

RESEARCH ARTICLE

ASSESSING THE IMPACT OF POTASSIUM ON GROWTH, YIELD AND YIELD CONTRIBUTING TRAITS OF ONION (*Allium cepa* L.) IN COASTAL REGION OF BANGLADESH

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ABSTRACT

Onion is a popular bulb crop in Bangladesh, valued not only as a spice but also a vegetable due to its nutritional value. The productivity of onion is hindered by several biotic and abiotic factors. Among the abiotic factors, one of the most crucial factors is salinity, which impacts negatively on the yield and quality of onion. A field study was carried out in the research field of the Department of Agriculture at Noakhali Science and Technology University, Bangladesh, during the period from November 2021 to January 2022, in order to identify the suitable dosage of potassium in coastal zones. The study was laid out in a Randomized Complete Block Design (RCBD) with three replications and three treatments, viz., T₀ (no potassium), T₁ (100 kg KCl ha⁻¹), T₂ (150 kg KCl ha⁻¹), and T₃ (200 kg KCl ha⁻¹). Data collection included different growth and development stages such as plant height, number of leaves, leaf length, bulb length, bulb diameter, individual bulb weight, and fresh bulb production per hectare of onion. The maximum yield (12.81 t ha⁻¹) and minimum yield (5.72 t ha⁻¹) were recorded from T₃ treatment (200 kg KCl ha⁻¹) and T₀ treatment, respectively. The highest plant height (46.92 cm), number of leaves (10.03), leaf length (31.18 cm), bulb diameter (4.79 cm), bulb length (4.18 cm), and individual bulb weight (30.51 g) were observed from treatment T₃ (200 kg KCl ha⁻¹), whereas the lowest data were obtained from treatment T₀ (no potassium). Based on the results, T₃ treatment, i.e., 200 kg KCl ha⁻¹, showed improved growth, yield, and yield contributing characteristics of onion in coastal areas of Bangladesh.

KEYWORDS

Onion, Salinity, Growth, Yield, Coastal area

1. INTRODUCTION

worldwide and member of the Alliaceae family. Onion is a popular vegetable crop that grown commercially on a large scale. It is widely grown globally, particularly in Australia, Bangladesh, China, India, Netherland, and Pakistan (Kumara et al., 2018). In Bangladesh, about 2546994.26 metric tons of onion was produced from approximately 203606.97 hectare of land in 2022–23 (BBS, 2023). The majority of people in Bangladesh produce onions during the Rabi season (Mazumder et al. 2023; Rashid, 1976).

Onion is regarded as one of the most significant spice commodities cultivated worldwide throughout the world and used in a variety of forms (Sim et al., 2020). Moreover, it is considered to be the oldest crop among vegetables (Teshika, 2012). Some researchers referred onion as the "Queen of the Kitchen" due to its distinct flavour, scent, and therapeutic properties (Selvaraj, 1976; Griffiths et al., 2002). The crop is cultivated to consume in green state, as fresh, mature bulbs or in slices that are dehydrated (Ghaffoor et al., 2003). In traditional medicine, onion has been used to cure and prevent a variety of ailments (Sim et al., 2020). Ascorbic acids, flavanols, carbohydrate prebiotics, and organosulfur compounds are the bioactive substances found in onion, with their byproducts containing a greater amount of flavonoids than the bulb (Sagar et al.,

2022). According to most of study, onion skin also has anti-asthmatic, anticarcinogenic, hypocholesterolemic, and positive cardiovascular effects (Hassan et al., 2014; Moreno et al., 2006). Allyl propyl disulphide, an alkaloid molecule is responsible for the pungent taste of onion and flavour, making them a common element in cuisines (Sagar et al., 2022).

Proper nutrient management is crucial for the growth and productivity of onion (Mazumder et al., 2019). Among the essential nutrients, potassium plays critical role according to a study, it is a vital component of plant physiology and growth, serving as a structural and regulatory element in a number of biochemical processes, including the synthesis of proteins, the metabolism of carbohydrates, and the activation of enzymes (Hasanuzzaman et al., 2018). This nutrient is indispensable for enhancing onion yields as well because it participates in various key physiological and biochemical processes in onion plants, including photosynthesis, the transport of assimilates, protein synthesis, water balance regulation, and enzyme activation (Marschner, 2011). Without sufficient potassium, onions may struggle to reach their full potential in both yield and quality. There is ample evidence of its importance for the quality and yield of onion (Yadav et al., 2002; Masalkar et al., 2000).

Moreover, to store well, the bulb must have sufficient potassium content (Deshpande et al., 2013). Potassium is often supplied to plants in substantial amounts through fertilizers and plants absorb potassium

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primarily in its cation form (K⁺) (Behairy et al., 2015). Deficits in potassium can affect assimilate transport and utilization as well as photosynthetic CO₂ fixation (Waraich et al., 2012). Potassium deficiency in onion can be identified by brown tips on older leaves and stunted bulb growth (Deshpande et al., 2013). Applying the right amount and type of potassium to onion during crucial growth phases is necessary to support growth and quality (Kumara et al., 2018). Potassium aids in root growth and plays an important role in promoting vegetative growth (stems and leaves).

Numerous biotic and abiotic stress factors, including soil salinity, have a major impact on onion production. According to a study, soil salinity has a detrimental effect on crop development, yield, and quality (Razzouk and Whittington, 1991). The accumulation of salt in the soil in coastal regions of Bangladesh has caused the growth conditions unfavorable for several crops, including onion (Ali et al., 2023). Many reports support the notion that potassium (K) enhances antioxidant defense in plants and therefore protect them from oxidative stress under various environmental adversities and aids in preserving ion homeostasis and controlling the osmotic balance when exposed to salt stress (Hasanuzzaman et al., 2018). Furthermore, a significant number of farmers in these regions lack expertise in the proper potassium fertilizer dosages needed for the best potential onion development. Lower yields in coastal zones of Bangladesh are primarily caused by this nutrient deficit. With this background, the current study aims to ascertain the ideal potassium dosage in coastal districts of Bangladesh to maximize onion yield. It is expected that the results will be beneficial, boosting the expansion of the agricultural industry in these regions and increasing onion production.

2. MATERIALS AND METHODS

2.1 Description of the experimental site

In Agro Ecological Zones (AEZ-18), Young Meghna Estuarine Flood Plain the study site was located, where both grain and horticulture crops are cultivated throughout the year. With 0.68% organic matter and 0.18 meq/100 g of accessible K, the soil type is loamy. The soil has a pH of 7.4 and a salinity of 5.08 dSm⁻¹ (Ali et al., 2023).

Table 1: Fertilizer dosage recommendations for onion production	
Manure/ Fertilizer	Amount
Cowdung	5 t ha ⁻¹
Urea	240 kg ha ⁻¹
TSP	260 kg ha ⁻¹
Gypsum	110 ha ⁻¹

2.7 Intercultural operation

Weeding was done three times in plots to keep the plots free from weeds. First weeding was done 20 days after planting, followed by a second one 20 days later. Hand sprayers were used to apply irrigations when necessary. Two-time applications of imidacloprid and mancozeb were made to control fungus and insects, respectively.

2.8 Harvesting

The onion was harvested manually on January 20, 2022, when the leaves turned brown and the underground bulbs matured.

2.9 Data Collection

Nine randomly selected plants from each plot were used to collect data on plant height, number of leaves, Leaf length, bulb length, bulb diameter, individual plant weight, and fresh bulb production per hectare of onion.

2.10 Statistical Analysis

2.2 Experimental design and layout

Four treatments with three replications (a single factor) the experiment was set up using Randomized Complete Block Design (RCBD). Three blocks, each symbolizing a replication, were used to split up the experimental area. After that, each block was split up into four plots. Therefore, the total number of plots was 12. The size of unit plot was 1m

× 1m = 1m² where block to block and plot to plot distance was 0.5m and 0.5m respectively. The spacing was 10cm × 7cm.

2.3 Experimental treatment

The goal of the experiment was to investigate how potassium affects the growth and yield of onion. Four treatments such as T₀ (no potassium), T₁ (100 kg KCl ha⁻¹), T₂ (150 kg KCl ha⁻¹), T₃ (200 kg KCl ha⁻¹) were used for this experiment.

2.4 Planting material

Bulb of onion variety, 'BARI Peyaj-6' was used and planting on 10th November 2021.

2.5 Land preparation and planting

Using a power tiller, the experimental field was opened on November 1, 2021. Before further ploughing, it was left exposed to the sun for seven days. After that, it was ploughed, then cross-ploughed, and finally laddered. Bulbs were planted on plot by hand and planting on 10th November 2021. Each laddering was followed by the removal of weeds and stubble.

2.6 Fertilizer application

According to the recommended fertilizer doses (Table 1), nitrogen and phosphorus were supplied to the experimental field through the application of urea and triple super phosphate (TSP), respectively. At the end of the land preparation, full dose of TSP, Cowdung and Gypsum and half of the urea and muriate of potash (MOP) was applied. The remaining urea and MOP was top-dressed 20 and 40 days after planting.

The recorded data on the different parameters of the study were analyzed statistically by using Minitab 17. Analysis of variance of different parameters was performed by the "F" test. The least significant difference (LSD) test was used to determine the significance of the difference between two means at the 1% probability level (Gomez and Gomez, 1984).

3. RESULTS

3.1 Plant Height

The height of onion plants was considerably influenced by the application of potassium fertilizer (Figure 01). The maximum plant height was measured from treatment T₃ (200 kg KCl ha⁻¹), reaching 46.92 cm, followed by 42.29 cm recorded from treatment T₂. In contrast, the minimum plant height was 36.33 cm observed from the plants of the control plot, which was not supplied with any potassium fertilizer. This showed that the application of K fertilizer resulted in increased plant height in the coastal region, with the dose 200 kg KCl ha⁻¹.

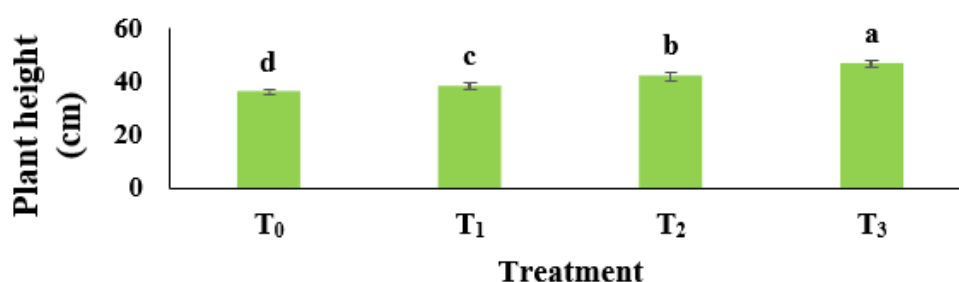


Figure 1: Effect of various doses of potassium treatments on plant height of onion

3.2 Number of leaves

The number of leaves per plant varied statistically ($p < 0.01$) in response to the application of fertilizer potassium (Figure 2). The highest number of leaves per plant (10.03) were counted from treatment T_3 (200 kg KCl ha⁻¹).

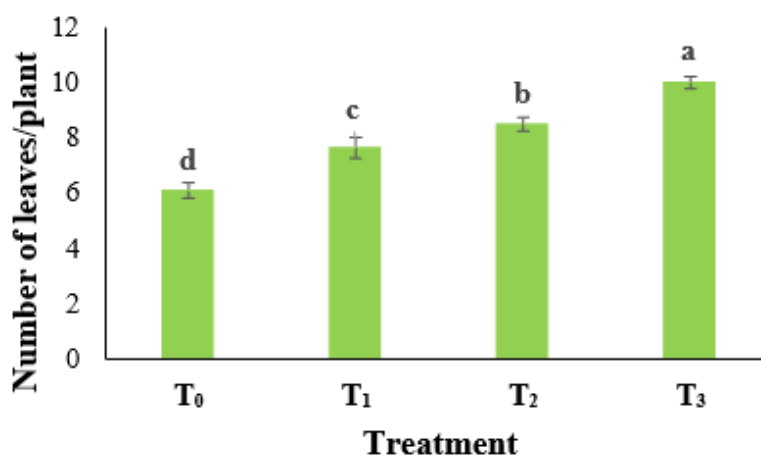


Figure 2: Effect of various doses of potassium treatments on number of leaves per plant of onion

3.3 Leaf length

The significant effect of potassium on leaf length was demonstrated in Figure 3, where results indicated a statistically significant variation ($p < 0.01$) among treatments. Treatment T_3 (200 kg KCl ha⁻¹) had the

longest leaves, measuring 38.10 cm, while the control plot (T_0), which did not receive any potassium, had leaf length of 26.86 cm. However, T_1 and T_2 treatments produced leaves with the shortest length 27.66 cm and 28.86 cm, respectively. According to these results, longer leaves tend to result from increased vegetative growth induced by potassium fertilizer.

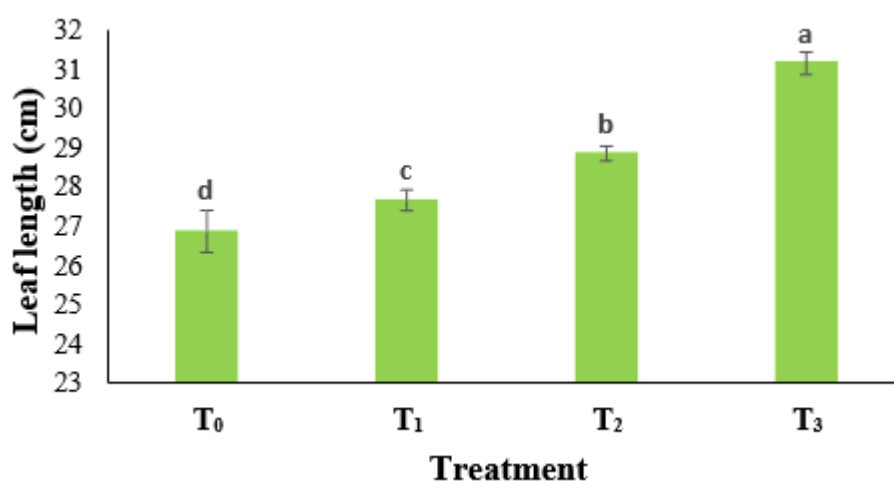


Figure 3: Effect of various doses of potassium treatments on leaf length of onion

3.4 Bulb diameter

There was a substantial ($p < 0.01$) difference in bulb diameter when varied potassium fertilizer doses were applied (Table 3). Treatment T_3 (200 kg KCl ha⁻¹) had the highest bulb diameter at 4.79 cm, followed by T_2 (4.38 cm), whereas the control plot (no potassium) produced the lowest bulb diameter at 3.53 cm. These results showed a considerable increase in bulb diameter with rising potassium levels.

3.5 Bulb length

As shown in Table 3, the application of varying rates of potassium fertilizer had a substantial impact on bulb length. The maximum bulb length 4.18 cm was observed in the T_3 treatment (200 kg KCl ha⁻¹), while the minimum bulb length, 3.39 cm measured in the control (T_0) treatment. It is possible that the ideal potassium concentrations encouraged more vegetative development, which contributed to the longer bulb length. Nevertheless, further increases in potassium dosage did not result in further expansion of bulb length, suggesting that the maximum potassium dosage had achieved its maximal impact on bulb length.

Table 3: Effect of varying doses of potassium treatments on yield parameters of onion

Treatment	Bulb diameter (cm)	Bulb length (cm)	Individual bulb weight (g)	Yield per hectare (ton)
T ₀	3.53d	3.39d	13.61d	5.72d
T ₁	4.12c	3.69c	20.35c	8.55c
T ₂	4.38b	4.01b	25.15b	10.56b
T ₃	4.79a	4.18a	30.51a	12.81a
CV (%)	2.69	1.20	1.07	1.07
LSD	0.34	0.14	0.73	0.31
Level of Significance	**	**	**	**

T₀ = (no potassium), T₁ = (100 kg KCl ha⁻¹), T₂ = (150 kg ha⁻¹), T₃ = (200 kg ha⁻¹). CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability.

3.6 Individual bulb weight

The application of potassium fertilizer resulted in a statistically significant difference ($p < 0.01$) in the fresh weight of onion bulb (Table 3). The fresh bulb weight 30.51 g was the highest for treatment T₃ (200 kg KCl ha⁻¹), whereas the bulb weight 13.61 g was the lowest for control treatment T₀ (no potassium). These findings demonstrate that potassium application significantly enhanced bulb weight.

3.7 Yield

Onion fresh bulb yield was significantly affected ($p < 0.01$) by the application of potassium fertilizers (Table 3). Treatment T₃ had the maximum yield (12.81 t ha⁻¹), while treatment T₀, produced the lowest yield (5.72 t ha⁻¹). These findings show that the application of potassium fertilizer significantly boosted the production of fresh bulbs.

4. DISCUSSION

Abiotic stresses hamper the plant productivity by altering plant growth patterns and physiological responses (Hasanuzzaman et al., 2013). An optimal dosage of fertilizer is also essential for the growth, yield, and quality of crops. Nutrient deficiency not only reduces quality and yield, but also leads to the death of a plant. While applying fertilizer, it is crucial to take into consideration that the supplied dose is accurate for the respective plant. Potassium is an essential element that plants receive in large quantities through fertilizers in order to increase crop (onion) yield while simultaneously contributing to critical physiological and biochemical activities (Marschner, 2011; Behairy et al., 2015). Potassium helps to maintain osmotic potential, root permeability, and water use efficiency (Hasanuzzaman et al., 2018). Among all the mineral nutrients, potassium (K) was very important for plants to survive a variety of biotic and abiotic stressors (Soumare et al., 2023).

Potassium impacts significantly the growth and yield of onion as well. The four treatments affected significantly all the studied plant characters, such as plant height, number of leaves, leaf length, bulb diameter, bulb length, individual bulb weight, and yield. The experiment indicated that higher potassium doses caused a noticeable rise in plant height, in agreement with the findings of who reported a positive correlation between potassium levels and plant height (Baloch et al., 1991; Islam, 1999). Similarly, some researcher demonstrated that potassium aids in the growth of plants, which supported the present study (Vachhani and Patel, 1993). Research done by most of researches had shown that increasing potassium use led to increased plant height, number of leaves, and fresh and dry weight (Mohanty and Das 2001; Sing and Verma, 2001; Sharma et al., 2007; Bybordi and Makouti, 2003). According to other study, numerous physiological and metabolic activities, including cell division, elongation, and the metabolism of protein and carbohydrate molecules, depended heavily on potassium (Marschner, 1997). Therefore, applying optimum potassium fertilizer not only improved leaf growth but also encouraged general vegetative development. This result supported by other research findings of some researchers that potassium application enhanced the number of leaves per plant and length of leaves (Vachhani and Patel, 1993; Aftab et al., 2017). A group of researchers reported that potassium application increases the outward translocation of photosynthetic from the leaf (Ashley and Goodson, 1972).

This study confirmed that in addition to increasing plant growth, increased potassium application had an impact on bulb weight, diameter, as well as other yield characteristics. Similar research conducted by a group of researchers revealed that increased potassium levels facilitated better bulb development and higher bulb size (Yadav et al., 2003; Chroboczek, 1936). Additionally, researchers reported that potassium stimulates photosynthesis, and the movement of photosynthetic products to the bulbs is most likely the main factor contributing to its beneficial impacts (Deshpande et al., 2013). The experiment observed that with the increase in potassium doses, the bulb weight and yield also enhanced. These findings coincided with earlier research done by which similarly found that increased potassium levels were linked to an increase in bulb weight (Singh et al., 1974; Nagaich et al., 1999). A study showed improved onion bulb yield with increased potassium fertilizer levels (Rizk, 1997; Mahmoud, 1999). Most of researchers reported similar outcomes, ensuring the benefit of potassium on onion yield (Bereniewicz and Nowosiceski, 1986; Pandev et al., 1990). Higher K concentrations might be the cause of this, since they had been shown to enhance protein synthesis, assimilate translocation, as well as enzyme activity and photosynthesis (Shaheen et al., 2011; Shusheel Kumar et al., 2006). Furthermore, some researchers reported that potassium was a key element in the entire metabolism of plant enzyme activity, which plays a crucial function in photosynthesis by directly boosting total bulb yield and growth (Behairy et al., 2015). Therefore, it was obvious that an increased dose of potassium enhances the vegetative, yield, and yield-contributing traits of onions.

5. CONCLUSION

The findings indicated that the application of potassium fertilizer had a significant positive impact on various growth and yield parameters of onion, including plant height, number of leaves, leaf length, bulb diameter, bulb length, individual bulb weight, and overall bulb yield per hectare. Comparative results of various parameters studied in the present investigation suggested that T₃ was the best treatment because individual weight of bulb was highest (30.51 g) in treatment T₃ and also the highest fresh bulb yield (12.811 t ha⁻¹) was found in treatment T₃ (200 kg ha⁻¹ of KCl). Based on these results, it can be concluded that a potassium fertilizer dose of 200 kg KCl ha⁻¹ provided better performance in the coastal region. In addition, it is recommended that further research should be conducted to verify the effect of potassium doses on onion in the coastal region to optimize fertilizer application.

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