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Effects of Different Amount of Diammonium Phosphate (DAP) Fertilizer on Growth and Yield of Common Bean

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ABSTRACT: This study evaluated the effects of different rates of diammonium phosphate fertilizer on the growth, yield, and yield components of common bean under field conditions at the Faculty of Agriculture Research Farm, Kabul University, during the 2025 growing season. The experiment was conducted using a randomized complete block design with three replications and four fertilizer treatments: 0 (control), 30, 60, and 90 kg ha^{-1} of diammonium phosphate. Data were collected on vegetative growth traits, including plant height, number of branches, and number of leaves, as well as reproductive traits such as number of pods per plant, grains per pod, pod length, pod width, 100-seed weight, and grain yield. The data were analyzed using analysis of variance, and treatment means were separated using the least significant difference test at the 5% significance level. Fertilizer application significantly affected most growth and yield parameters. The application of 60 kg ha^{-1} produced the greatest vegetative growth, recording the highest plant height (33.8 cm) and number of branches (4.47), while the unfertilized control produced the highest number of leaves (36.4). The application of 90 kg ha^{-1} resulted in the highest reproductive performance, including number of pods per plant (12.33), grains per pod (4.00), pod size, 100-seed weight (66 g), and grain yield (1090 kg ha^{-1}). The findings indicate that moderate fertilizer application promotes vegetative growth, whereas a higher application rate maximizes reproductive development and grain yield. Therefore, applying 90 kg ha^{-1} of diammonium phosphate is recommended to improve common bean productivity under agroecological conditions similar to those of the study area.

KEYWORDS: DAP fertilizer, Grain yield, Phosphorus nutrition, Reproductive traits, Vegetative growth

INTRODUCTION

Common bean (Phaseolus vulgaris L.) is one of the most widely cultivated grain legumes worldwide and is recognized for its nutritional, economic, and agronomic importance. It is a rich source of dietary protein, carbohydrates, vitamins, and minerals, making it an essential component of human diets, particularly in developing countries where access to animal protein is limited. In addition to its nutritional value, common bean contributes to sustainable agricultural production through biological nitrogen fixation, which improves soil fertility and reduces dependence on synthetic nitrogen fertilizers. Consequently, the crop plays a significant role in enhancing food security, nutrition, and the livelihoods of smallholder farmers (Habibi et al., 2025; Karangwa et al., 2025; Tadesse et al., 2022).

In Afghanistan, common bean has become an increasingly important crop for both household consumption and income generation. However, its productivity remains considerably below its genetic potential because of several production constraints, among which declining soil fertility is one of the most important. Continuous cultivation, limited application of organic amendments, and imbalanced fertilizer use have resulted in widespread deficiencies of essential nutrients, particularly nitrogen and phosphorus, thereby restricting plant growth and grain yield (Aram et al., 2024; Habibi et al., 2025; Baghlani et al., 2023).

Phosphorus is a key macronutrient required for several physiological and biochemical processes in legumes. It plays a critical role in energy transfer, root development, nodulation, biological nitrogen fixation, flowering, pod development, and seed filling. Adequate phosphorus availability promotes vigorous plant growth and enhances yield, whereas phosphorus deficiency reduces root growth, nodulation, pod formation, seed development, and ultimately grain production (Jaleta et al., 2025; Alemayehu et al., 2025; Khan et al., 2022).

Diammonium phosphate is widely used as a fertilizer because it supplies both nitrogen and phosphorus, two nutrients that are essential for optimum crop growth. Nevertheless, fertilizer application in Afghanistan is generally based on farmers' experience rather than soil testing or scientifically established recommendations. As a result, fertilizers are often either under-applied, causing

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nutrient deficiencies and low yields, or over-applied, increasing production costs and potentially contributing to nutrient imbalances and long-term soil degradation (Aram et al., 2024; Jaleta et al., 2025; Habibi et al., 2025).

Previous studies have demonstrated that appropriate nutrient management can substantially improve the growth and productivity of common bean and other grain legumes. Integrated nutrient management, involving the combined use of organic and inorganic fertilizers, has been reported to increase biomass production, nodulation, pod formation, and grain yield. Similarly, balanced phosphorus fertilization has consistently improved growth, yield components, and nutrient use efficiency across different agro-ecological regions (Mathewos et al., 2025; Khan et al., 2022; Osmani & Amin, 2025; Chuma et al., 2022; Tadesse et al., 2022; Karangwa et al., 2025).

Although these studies provide valuable information, most have been conducted outside Afghanistan under different soil, climatic, and management conditions. Consequently, there is limited scientific evidence regarding the optimum rate of diammonium phosphate fertilizer for common bean production under Afghan agro-ecological conditions. This lack of locally generated recommendations has resulted in inefficient fertilizer use and inconsistent crop productivity. Determining an appropriate fertilizer rate is therefore essential for improving nutrient use efficiency, increasing grain yield, reducing unnecessary production costs, and promoting sustainable common bean production.

Accordingly, this study was conducted to evaluate the effects of different rates of diammonium phosphate fertilizer on the growth, yield, and yield components of common bean under the agro-ecological conditions of Afghanistan. The specific objectives were to: (i) determine the effects of different diammonium phosphate application rates on vegetative growth characteristics; (ii) assess their influence on yield components and grain yield; and (iii) identify the optimum fertilizer rate for maximizing common bean productivity under local field conditions.

It was hypothesized that diammonium phosphate application would significantly improve the growth, yield components, and grain yield of common bean compared with the unfertilized control, and that an optimum fertilizer rate exists that maximizes productivity under Afghan agro-ecological conditions.

MATERIALS AND METHODS

Study Site

The experiment was conducted during the 2025 growing season at the Research Farm of the Faculty of Agriculture, Kabul University, Afghanistan (34.31° N, 69.08° E; 1,809 m above sea level). The experimental site has a semi-arid climate. Before sowing, composite soil samples (0–30 cm depth) were collected and analyzed to determine the initial soil properties. The experimental soil was sandy loam, slightly alkaline (pH 7.8), and low in organic matter (0.9%), total nitrogen (0.03%), and available phosphorus (1.83 ppm).

Experimental Design and Treatments

The experiment was arranged in a randomized complete block design (RCBD) with four fertilizer treatments and three replications. The treatments consisted of:

- **T_1:** Control (0 kg DAP ha^{-1})
- **T_2:** 30 kg DAP ha^{-1}
- **T_3:** 60 kg DAP ha^{-1}
- **T_4:** 90 kg DAP ha^{-1}

Each experimental plot measured 2 m × 2 m (4 m^2). Adjacent plots and blocks were separated by appropriate buffer spaces to minimize treatment interference. The mung bean (*Vigna radiata* L.) variety Enam was sown on 25 May 2025 at a seed rate of 25 kg ha^{-1} using a spacing of 30 cm between rows and 10 cm between plants.

Crop Management

Diammonium phosphate fertilizer was applied according to the treatment rates and incorporated into the soil during land preparation. In addition, the recommended rate of nitrogen fertilizer was applied uniformly to all treatments in two equal splits to avoid nitrogen deficiency, while the recommended rate of well-decomposed farmyard manure was incorporated into all plots before planting. All other agronomic practices, including irrigation, thinning, hand weeding, and pest management, were carried out uniformly across treatments following the standard production practices recommended for mung bean.

Data Collection

Data were collected from randomly selected representative plants within each plot. Growth parameters included plant height (cm), number of branches per plant, and number of leaves per plant. Yield components included number of pods per plant, number of seeds per pod, and 100-seed weight (g). The crop was harvested at physiological maturity in two pickings. Grain yield was determined from the net harvested area of each plot and converted to kilograms per hectare (kg ha⁻¹).

Statistical Analysis

The collected data were subjected to analysis of variance (ANOVA) appropriate for a randomized complete block design to determine the effects of diammonium phosphate fertilizer rates on growth and yield parameters. Treatment means were separated using the Least Significant Difference (LSD) test at the 5% probability level ($p \leq 0.05$). Statistical analyses were performed using STAR software.

RESULTS

Vegetative Growth

The effects of different rates of diammonium phosphate (DAP) fertilizer on vegetative growth parameters are presented as bellow. Plant height was not significantly affected by DAP application ($p > 0.05$). The tallest plants were recorded under 60 kg DAP ha^{-1} (33.80 cm), followed by 90 kg DAP ha^{-1} (32.87 cm), the control (32.40 cm), and 30 kg DAP ha^{-1} (31.07 cm) (Figure 1).

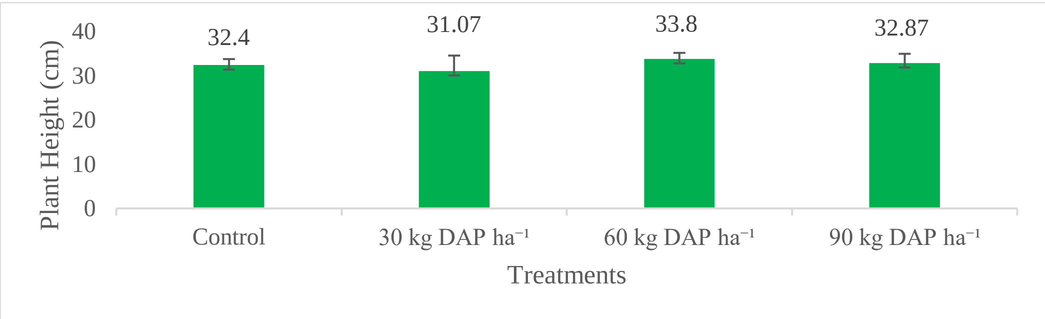

Fig. 1 effects of DAP on plant height (cm) of common bean

Similarly, the number of branches per plant did not differ significantly among treatments ($p > 0.05$). The highest number of branches (4.47) was obtained with 60 kg DAP ha^{-1}, while the lowest value (3.27) was recorded with 30 kg DAP ha^{-1}. The control and 90 kg DAP ha^{-1} treatments produced intermediate values.

The number of leaves per plant was also not significantly influenced by DAP fertilizer ($p > 0.05$). The control treatment recorded the highest number of leaves (36.40), whereas the fertilized treatments ranged from 27.33 to 30.40 leaves per plant.

Reproductive Growth and Yield Components

The effects of DAP fertilizer on reproductive growth and yield components are presented as bellow.

The number of pods per plant was not significantly affected by DAP application ($p > 0.05$). The highest mean value (12.33 pods plant^{-1}) was observed under 90 kg DAP ha^{-1}, while the control and 60 kg DAP ha^{-1} produced similar values (10.67 pods plant^{-1}).

The number of seeds per pod was significantly affected by DAP fertilizer ($p \leq 0.05$). The highest value (4.00 seeds pod^{-1}) was recorded under 90 kg DAP ha^{-1}, whereas the control, 30 kg DAP ha^{-1}, and 60 kg DAP ha^{-1} treatments were statistically similar.

Pod length differed significantly among treatments ($p \leq 0.05$). The longest pods (11.27 cm) were obtained with 90 kg DAP ha^{-1}, while the remaining treatments produced shorter pods ranging from 8.80 to 9.60 cm.

Pod width was also significantly affected by DAP application ($p \leq 0.05$). The highest values were recorded under 90 kg DAP ha^{-1} (0.9667 cm), whereas the control produced the lowest pod width (0.8667 cm).

Seed length showed a significant response to fertilizer application ($p \leq 0.05$). The greatest seed length (0.9667 cm) was recorded under 90 kg DAP ha^{-1}, while the control produced the lowest value (0.8667 cm).

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The 100-seed weight was not significantly affected by DAP fertilizer ($p > 0.05$). The highest value (66.00 g) was observed under 90 kg DAP ha^{-1}, while the lowest value (62.33 g) occurred under 60 kg DAP ha^{-1}.
Grain yield was significantly influenced by DAP application ($p \leq 0.05$). The highest grain yield (1090 kg ha^{-1}) was obtained with 90 kg DAP ha^{-1}, whereas the control, 30 kg DAP ha^{-1}, and 60 kg DAP ha^{-1} produced statistically similar yields (Figure 2).

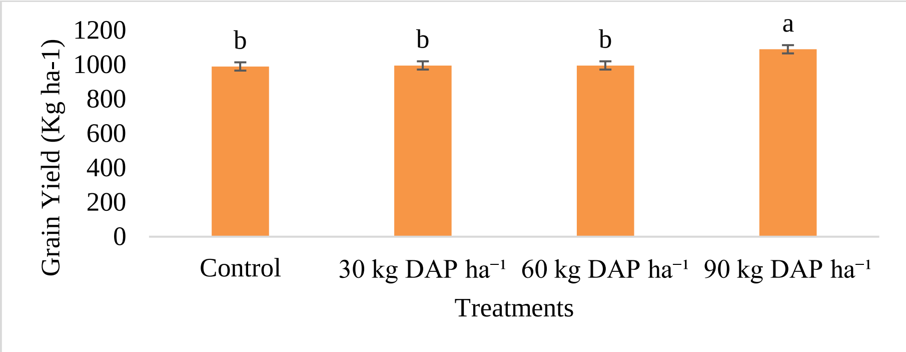

Fig. 2 effects of DAP on yield per hectare of common bean

DISCUSSION

The present study demonstrated that different rates of diammonium phosphate (DAP) fertilizer influenced several growth and yield characteristics of common bean under the agro-ecological conditions of Kabul, Afghanistan. Although vegetative traits, including plant height, number of branches, and number of leaves, were not significantly affected by DAP application, numerical differences among treatments indicated that moderate phosphorus supply (60 kg DAP ha^{-1}) tended to promote vegetative growth. In contrast, reproductive traits, particularly the number of seeds per pod, pod dimensions, and grain yield, responded positively to the highest DAP application rate (90 kg ha^{-1}), suggesting that adequate phosphorus availability is more critical during reproductive development than during early vegetative growth.
The absence of significant differences in vegetative growth parameters agrees with the findings of Afrillah et al. (2022) and Ejigu et al. (2024), who reported that vegetative growth in legumes is often influenced more by genotype and environmental conditions than by phosphorus application alone. However, the numerical increase in plant height and branching observed at 60 kg DAP ha^{-1} is consistent with studies by Baghlani et al. (2023), Habibi et al. (2025), and Aram et al. (2024), who reported improved vegetative development under balanced phosphorus fertilization. These observations indicate that moderate phosphorus availability supports root growth and nutrient acquisition, although the response may not always reach statistical significance under all environmental conditions.
The significant improvement in reproductive traits and grain yield with 90 kg DAP ha^{-1} is consistent with previous reports demonstrating the importance of phosphorus in flowering, pod formation, seed development, and assimilate translocation. Similar improvements in yield components have been reported by Chuma et al. (2022), Khan et al. (2022), Tadesse et al. (2022), Mathewos et al. (2025), Habibi et al. (2025), and Ruelas-Islas et al. (2024). Phosphorus plays a central role in energy transfer, photosynthesis, and biological nitrogen fixation, thereby improving reproductive efficiency and ultimately increasing grain yield. The superior performance of the highest DAP rate suggests that phosphorus availability was a limiting factor in the experimental soil, which was initially low in available phosphorus.
The lack of a significant response in 100-seed weight indicates that this trait was relatively stable across fertilizer treatments. Similar findings have been reported by Afrillah et al. (2022), Habibi et al. (2025), and Mathewos et al. (2025), who concluded that seed weight is generally less responsive to nutrient management than reproductive traits such as pod number and seeds per pod. This observation suggests that phosphorus primarily increased yield through improved reproductive success rather than by increasing individual seed size.
This study provides locally generated information on DAP fertilizer management for common bean production under Afghan agro-ecological conditions, where scientifically validated fertilizer recommendations remain limited. The use of a randomized complete block design with replicated treatments strengthened the reliability of the results by minimizing experimental error and improving

treatment comparisons. Nevertheless, the study has several limitations. It was conducted during a single growing season at one location using one common bean variety, and therefore the results may not represent responses under different climatic conditions, soil types, or genotypes. Furthermore, soil nutrient dynamics, phosphorus use efficiency, and economic returns were not evaluated. The findings have practical implications for improving common bean production in Afghanistan. Under the soil and environmental conditions of this study, the application of 90 kg DAP ha^{-1} produced the highest grain yield and may serve as a useful recommendation for farmers cultivating common bean in similar environments. However, fertilizer recommendations should ideally be based on soil testing and integrated nutrient management practices to improve nutrient use efficiency and maintain long-term soil fertility.

Future research should evaluate DAP fertilizer rates across multiple locations, seasons, and common bean varieties to confirm the consistency of the observed responses. Additional studies should also investigate integrated nutrient management strategies combining DAP with organic amendments, assess phosphorus use efficiency, biological nitrogen fixation, soil health, and conduct economic analyses to develop sustainable and cost-effective fertilizer recommendations for common bean production in Afghanistan.

CONCLUSION

This study evaluated the effects of different rates of diammonium phosphate (DAP) fertilizer on the growth, yield, and yield components of common bean under the agro-ecological conditions of Kabul, Afghanistan. The results showed that DAP application significantly improved several reproductive traits, including the number of seeds per pod, pod length, pod width, seed length, and grain yield, whereas most vegetative growth parameters and 100-seed weight were not significantly affected. Among the fertilizer treatments, the application of 90 kg DAP ha^{-1} produced the highest grain yield and the best overall reproductive performance. These findings indicate that adequate phosphorus supply plays an important role in enhancing common bean productivity under phosphorus-deficient soil conditions. The study provides locally generated evidence that can support fertilizer management recommendations for common bean production in Afghanistan and suggests that applying 90 kg DAP ha^{-1} is the most effective rate for maximizing grain yield under conditions similar to those of the present study.

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