10), 1986.

Riaz, M. U., Siddique, N., Riaz, R., & Bhatti, A. (2022). Enhanced nursery techniques: Impact on seedling survival and growth of Moringa oleifera and Azadirachta indica in Bahawalpur. *Global Forests*, *1*(01), 1-10.

Ridzuan, R., Rafii, M. Y., Mohammad Yusoff, M., Ismail, S. I., Miah, G., & Usman, M. (2019). Genetic diversity analysis of selected Capsicum annuum genotypes based on morphophysiological yield characteristics and their biochemical properties. *Journal of the Science of Food and Agriculture*, *99*(1), 269-280.

Sarwar, A., & Khan, S. A. (2020). Implementation of Best Practices to Ensure Aflatoxin Controlled Chilli Production from Post Harvesting to Customer in Developing Country. *Journal of Educational Management and Social Sciences*, *1*(1), 24-32.

Saxena, A., Raghuwanshi, R., Gupta, V. K., & Singh, H. B. (2016). Chilli anthracnose: the epidemiology and management. *Frontiers in Microbiology*, *7*, (1527), 1-18.

Sayekti, T. W. D. A., Syukur, M., Hidayat, S. H., & Maharijaya, A. (2021). Diversity and genetic parameter of chili pepper (*Capsicum annuum* L.) based on yield component in three locations. *Biodiversitas Journal of Biological Diversity*, *22*(2).

Sharmeen, F., Saikat, M. M. H., Ahmed, J. U., Islam, M. T., & Islam, A. A. (2022). Parent selection for hybridization in chilli (*Capsicum annuum* L.) using multivariate analysis and K-means clustering. *Fundamental and Applied Agriculture*, *7*(4), 327-335.

Syed, M., Butt, M. S., Arqam, U., Syed, A., & Manzoor, M. S. (2022). Study on Quality Attributes of Mint Extract in Combination with Animal and Vegetable Fat in Ice-Cream. *Journal of Food and Agricultural Technology Research*, *1*(01), 1-16.

Talwar, D., Singh, K., & Jindal, S. K. (2022). Influence of nitrogen and potassium on growth and yield of chilli (*Capsicum annuum* L.). *Vegetable Science*, *49*(1), 41-46.

Tariq, N., Ashfaq, M., Khan, M. A. K., Khan, S. Z., Farooq, M. A., & Ashraf, M. R. (2022). Toxicity of Different Insecticides Against Feeding Behavior of Bactrocera Zonata (Diptera: Tephritidea) Under Laboratory Conditions. *Journal of Food and Agricultural Technology Research*, *1*(01), 17-27.

Tripodi, P., Cardi, T., Bianchi, G., Migliori, C. A., Schiavi, M., Rotino, G. L., & Lo Scalzo, R. (2018). Genetic and environmental factors underlying variation in yield performance and bioactive compound content of hot pepper varieties (*Capsicum annuum* L.) cultivated in two contrasting Italian locations. *European Food Research and Technology*, *244*(9), 1555-1567.

Umair, M., Aamer, M., Chattha, M., Haiying, T., Shahzad, B., Barbanti, L., & Guoqin, H. (2020). The critical role of potassium in plants facing the drought stress. *Journal of Agriculture*, *10*(9), 396.

Vidya, C., V.S. Jagtap & Santhosh. N. (2018). Correlation and path coefficient analysis for yield and yield attributing characters in chilli genotypes. *Journal of Current Microbiology and Applied Sciences*, *7*(1), 3265-3268.

Wahocho, N. A., Zeshan Ahmed, S., Jogi, Q., Talpur, K. H., & Leghari, S. J. (2016). Growth And Productivity Of Chilli (*Capsicum Annuum* L.) Under Various Nitrogen Levels. *Science International*, *28*(2).

Wang, J., Gao, Z., Sun, T., Huang, W., Jia, Y., Li, X., & Hu, X. (2022). Preharvest reduction in nutrient solution supply of pepper (*Capsicum annuum* L.) contributes to improve fruit quality and fertilizer efficiency while stabilising yields. *Agronomy*, *12*(12), 3004.

Yadav, M., Dubey, M. K., & Upadhyay, R. S. (2021). Systemic resistance in chilli pepper against anthracnose (caused by Colletotrichum truncatum) induced by Trichoderma harzianum, Trichoderma asperellum and Paenibacillus dendritiformis. *Journal of Fungi*, *7*(4), 307.