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Effects of Different Levels of DAP on Agronomical Characteristics and Yield of Mung bean

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ABSTRACT: Phosphorus deficiency is one of the main factors restricting mung bean (*Vigna radiata* L.) production in many parts of the world, including Afghanistan. Therefore, a field experiment was carried out in the 2025 growing season at the Research Farm of the Faculty of Agriculture, Kabul University, to determine the influence of different diammonium phosphate (DAP) fertilizer levels on mung bean growth and yield. The experiment was arranged in a randomized complete block design (RCBD) with three replications, consisting of four DAP rates: 0, 30, 60, and 90 kg ha^{-1}. The collected growth and yield data were analyzed using analysis of variance (ANOVA), and mean comparisons were performed using the Least Significant Difference (LSD) test at a 5% probability level. The application of DAP fertilizer significantly improved plant height, shoot dry matter, number of branches, pods per plant, pod length, seeds per pod, and 100-seed weight. However, leaf number, grain weight per square meter, seed yield, and harvest index did not show significant differences among fertilizer treatments, although higher values were generally observed compared with the control treatment. The maximum seed yield (870.83 kg ha^{-1}) was obtained from the application of 60 kg DAP ha^{-1}, while the highest performance for most growth and yield-related traits was recorded under 90 kg DAP ha^{-1}. The findings suggest that DAP fertilizer application enhances mung bean growth and yield performance under the environmental conditions of Kabul. Among the tested fertilizer levels, 60 kg DAP ha^{-1} was found to be the most effective rate for achieving higher grain yield.

KEYWORDS: diammonium phosphate (DAP), growth, mung bean, yield

INTRODUCTION

Mung bean (*Vigna radiata* L.) is an important short-season grain legume widely cultivated in tropical and subtropical regions. It is highly valued for its nutritional quality, containing considerable amounts of protein, essential amino acids, vitamins, and minerals. Due to its affordability and nutritional benefits, mung bean serves as an important source of dietary protein for millions of people, particularly in developing countries. In addition to its nutritional importance, mung bean contributes to sustainable agricultural systems through its association with *Rhizobium*, which enables biological nitrogen fixation. This process improves soil fertility, reduces dependence on synthetic nitrogen fertilizers, and supports low-input and environmentally friendly cropping systems (Kishor et al., 2021; Kumari et al., 2025).

Despite its importance, mung bean productivity remains low and inconsistent in many production areas. One of the major factors limiting yield is poor soil fertility, particularly phosphorus deficiency. Inadequate phosphorus availability affects root development, nodulation, flowering, and pod formation, which ultimately reduces plant growth and crop productivity (Baghlani et al., 2023; Ayele, 2023).

Phosphorus is an essential plant nutrient involved in energy transfer, root growth, cell division, and reproductive development. In legume crops, adequate phosphorus supply is especially important because it promotes nodulation and enhances biological nitrogen fixation. Phosphorus deficiency can restrict these processes, resulting in poor plant development and reduced yield. Diammonium phosphate (DAP) is a commonly used phosphorus fertilizer that provides both phosphorus and nitrogen, making it effective for improving early crop establishment and supporting the growth of pulse crops (Hussain et al., 2021; More et al., 2024).

Previous studies have demonstrated positive responses of mung bean to phosphorus application. Parvez et al. (2013) reported that increasing phosphorus levels improved plant height, branch number, pods per plant, seed weight, and grain yield, with better performance at higher fertilizer rates. Similarly, Baghlani et al. (2023) found that the application of 60 kg P_2O_5 ha^{-1} improved important growth and yield characteristics of mung bean. Eyaya Tigabie Shiferaw and Abewoy (2023) also reported improved mung bean performance under phosphorus application, although the optimum level varied according to cultivar and environmental conditions.

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Balanced nutrient management has also been recognized as an important factor in improving crop growth and productivity. Islam (2021) observed that combined NPK fertilizer application enhanced vegetative growth, nutrient uptake, and yield-related characteristics. Hussain et al. (2021) further reported that balanced fertilization improved physiological traits, including leaf area development and crop growth rate, resulting in increased grain yield. These findings emphasize the importance of phosphorus and balanced nutrient supply for both vegetative growth and reproductive development in mung bean.

Recently, integrated nutrient management approaches involving mineral fertilizers, organic sources, and beneficial microorganisms have gained attention for improving nutrient availability and long-term soil productivity. Batubara (2022) reported that combining organic fertilizer with NPK increased mung bean yield compared with untreated conditions. Similarly, Hosen (2021) found that vermicompost combined with reduced chemical fertilizer rates improved growth and yield performance while maintaining crop productivity.

The combined use of biological inputs and mineral fertilizers has also shown beneficial effects on mung bean production. Kumari et al. (2025) reported that the application of vermicompost, *Rhizobium*, and recommended fertilizer levels improved nutrient uptake and grain protein content. Khan et al. (2022) demonstrated that phosphate-solubilizing bacteria combined with mineral phosphorus fertilizer increased phosphorus availability, improved nitrogen fixation, and enhanced grain yield. These findings indicate that appropriate nutrient management strategies can improve phosphorus efficiency and crop productivity.

Although the importance of phosphorus fertilization in mung bean production is well documented, limited information is available regarding the suitable DAP application rate under specific agroecological conditions. Crop response to phosphorus generally increases up to an optimum level; however, excessive fertilizer application may provide limited additional benefits and reduce nutrient use efficiency (Parvez et al., 2013; Baghlani et al., 2023; More et al., 2024). Therefore, determining an appropriate DAP rate under local production conditions is necessary to improve yield, enhance fertilizer efficiency, and promote sustainable mung bean cultivation.

Therefore, this study was conducted to evaluate the effects of different DAP application rates on the growth, yield components, and grain yield of mung bean under the agroecological conditions of Kabul, Afghanistan. The study aimed to identify an effective phosphorus management practice that improves crop productivity and nutrient use efficiency while supporting sustainable mung bean production in the region.

MATERIALS AND METHODS

Study Design and Experimental Site

The experiment was conducted during the 2025 cropping season at the Research Farm of the Faculty of Agriculture, Kabul University, Afghanistan. The experimental site is located at 34.3104° N latitude and 69.0823° E longitude, with an elevation of 1,809 m above sea level. The area represents the irrigated farming conditions commonly practiced in central Afghanistan, where mung bean is cultivated during the summer season.

Kabul has a cold semi-arid climate characterized by warm summers, cold winters, and limited annual rainfall. During the study period, the average annual temperature was approximately 12.1°C, while summer temperatures often exceeded 30°C. The annual precipitation is about 332 mm, with most rainfall occurring in spring. Since rainfall during the crop-growing period is insufficient, irrigation was applied throughout the experiment to maintain adequate soil moisture.

Soil Sampling and Initial Soil Analysis

Before sowing, composite soil samples were collected from the 0–30 cm soil depth and analyzed to determine the initial fertility status of the experimental field. The soil had a sandy loam texture with a slightly alkaline pH (7.8) and low electrical conductivity (0.259 mS cm^{-1}), indicating non-saline conditions. The soil contained 0.9% organic matter, 0.03% total nitrogen, and 1.83 ppm available phosphorus. The low phosphorus content confirmed the suitability of the site for evaluating the effect of phosphorus fertilizer on mung bean growth and yield.

Plant Material and Experimental Design

Certified mung bean (*Vigna radiata* L.) seeds were obtained from the Badam Bagh Research Farm. Seed quality was evaluated before planting through a germination test, which showed 98% germination.

The experiment was established using a Randomized Complete Block Design (RCBD) with three replications. Four DAP fertilizer rates were tested: 0, 30, 60, and 90 kg ha^{-1}. The treatments were randomly assigned within each block. All other agronomic practices were maintained uniformly across treatments to ensure that differences in crop performance were mainly due to DAP application.

Crop Management Practices

The field was prepared through conventional ploughing followed by leveling to obtain a suitable seedbed. Mung bean was sown using the recommended planting spacing for the crop. Irrigation was provided whenever necessary to prevent moisture stress, particularly during critical growth stages. Weed control and other routine field operations were carried out equally in all plots throughout the growing season.

Data Collection and Measurement Procedures

Growth and yield data were collected from randomly selected plants in the central rows of each plot to avoid border effects. The recorded traits included plant height, number of leaves per plant, number of branches per plant, shoot dry weight, pods per plant, seeds per pod, pod length, 100-seed weight, grain yield, and harvest index. Standard procedures were followed during data collection to ensure reliable and consistent measurements.

3.6. Statistical Analysis

The collected data were analyzed using analysis of variance (ANOVA) according to the Randomized Complete Block Design. When significant differences were observed among treatments, treatment means were compared using the Least Significant Difference (LSD) test at the 5% probability level ($P \leq 0.05$).

RESULTS

The analysis of variance showed that DAP fertilizer application had a significant effect on plant height ($P < 0.05$). Plant height increased with DAP application compared with the control treatment. The highest plant height was recorded with 60 kg DAP ha^{-1} (27.20 cm), followed by 90 kg DAP ha^{-1} (27.19 cm) and 30 kg DAP ha^{-1} (25.68 cm). The treatments receiving 30, 60, and 90 kg DAP ha^{-1} were statistically similar and were grouped in the same category ("a"). The lowest plant height was recorded in the control treatment (0 kg DAP ha^{-1}), with an average value of 23.02 cm, which was classified in group ("b") (Figure 1).

The results indicate significant variation in plant height among DAP treatments, with fertilizer-applied treatments showing higher values than the untreated control.

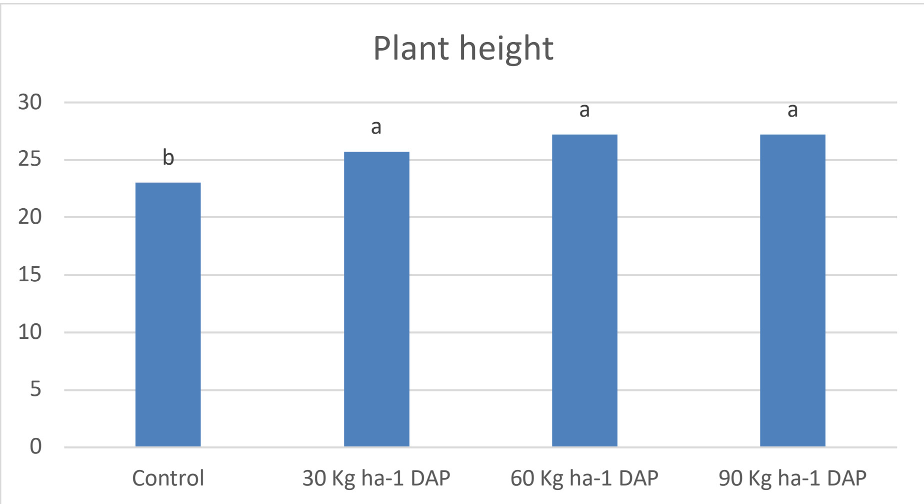

Figure 1. Effect of different DAP fertilizer rates on plant height of mung bean.

The highest number of leaves per plant was recorded in the treatment receiving 90 kg DAP ha^{-1} (28.63 leaves), followed by 60 kg DAP ha^{-1} (28.48 leaves). The lowest value was observed in the control treatment without DAP application (22.84 leaves per plant). The coefficient of variation (CV) for this trait was 17.35% (Figure 2).

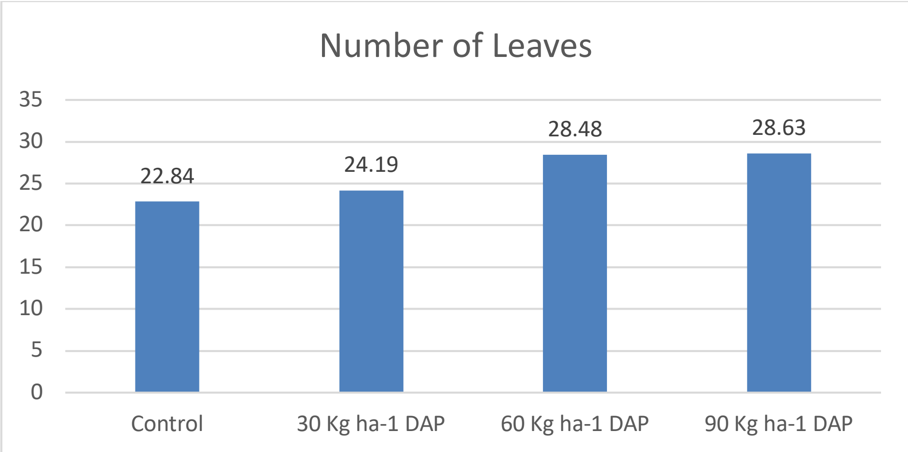

Figure 2. Effect of different DAP fertilizer rates on the number of leaves per plant of mung bean.

The application of DAP fertilizer significantly affected shoot dry weight. The highest shoot dry weight was recorded with 90 kg DAP ha^{-1} (92.83 g), followed by 60 kg DAP ha^{-1} (81.17 g). The lowest value was observed in the control treatment without DAP application (53.17 g). According to the LSD test, the 60 and 90 kg DAP ha^{-1} treatments were statistically similar and classified in the same group ("a"), while the 0 and 30 kg DAP ha^{-1} treatments were grouped as ("b").

No significant difference was observed between the 0 and 30 kg DAP ha^{-1} treatments. The coefficient of variation (CV) for shoot dry weight was 10.72% (Figure 3).

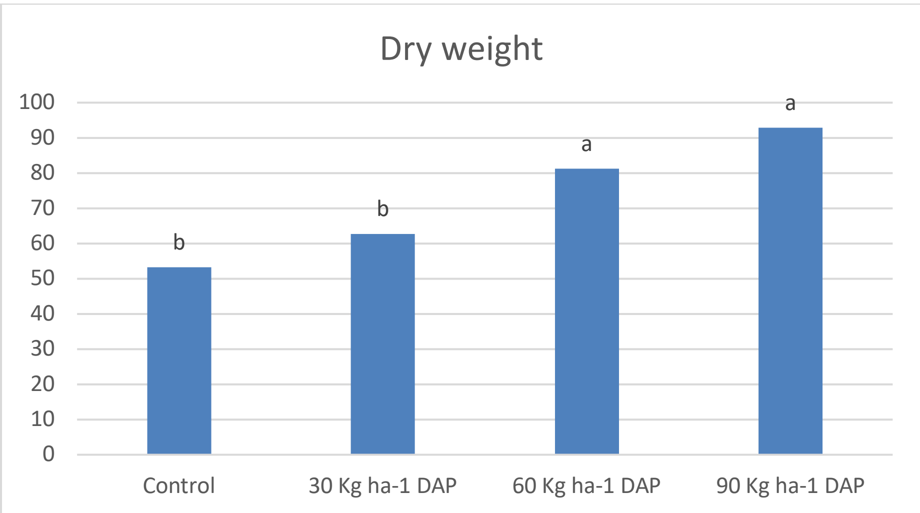

Figure 3. Effect of different DAP fertilizer rates on shoot dry weight of mung bean.

DAP fertilizer application significantly affected the number of branches per plant. The highest number of branches was recorded with 90 kg DAP ha^{-1} (3.37), followed by 60 kg DAP ha^{-1} (2.83) and 30 kg DAP ha^{-1} (2.33). The lowest number of branches was observed in the control treatment without DAP application (1.53).

According to the LSD mean comparison, significant differences were observed among all treatments. The treatments were classified into separate statistical groups in the following order: 90 kg DAP ha^{-1} (a), 60 kg DAP ha^{-1} (b), 30 kg DAP ha^{-1} (c), and 0 kg DAP ha^{-1} (d). The coefficient of variation (CV) for this trait was 7.86% (Figure 4).

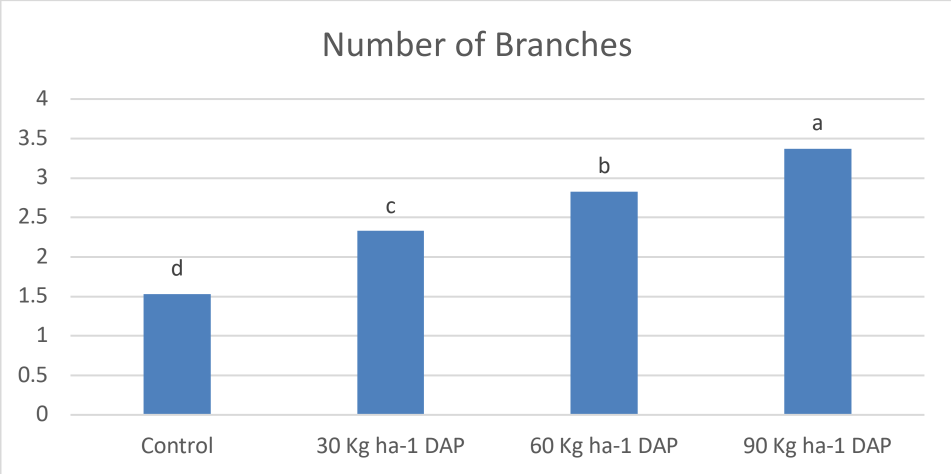

Figure 4. Effect of different DAP fertilizer rates on the number of branches per plant of mung bean.

DAP fertilizer application significantly affected the number of pods per plant. The highest number of pods was recorded with 90 kg DAP ha^{-1} (9.13), followed by 60 kg DAP ha^{-1} (8.83) and 30 kg DAP ha^{-1} (7.97). The lowest number of pods per plant was observed in the control treatment without DAP application (7.20).

The LSD mean comparison showed that the 60 and 90 kg DAP ha^{-1} treatments were statistically similar and classified in the same group ("a"). The 30 kg DAP ha^{-1} treatment was placed in group ("b"), while the control treatment was classified in group ("c"). The coefficient of variation (CV) for this trait was 4.12% (Figure 5).

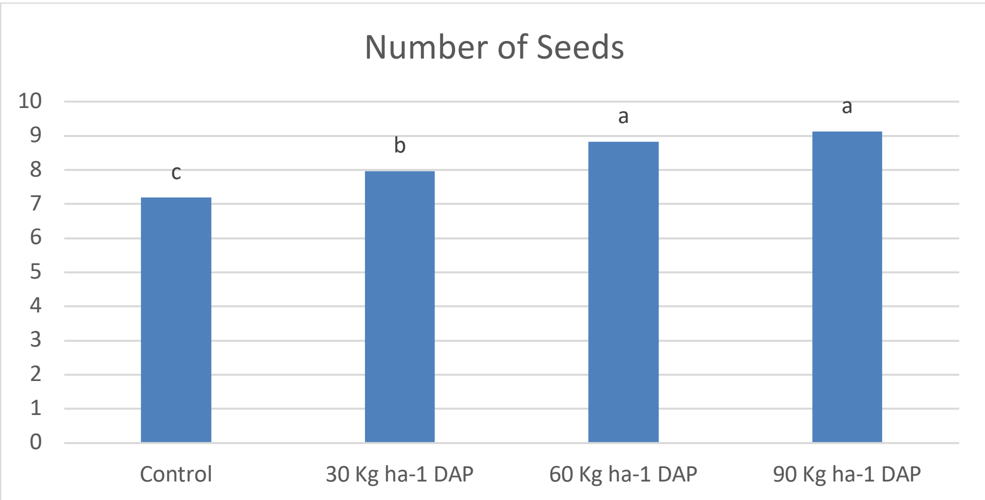

Figure 5. Effect of different DAP fertilizer rates on the number of pods per plant of mung bean.

DAP fertilizer application significantly affected 100-seed weight. The highest 100-seed weight was recorded with 90 kg DAP ha^{-1} (7.17 g), followed by 60 kg DAP ha^{-1} (6.33 g). The lowest value was observed in the control treatment without DAP application (5.17 g), while the 30 kg DAP ha^{-1} treatment recorded 5.50 g.

The LSD mean comparison showed that the 90 kg DAP ha^{-1} treatment was significantly higher than all other treatments and was classified in group ("a"). The 60 kg DAP ha^{-1} treatment was placed in group ("b"), whereas the 0 and 30 kg DAP ha^{-1} treatments were statistically similar and classified in group ("c"). The coefficient of variation (CV) for this trait was 5.69% (Figure 6).

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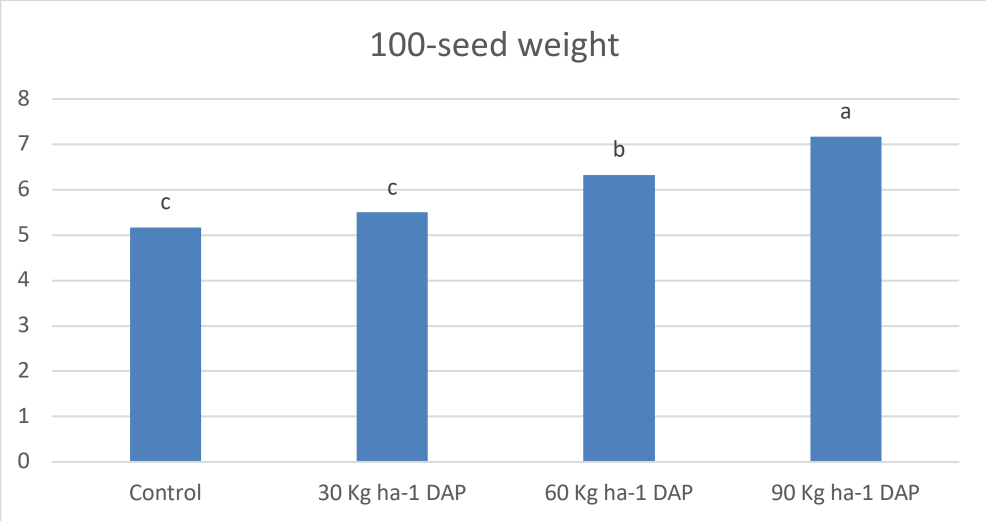

Figure 6. Effect of different DAP fertilizer rates on 100-seed weight of mung bean.

The analysis of variance showed that DAP application had no significant effect on grain weight per m² ($P > 0.05$). However, numerical differences were observed among treatments. The highest grain weight was recorded with 90 kg DAP ha^{-1} (74.83 g), followed by 60 kg DAP ha^{-1} (66.33 g) and 30 kg DAP ha^{-1} (46.50 g). The lowest grain weight was observed in the control treatment without DAP application (42.33 g).
The coefficient of variation (CV) for grain weight per m² was 21.75% (Figure 7).

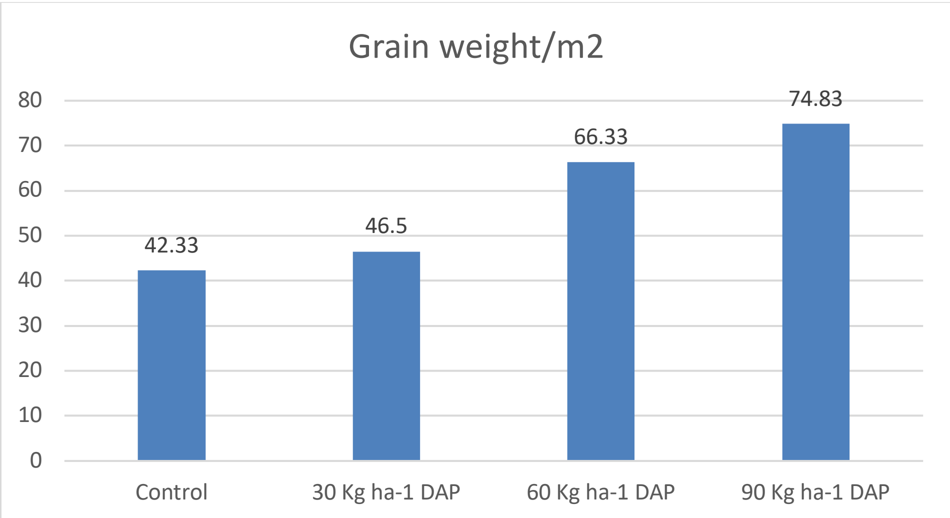

Figure 7. Effect of different DAP fertilizer rates on grain weight per m² of mung bean.

DAP fertilizer application significantly affected the number of pods per plant. The highest number of pods was recorded with 90 kg DAP ha^{-1} (21.87), followed by 60 kg DAP ha^{-1} (17.07) and 30 kg DAP ha^{-1} (14.77). The lowest number of pods per plant was observed in the control treatment without DAP application (11.30).
The LSD mean comparison showed that the 90 kg DAP ha^{-1} treatment was significantly higher than all other treatments and was classified in group ("a"). The 60 kg DAP ha^{-1} treatment was placed in group ("b"), while the control treatment was classified in group ("c"). The 30 kg DAP ha^{-1} treatment was categorized as ("bc"). The coefficient of variation (CV) for this trait was 12.64% (Figure 8).

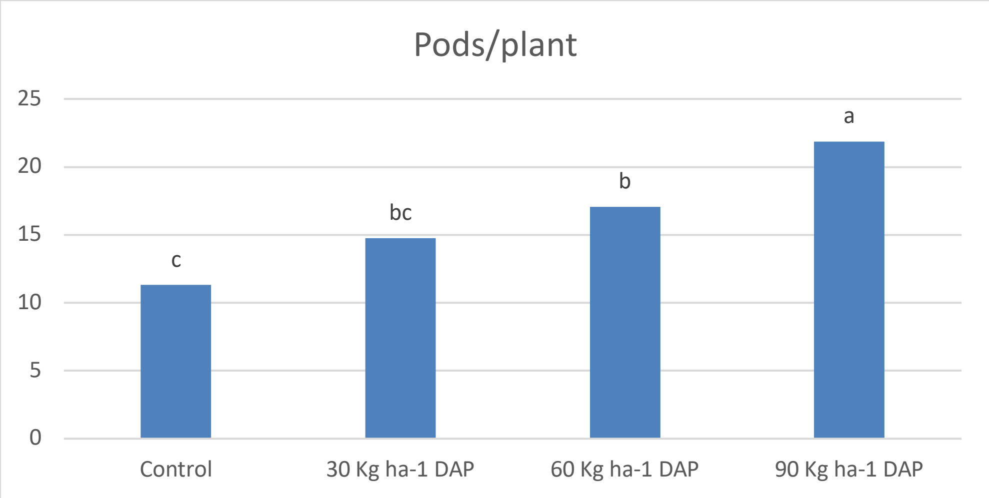

Figure 8. Effect of different DAP fertilizer rates on pods per plant of mung bean.

DAP fertilizer application significantly affected pod length. The longest pods were recorded with 90 kg DAP ha^{-1} (8.97 cm), followed by 60 kg DAP ha^{-1} (8.73 cm). The shortest pod length was observed in the 30 kg DAP ha^{-1} treatment (7.47 cm), while the control treatment without DAP application recorded 7.77 cm.
The LSD mean comparison showed that the 60 and 90 kg DAP ha^{-1} treatments were statistically similar and classified in the same group ("a"). The 0 and 30 kg DAP ha^{-1} treatments were placed in group ("b"). The coefficient of variation (CV) for pod length was 4.28% (Figure 9).

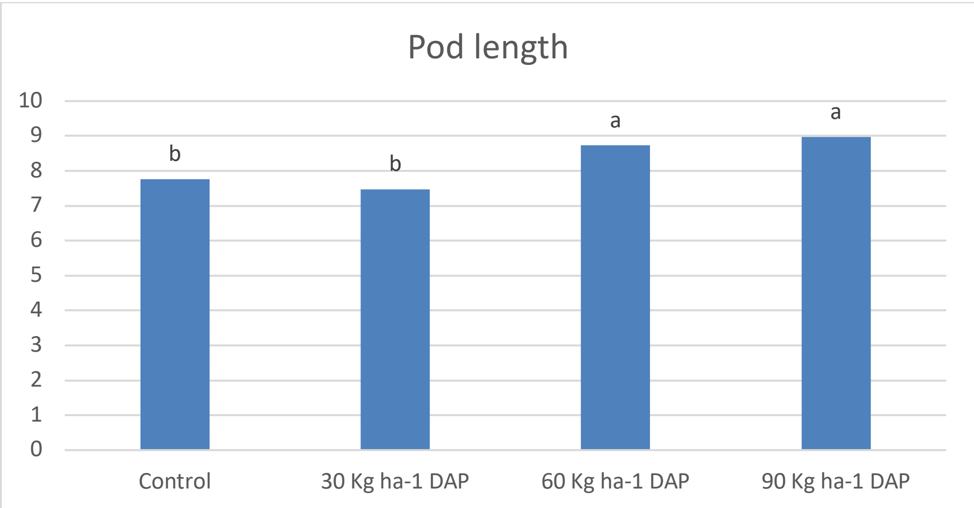

Figure 9. Effect of different DAP fertilizer rates on pod length of mung bean.

The analysis of variance showed that DAP application had no significant effect on seed yield ($P > 0.05$). However, numerical differences were observed among treatments. The highest seed yield was recorded with 60 kg DAP ha^{-1} (870.83 kg ha^{-1}), followed by 90 kg DAP ha^{-1} (745.00 kg ha^{-1}) and 30 kg DAP ha^{-1} (660.83 kg ha^{-1}). The lowest seed yield was obtained from the control treatment without DAP application (492.50 kg ha^{-1}).
The coefficient of variation (CV) for seed yield was 23.65% (Figure 10).

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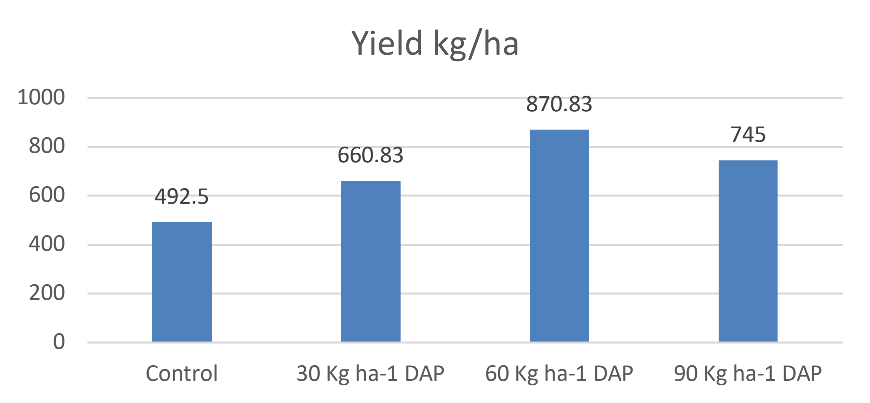

Figure 10. Effect of different DAP fertilizer rates on seed yield of mung bean.

The analysis of variance showed that DAP application had no significant effect on harvest index ($P > 0.05$). However, numerical differences were observed among treatments. The highest harvest index was recorded with 90 kg DAP ha^{-1} (110.83), followed by 60 kg DAP ha^{-1} (73.67) and 30 kg DAP ha^{-1} (52.18). The lowest harvest index was observed in the control treatment without DAP application (40.32).
The coefficient of variation (CV) for harvest index was 92.02% (Figure 11).

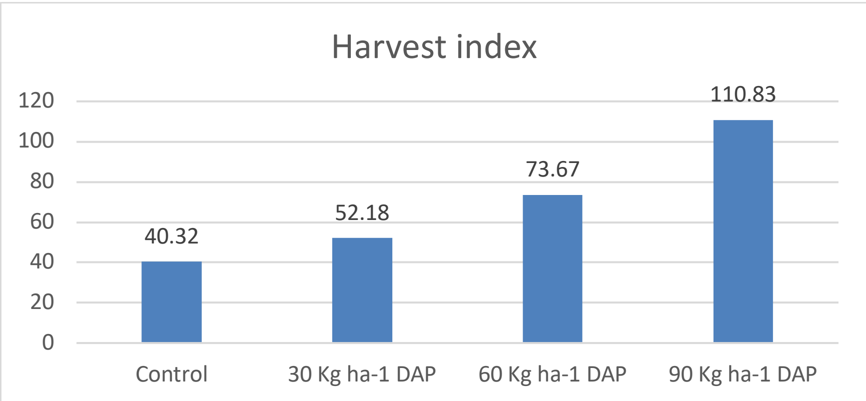

Figure 11. Effect of different DAP fertilizer rates on harvest index

DISCUSSION

The present study demonstrated that DAP application positively influenced the growth and yield-related characteristics of mung bean, although the magnitude of response varied among different traits. Plant height increased significantly with DAP application compared with the control, but further increases beyond 60 kg ha^{-1} did not produce additional improvement. The highest plant height was recorded at 60 kg ha^{-1} (27.20 cm), which was statistically similar to 90 kg ha^{-1} (27.19 cm). This indicates that mung bean growth responded positively to phosphorus availability up to an effective level, beyond which the response became limited. Similar results were reported by Parvez et al. (2013), Baghlani et al. (2023), and Rashidi et al. (2025), who found that phosphorus application improves early vegetative growth and plant height by enhancing root development and nutrient acquisition. The present findings further support the importance of phosphorus in promoting vegetative growth and suggest that moderate DAP application may be sufficient for achieving improved plant development.
Leaf number showed a numerical increase with DAP application, although the differences were not statistically significant. The highest leaf number was recorded at 90 kg ha^{-1} (28.63) and 60 kg ha^{-1} (28.48), compared with 22.84 leaves in the control. This indicates that phosphorus contributed to better vegetative growth, but leaf production was less responsive compared with other growth parameters. Similar observations were reported by Parvez et al. (2013), Baghlani et al. (2023), and Rashidi et al. (2025),

who found that phosphorus application had stronger effects on plant height and biomass than on leaf number. The limited response of leaf number may be related to genetic characteristics and environmental factors that influence leaf formation.

Dry matter production showed a clear positive response to DAP application, with the highest value obtained at 90 kg ha^{-1} (92.83 g), followed by 60 kg ha^{-1} (81.17 g). The similarity between higher phosphorus levels indicates that biomass production increased up to a certain nutrient level, after which additional phosphorus had a smaller effect. This improvement can be explained by the role of phosphorus in root growth, energy transfer, and nutrient uptake, which enhances overall plant growth and biomass accumulation. Similar findings were reported by Parvez et al. (2013), Baghlani et al. (2023), Hussain et al. (2021), and Rashidi et al. (2025), who observed increased biomass production with phosphorus and balanced nutrient application. These results strengthen the understanding that phosphorus availability is essential for improving plant vigor and dry matter accumulation in mung bean.

Branch production showed a strong response to increasing DAP rates, with branches increasing from 1.53 in the control to 3.37 at 90 kg ha^{-1}. Unlike some vegetative traits, branching showed a clear dose-dependent response, indicating that phosphorus supply directly influenced plant structural development. Increased branching may have resulted from improved root growth, enhanced metabolic activity, and greater nutrient availability under higher phosphorus levels. Similar improvements in branching were reported by Parvez et al. (2013), Baghlani et al. (2023), and Kumar & Maurya (2024), who found that phosphorus-based nutrient management improves vegetative development and plant architecture. These findings highlight the importance of phosphorus in improving canopy structure and growth potential of mung bean.

The yield-related traits also showed positive responses to DAP application. Pod number increased with increasing phosphorus levels, with the highest values recorded at 90 kg ha^{-1} (9.13) and 60 kg ha^{-1} (8.83). Similarly, pods per plant increased significantly with higher DAP application, reaching the maximum at 90 kg ha^{-1} (21.87). These improvements indicate that phosphorus played an important role in reproductive development by enhancing flowering, pod formation, and assimilate movement toward reproductive organs. Previous studies by Parvez et al. (2013), Baghlani et al. (2023), Hussain et al. (2021), and Rashidi et al. (2025) also reported that phosphorus improves reproductive traits and yield components in mung bean. The current findings contribute further evidence that adequate phosphorus supply is essential for improving yield formation through better reproductive growth.

The increase in 100-seed weight with increasing DAP levels, reaching the highest value at 90 kg ha^{-1} (7.17 g), indicates the positive influence of phosphorus on seed development and filling. Phosphorus improves energy transfer and nutrient movement during seed formation, which supports better seed growth. Similar improvements in seed weight and quality under phosphorus application were reported by Parvez et al. (2013), Baghlani et al. (2023), and Mota et al. (2021). These results confirm that phosphorus availability during reproductive stages plays a key role in improving seed characteristics.

Grain weight per m² also increased with DAP application, with the highest value observed at 90 kg ha^{-1} (74.83 g). Although the differences were statistically non-significant, the increasing trend indicates that phosphorus improved grain production through better plant growth and reproductive efficiency. Similar responses have been reported by Hussain et al. (2021), Rashidi et al. (2025), Kumar & Maurya (2024), and Kishor et al. (2021), who observed improved yield attributes under balanced nutrient management. The results suggest that phosphorus application contributes to better resource utilization and grain formation, even when statistical differences are limited.

Pod length increased with phosphorus application, with the longest pods recorded at 90 kg ha^{-1} (8.97 cm) and 60 kg ha^{-1} (8.73 cm). This indicates that phosphorus availability supported better pod development and structural growth. Similar effects were reported by Parvez et al. (2013), Baghlani et al. (2023), and Mota et al. (2021), who emphasized the role of phosphorus in improving reproductive characteristics of mung bean.

Seed yield showed an optimum response pattern, where the highest yield was recorded at 60 kg ha^{-1} DAP (870.83 kg ha^{-1}), followed by 90 kg ha^{-1} (745.00 kg ha^{-1}). Although differences were not statistically significant, the results indicate that moderate phosphorus application provided the best yield performance. The lower yield at 90 kg ha^{-1} compared with 60 kg ha^{-1} suggests that excessive phosphorus application may not always increase productivity and that the crop has an optimum nutrient requirement. Similar observations were reported by Hussain et al. (2021), Rashidi et al. (2025), Kumar & Maurya (2024), and Kishor et al. (2021), who noted that nutrient application beyond crop requirements may result in limited additional yield benefits.

Harvest index showed variation among treatments, with the highest value recorded at 90 kg ha^{-1} (110.83). Although differences were not statistically significant, the trend indicates improved partitioning of plant biomass toward economic yield with increased phosphorus availability. Similar findings were reported by Parvez et al. (2013), Baghlani et al. (2023), and Mota et al. (2021), who indicated that phosphorus improves assimilate distribution and crop efficiency.

Overall, the findings advance current knowledge by demonstrating that DAP application improves both vegetative and reproductive performance of mung bean, but the response depends on the specific growth trait. While some traits such as branching, pod number, and seed weight showed continuous improvement with increasing phosphorus levels, traits such as plant height, dry matter, and seed yield reached an optimum response at moderate fertilizer levels. This highlights the importance of applying phosphorus at an appropriate rate rather than increasing fertilizer inputs without considering crop requirements.

A major strength of this study is the evaluation of multiple growth and yield parameters, allowing a comprehensive assessment of DAP effects on mung bean performance. The comparison of different phosphorus levels also provides useful information for identifying effective fertilizer rates. However, the study was limited by the evaluation of phosphorus levels under specific environmental and soil conditions, which may influence nutrient response. The non-significant differences observed in some traits also indicate that additional factors such as soil fertility, climate, and genetic variation may influence crop performance.

The findings have practical implications for mung bean production by suggesting that moderate DAP application can improve growth, yield components, and productivity while avoiding unnecessary fertilizer use. These results can support improved phosphorus management practices for farmers aiming to increase mung bean yield efficiency. Future research should focus on evaluating DAP application across different soil types, locations, and seasons, as well as investigating combinations of phosphorus with other nutrients and integrated nutrient management approaches to develop more efficient fertilizer recommendations.

CONCLUSION

The study concluded that DAP application improved the growth and yield-related performance of mung bean compared with the control treatment. Phosphorus application enhanced important traits such as plant height, dry weight, branch number, pod formation, pod length, and 100-seed weight. Although some parameters did not show significant differences, they followed a positive trend with increasing DAP levels. Among the tested treatments, 60 kg DAP ha^{-1} produced the highest seed yield, while 90 kg DAP ha^{-1} showed better performance for several growth and yield attributes. Overall, the study highlights the beneficial role of DAP in improving mung bean productivity and identifies 60 kg DAP ha^{-1} as a suitable rate under the conditions of the study.

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