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Improvement of Drought Tolerance and Yield of Mungbean through Potassium Fertilization with Rhizobium Inoculants

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Abstract: A pot trail was implemented at the net house of Patuakhali Science and Technology University, Dumki, Patuakhali during the February to April 2025 to study the drought tolerance and production of mungbean that are impacted by Potassium (K) fertilization and Rhizobium inoculation. The mungbean seed was treated with Rhizobium inoculant at 3% of seed weight before sowing. Seven levels of potassium fertilizer (0, 9.0, 7.5, 6.0, 4.5, 3.0, 1.5 g/10 kg soil) were used as treatment in the study. The experiment was set out in randomized complete block design (RCBD) with three replications. The stress was put in five leaves (vegetative) and silking (reproductive) stages. The results revealed that growth variable and grain production of mungbean were augmented with the increasing rate of potassium fertilizer level. Thus, the results are encouraging in the application of potassium fertilizer and seed treating with Rhizobium inoculant for sustainable production of mungbean under water deficit conditions.

Keywords: Drought Tolerance; Mungbean; Potassium Fertilization and Rhizobium Inoculants.

INTRODUCTION

Mungbean (Vigna radiata L.) is a widely cultivated pulse crop which is also grownup in Bangladesh mainly in alternation with cereal crops like rice wheat etc. Mungbean has a higher market value that it holds first position in market values, also high protein content (3rd of all pulses) and 4th in both acreage by covering 11.66% of the whole pulse production area (BBS, 2019). It is taken as a crucial source of protein (19.4-28.5%) among the Asian countries (Nair and Schreinemachers, 2020). It has a height of about 15-125 cm. It is self-fertilizing, fast-growing, short-term and has the capacity to bind atmospheric nitrogen which can fulfill the requirement of chemical nitrogen fertilizer to a certain extent (Khan et al., 2018). It is used as an ingredient in both savory and sweet dishes. In Bangladesh, Mungbean cultivation is following the late harvest of Aman rice (Moonsoon) in the month of Mid-January to Mid-February as a low input cash crop. In the 2020-2021 fiscal year, the area under mungbean cultivation was 109,304.77 acres, with a production of 41,189.26 metric tons. Much of this crop has been grown in Southern coastal districts of Bangladesh, specifically it is extensively cultivated in Barisal division. Drought stress (DS) is a major environmental obstacle that destructively hampers crop growth and progression (Yang et al., 2022). In the context of a changing climate, the sustainability of grain legume productivity is increasingly threatened by severe abiotic stresses (Hussain et al., 2018; 2023). Among these, water stress is particularly detrimental, particularly in arid and semi-arid parts, where it often persists for extended periods. Drought stress alone is responsible for an estimated 40–60% of global crop yield losses, making it the most significant abiotic factor contributing to crop failure. To combat these challenges, appropriate fertilization strategies have emerged as critical tools for enhancing plant growth, development, and resilience under adverse environmental states.

Potassium (K), a crucial macronutrient, plays a vital role in various physiological procedures, including photosynthesis, protein synthesis, stomatal regulation, and osmoregulation. Recognized for its role as a stress mitigator, potassium helps plants cope with drought stress by modulating key physiological and biochemical traits.

These include reducing water loss through transpiration (Farahani et al., 2020), enhancing photosynthetic efficiency (Zahoor et al., 2017), and regulating phytohormone metabolism. Thus, adequate potassium nutrition is crucial for improving the drought tolerance and overall productivity of grain legumes under water-deficit conditions.

Rhizobium fertilizer helps control drought stress in plants, especially legumes like mungbean, by improving their ability to fix nitrogen and enhance root development. Rhizobium bacteria form symbiotic relationships with legume roots, creating nodules where atmospheric nitrogen is converted into a usable form for the plant. This boosts plant growth even under drought conditions, when soil nitrogen availability may be low. Enhanced nitrogen availability promotes stronger and deeper root growth (Chen et al., 2013). A more developed root system supports the plant to acquire water from deeper soil layers at the time of drought. The cumulative use of potassium and Rhizobium has been subjected to have synergistic effects. For instance, (Hasan et al., 2023) demonstrated that mungbean treated with both potassium fertilizer and Rhizobium showed improved chlorophyll content, nodulation, yield components, and water-use efficiency. This integrated approach is gaining recognition as a sustainable and eco-friendly strategy to mitigate the effects of drought and enhance crop performance. The goal of the study was to determine the best K application phase for increasing crops survival at drought stress as well as production of Mungbean. By applying different potassium rates under drought stress conditions, this research seeks to provide valuable insights into how potassium can be used as an agronomic tool to improve mungbean productivity in water-limited areas.

Research Objectives:
i. Determine the consequences of potassium fertilizer and Rhizobial inoculants on water stress tolerance of Mungbean grown in salt affected soils.
ii. Evaluate the impact of potassium fertilizer and Rhizobial inoculants on the growth efficiency and yield of Mungbean.
iii. Estimate the consequence of potassium fertilizer and Rhizobial inoculants on physicochemical characteristics of soils.
iv. Assess the residual nutrient status in soil for consecutive crops

MATERIALS AND METHODS

A pot experiment was implemented in a net house at the Department of Soil Science, Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali, from February 2025 to 30th April 2025. The objective was to assess the effects of potassium fertilizer and *Rhizobium* inoculation on drought tolerance and production of mungbean (*Vigna radiata* L.). This chapter outlines the experimental site, period, climate, crop variety, soil preparation, experimental design and layout, crop management practices, treatments, data collection, chemical analyses, and statistical methods used.

Location

The experiment was carried out in the net house of the Department of Soil Science, PSTU, Dumki, Patuakhali. The geographical coordinates of the location are 22.46465° N latitude and 90.38843° E longitude. The altitude ranges between 0.9 and 2.1 meters more from mean sea level.

Soil

Soil was collected from the PSTU research farm. The texture of the soil was silty loam. Soil samples were analyzed in the Soil Science Laboratory, PSTU, to determine their initial physicochemical properties.

Climate and Weather

The climate of the study area is semitropic, distinguished by moderately high temperatures and massive rainfall in the time of Kharif season (April–September), and lower temperatures with modest rainfall throughout the Rabi season (October–March).

Planting Material

The mungbean variety accustomed for the study was **BINA Mung-5**, a highly productive, late winter–cum–summer variety released in 1998. Seeds were sourced from the Department of Soil Science, PSTU.

Salient Features of BINA Mung-5:

- Maturity: 70–80 days
- Seed: Green, shiny, and larger than Binamoog-1
- Synchronous pod maturity
- Plant height: Short
- Disease tolerance: Cercospora leaf spot and yellow mosaic virus
- Yield potential: 2.0 t/ha (average: 1.5 t/ha)

Experimental Season and Stress Level

The experiment was supervised during the **Kharif season**. Drought stress was imposed by withholding irrigation at the flowering stage to simulate water deficit condition

Experimental Design and Layout

The experiment was organised in a randomized complete block design (RCBD) with seven treatments and three replications.

Treatment Details:

- T1: 0 g K / 10 kg soil (Control)
- T2: 9 g K / 10 kg soil
- T3: 7.5 g K / 10 kg soil
- T4: 6.0 g K / 10 kg soil
- T5: 4.5 g K / 10 kg soil
- T6: 3.0 g K / 10 kg soil
- T7: 1.5 g K / 10 kg soil

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Soil Collection and Preparation

Soil was air-dried after collection, and large clods were broken using a wooden hammer. Weeds and stubbles were removed manually. A total of 10 kg of soil was placed into every 21 plastic pots.

Fertilizer Application

Organic fertilizers (500 g cow dung and 500 g vermicompost per pot) were mixed into the soil seven days before sowing to avoid any toxic effects on seeds. Inorganic fertilizers included 250 g of urea, TSP, gypsum, and 2 packets of *Rhizobium* inoculant, applied during the final soil preparation.

Seed Sowing

Fresh, healthy seeds of BINA Mung-5 were hand-sown in February 2025. 4–5 seeds were placed in each pot. Light irrigation was applied prior to sowing to ensure proper seed germination.

Tagging and Labeling

After sowing, each pot was tagged and labeled according to the treatment and soil type for easy identification during data collection.

Intercultural Operations

Thinning

Seed germination began four days after sowing (DAS). Thinning was done on 8 DAS to ensure optimum plant population.

Irrigation and Weeding

Weeding was performed twice: once during thinning (8 DAS) and again at 35 DAS. Irrigation was done as per the demand of the crop, except during the drought stress period.

Insect and Pest Management

Initially, pest infestation was not observed. However, Ripcord 10 EC at 1 mL/L was sprayed twice at one-week intervals to manage potential insect pests.

Crop Sampling and Data Collection

Data was possessed at 15, 25, and 40 DAS from randomly selected three plants per treatment replication. Parameters recorded included:

- Plant height
- Number of leaves per plant
- Dry matter accumulation
- Number of flowers per plant
- Number of branches per plant
- Number of pods per plant
- Number of seeds per pod
- Pod length
- 1000-seed weight

3.11 Harvesting

Harvesting began when 80% of the pods matured, by hand-picking matured pods. Final harvest included uprooting the entire plant. Pods were separated and stored in labeled gunny bags. Roots were cleaned for biomass data.

Fresh shoot and root weights were noted, and dry weight was gotten after drying at 70°C for 72 hours in an oven.

Statistical Analysis

The data gathered were subjected to statistical analysis using Microsoft Excel and the STAR software (Statistical Tool for Agricultural Research). The data were analyzed through Analysis of Variance (ANOVA), and treatment means were compared using Fisher's Least Significant Difference (LSD) test at a 5% level of significance.

RESULTS AND DISCUSSION

This chapter presents and discusses the results obtained from the experiment executed to evaluate the effects of various rates of potassium fertilization and Rhizobium inoculation on drought stress tolerance and yield performance of mungbean (Vigna radiata L.). The impact of these treatments on various growth and yield components including plant length, number of leaves, pod length, number of pods per plant, and seed production are summarized in the following tables and figures.

Each parameter has been discussed under separate subheadings, with interpretations provided based on observed trends, supported by relevant literature where applicable.

Plant height (cm)

The utilization of potassium fertilizer had a noticeable impact on the plant length of mungbean across the different treatment levels. The plant length has enlarged with boosting potassium levels up to a definite point, after which the growth plateaued.

A substantial increase was seen in T5 (16 cm), which recorded the highest plant height among all treatments. This indicates that the potassium level in T5 was optimal for mungbean growth, significantly enhancing vegetative development. Besides, the smallest plant length (12 cm) was recorded from trail T1(control), indicating limited growth without potassium supplementation.

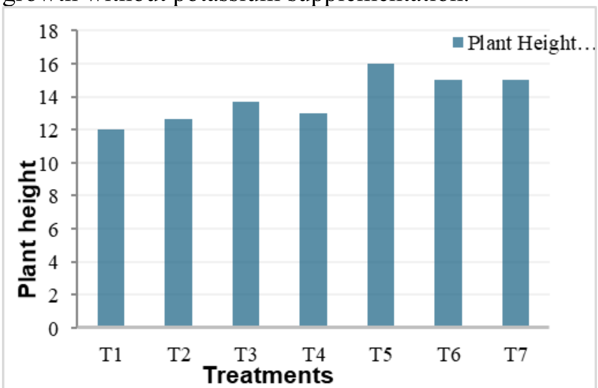

Figure 1. Effect of different levels of potassium on plant height of BINA mung-5

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Number of branches per plant

The quantity of branches per plant are alerted by various Potassium fertilizer rates exerted statistically notable difference.

The optimal number of branches was achieved at moderate potassium levels T4 and T5, with 8 and 8.67, respectively, whereas the fewest number of branches was noticed in the control treatment (T1) with 4.33, indicating poor vegetative branching in the absence of potassium. The results highlighted that moderate potassium application significantly enhances branch production in mungbean, likely due to its role in promoting enzymatic activities, protein synthesis, and overall vegetative vigor (Islam et al., 2024).

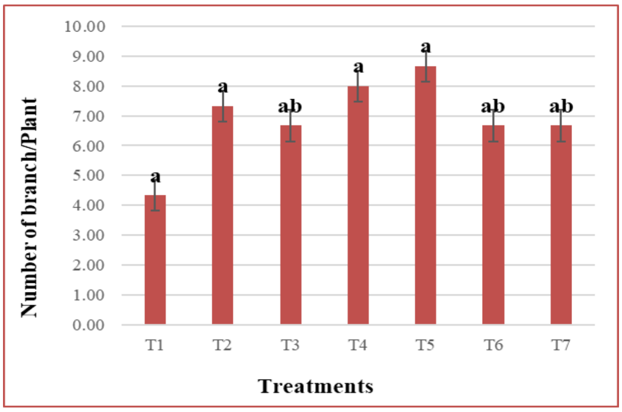

Figure 2. Consequence of varied level of potassium on number of branches plant -1 of BINA mung-5

Number of leaves per plant

In the we can notice the performance of mungbean toward distinct level of potassium fertilizer where no remarkable difference was followed on leaves plant^{-1}. Among all the treatments maximum no of leaves plant -1(16) was followed on T6 treatment. The minimum number of plant leaves-1 was observed from the T2 and T3(13).

Treatments	Total number of leaves per plant
T1	13
T2	14
T3	15
T4	14
T5	13
T6	16
T7	14
LSD (0.05)	**NS**
CV (%)	12.84

Table 1. Effect of varied potassium fertilizer level on the total number of leaves plant-1

Number of flowers per plant

Notable variation was found on the number of flowers per plant of mungbean because of the application of different levels of potassium fertilizer (Fig3). T5 showed the best performance, producing significantly more flowers (7.33) than most other treatments. On the other hand, lowest number of flowers was recorded from T1(2.33) where no Potassium fertilizer was applied. This may occur due to increased photosynthesis rate, water regulation and overall satisfied physiological functions at moderate application of potassium (Towfiq, K.M. 2008)

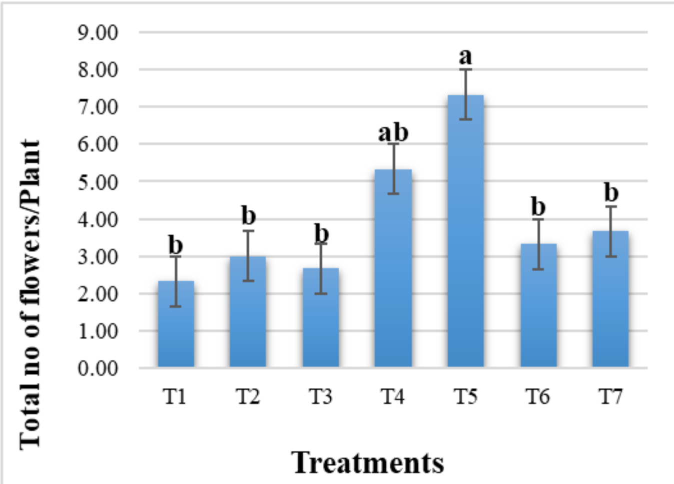

Figure 3. Impact of various levels of Potassium on total no of flowers/plant of BINA mung-5; figures having similar letter(s) do not vary remarkably whereas figures with dissimilar letter(s) vary remarkably as per DMRT

Number of pod bearing branches

There is no significant impact of treatment on the number of pod-bearing branches per plant. Highest value (2.33) appears in three treatments (T2, T6, T7) and the mimimal value (1.67) was recorded from treatment T4.

Number of pods per plant

The quantity of pods per plant manifested no considerable variation due to the different levels of potassium. (Fig.4). The maximum number of pods per plant (4.67) was observed from T7 (1.5 g/10kg soil) and the treatment T5 manifested the fewer number of pods per plant (2.67).

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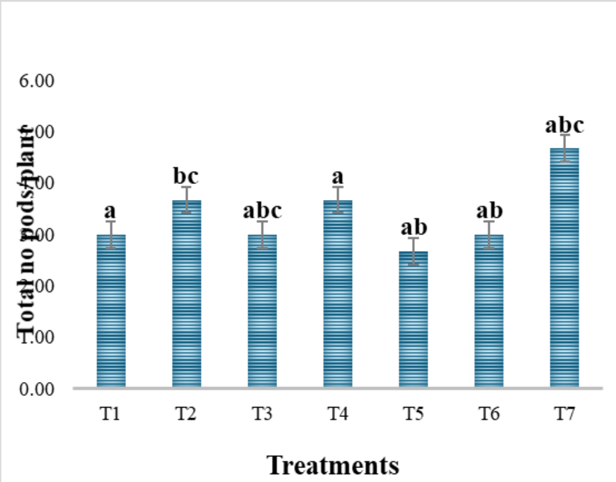

Figure 4. Influence of different levels of potassium on number of Pods plant -1 of BINA mung-5 ; figures having similar letter(s) do not vary remarkably whereas figures with dissimilar letter(s) vary remarkably as per DMRT

Number of seeds per plant

There were no significant differences in the number of seeds per pod because of application of different rates of potassium fertilizer (Fig 5). The highest number of seeds per pod were observed from treatment T5 (6.67) and the lowest number of seeds per pod were recorded from T6(4.67).

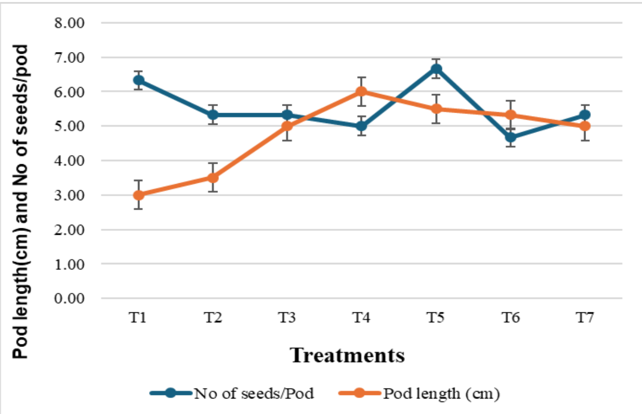

Figure 5. Effect of different level of potassium on number of seed/pod and pod length of BINA mung-5

Pod length (cm)

The pod length of mungbean was varied notably when different doses of potassium fertilizer were given (Fig 5). T4 (6.0 g K/10kg soil) had the longest pods (6.00 cm) followed closely by T5 and T6. On the other hand, T1 had the shortest pod length (3.00 cm) where no potassium was applied.

1000 seed weight (g)

Thousand seed weights were crucially affected due to application of various levels of potassium fertilizer in soil. Among the different fertilizer doses, T2 treatment (9.0 g k/10 kg soil) exerted the maximum thousand seed weight (42.79 g) and T1 treatment exerted the minimal thousand seed weight (21) where no potash was applied. It proves that increased amount of potassium also enhances the synthesis of carbohydrate and translocation of photosynthates to the seed of mungbean (Al-Wardy et al., 2022)

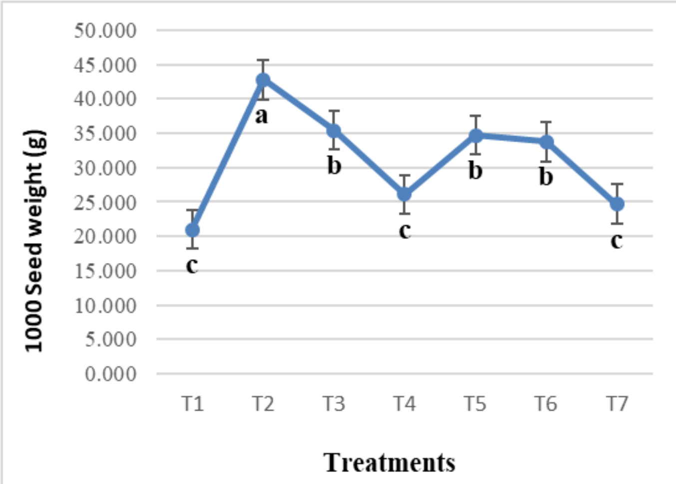

Figure 6. Effect of different doses of potassium on 1000 seed weight of BINA Mung-5; figures having similar letter(s) do not vary remarkably whereas figures with dissimilar letter(s) vary remarkably as per DMRT

Shoot Fresh Weight (g)

There was no significant difference in shoot fresh weight in Mungbean due to application of different levels of potassium fertilizer (Fig 7).

The highest number of shoot fresh weight was obtained from the treatment T5 (1.17 g) and the lowest from the treatment T6 (0.78 g).

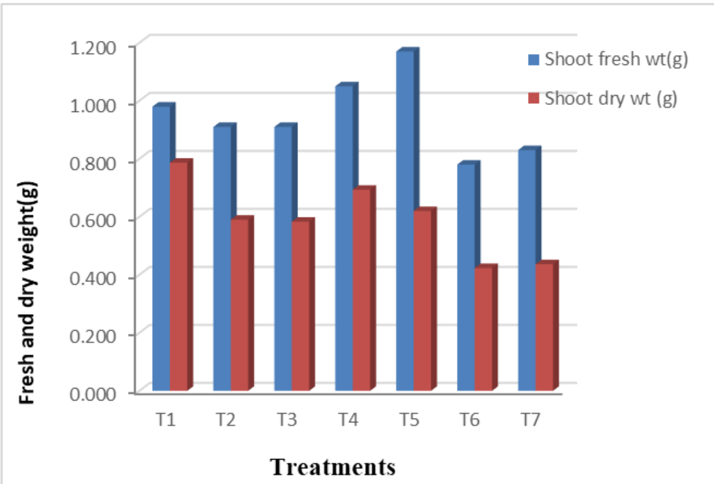

Figure 7. Effect of potassium fertilizer on Shoot fresh weight and dry weight of BINA mung-5

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Shoot Dry Weight (g)

There was no obvious difference between the treatments in shoot dry weight due to application of different doses of potassium fertilizer (Fig 7).

The highest number of shoot dry weight was recorded from T1(control) and the lowest was obtained from T6 (0.42g).

Root length (cm)

Application of potassium fertilizer at different doses exerted significant variation on root length (Fig 8). T3 had the longest root length (12.33cm) and the lowest root length was recorded from T7 (5.00 cm)

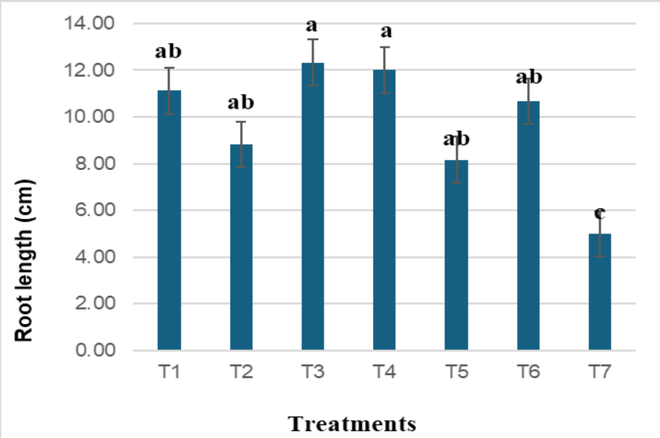

Figure 8. Effect of different doses of potassium on Root length (cm)of BINA Mung-5; having similar letter(s) do not vary remarkably whereas figures with dissimilar letter(s) vary remarkably as per DMRT

Root fresh weight (g)

There was significant difference in root fresh weight of Mungbean due to application of different doses of potassium fertilizer (Fig 9).

Maximum fresh weight was recorded from T4 (0.36 g) and the minimum weight was obtained from the treatment T7 (0.07 g)

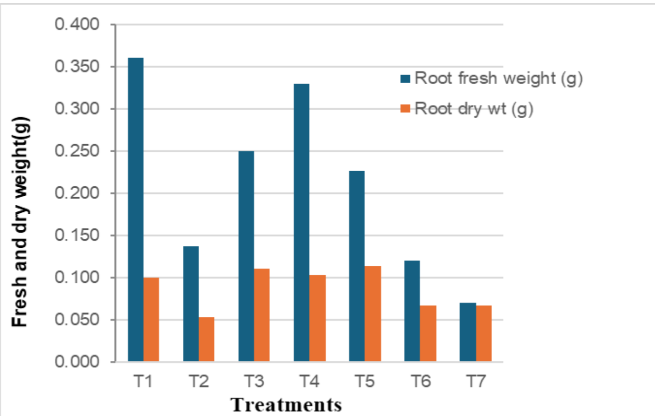

Figure 9. Effect of different doses of potassium on root fresh weight and dry weight of BINA Mung-5

Root dry weight (g)

Significant differences in root dry weight were not noticed due to application of different doses of potassium fertilizer (Fig 9).

The highest number of root weight was recorded from the treatment T5 (0.11 g) followed by T3 and T4. On the other hand, the lowest number of root dry weight was recorded from T6 and T7 (0.067 g).

CONCLUSION

The experiment was conducted in the net house of the Department of Soil Science, Patuakhali Science and Technology University, throughout the Kharif season of 2025. The objective was to evaluate the growth, yield performance, and drought tolerance of mungbean (BINA Mung-5) through potassium fertilization and Rhizobium inoculation. A single-factor experiment was organized in a Completely Randomized Block Design (CRD) with three replications. Seven potassium levels were tested: control (no potassium), 9.0, 7.5, 6.0, 4.5, 3.0, and 1.5 g K per 10 kg soil. Potassium was supplied as muriate of potash (KCl). A BARC-recommended dose of N, P, and S fertilizers was uniformly applied across treatments, along with cow dung and vermicompost as sources of organic matter. Data were statistically analyzed to assess treatment effects.

Key Findings

• Plant Height: The tallest plants (16.0 cm) were recorded in T5 (4.5 g K/10 kg soil), while the shortest were in control (T1).

• Branch Number: A significant variation was observed. The highest branch number (8.67) was found in T5.

• Leaf Number: Maximum leaves per plant (16) were observed in T6 (3.0 g K/10 kg soil), while the lowest occurred in the control.

• Reproductive Traits:

- Highest flowers per plant (7.33) and seeds per pod (6.67) were in T5.
- Maximum pods per plant (4.67) were recorded in T7 (1.5 g K/10 kg soil).

• Pod Length & Seed Weight: Pod length was highest (6.00 cm) in T4 (6.0 g K/10 kg soil). The heaviest thousand-seed weight (42.79 g) was obtained in T2 (9.0 g K/10 kg soil).

Recommendation

The results indicate that potassium fertilization, in combination with Rhizobium inoculation, effectively alleviates drought stress and enhances the growth and yield attributes of mungbean (BINA Mung-5). Among the treatments, T5 (4.5 g K/10 kg soil) showed consistently superior performance in terms of growth and reproductive traits.

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However, to formulate a definitive recommendation, further multi-location trials across different agro-ecological zones of Bangladesh are necessary.

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Conflict of Interest

This study was conducted without conflicts of interest.

Ethical Approval

Because this research did not include humans or animals, no ethical approval is required.

Consent for Publication

All authors read and approved the manuscript and agreed for publication.

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