Agriculture, Forestry and Fisheries
2025, Vol. 14, No. 4, pp. 144-148
https://doi.org/10.11648/j.aff.20251404.12

Editorial

Effect of Different Rates of Phosphorus Fertilizer on Yield and Yield Components of Faba Bean (Vicia Faba L.) at Sidamo Zone, Southern Ethiopia

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Abstract

Faba bean (Vicia faba L.) is a vital food legume globally. Low productivity, often due to suboptimal soil fertility management, is a major constraint in developing countries. This study aimed to determine the effects of different phosphorus (P) fertilizer rates on faba bean growth and yield components and to identify an optimum P rate. The field experiment was conducted at Hawassa University, College of Agriculture Research Farm, Ethiopia, in 2020 during the off-season under irrigation. A Randomized Complete Block Design (RCBD) was used with three replications and four P fertilizer levels (0, 50, 100, and 150 kg P/ha). Each plot (1.6m^2) contained four rows. Data on yield components were collected and analyzed. Results indicated that P application significantly ($P<0.05$) influenced the number of pods per plant, seeds per pod, and 100-seed weight. The highest values for these parameters were recorded with the application of 150 kg P/ha. Based on these yield components, applying 150 kg P/ha appeared promising for enhancing faba bean productivity in the study area. Further investigation across different localities is recommended to provide a broader recommendation for optimum P fertilization in faba bean production.

Keywords

Faba Bean, Vicia Faba L., Phosphorus Fertilization, Yield Components, Pods per Plant, Seeds per Pod

1. Introduction

1.1. Background and Justification

The faba bean (Vicia faba L.) is one of the world's earliest domesticated food legumes, with its center of origin suggested to be between the Oriental Mediterranean and Afghanistan [1]. It is a diploid species (2 n=12) with various botanical varieties differentiated by seed weight and use, including var. minor and equina (mainly for animal feed) and var. major (for human nutrition) [2]. Faba bean seeds possess a high protein content, averaging 30% [3], and the plant contributes to soil fertility through symbiotic nitrogen fixation, reducing the need for synthetic nitrogen inputs [4]. Globally, faba bean is extensively cultivated, particularly in North Africa and Asia [2, Query source for area statistics if different from Girm, 2008]. In Ethiopia, faba bean is a major pulse crop, covering a significant area [5] and serving as a key protein source in rural diets and for income generation [6].

Despite its importance, faba bean productivity in Ethiopia (average 1.5 tons/ha [6]) and other developing countries is often constrained by factors including low soil fertility, par-

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Received: 7 May 2025; **Accepted:** 23 May 2025; **Published:** 8 July 2025

ticularly phosphorus (P) deficiency [7, 8]. Phosphorus is crucial for plant health and vigor, influencing root development, stem strength, flower formation, nitrogen-fixing capacity, crop quality, and disease resistance [9]. Inadequate P nutrition leads to retarded growth, poor root systems, premature leaf fall, and impaired fruit setting [9]. While the productivity of crops can be improved with appropriate technologies like recommended fertilizer rates, these rates vary by crop, location, and soil type [10]. Although research has been conducted on faba bean, the specific impact of varying P rates on its performance in the Sidamo Zone has received limited attention. Therefore, this study was initiated to address this gap.

1.2. Objectives

The specific objectives of this study were:

1. To evaluate the effect of different phosphorus fertilizer application rates on the agronomic performance and yield components of faba bean in Hawassa.
2. To determine the optimum phosphorus fertilizer rate for faba bean production under Hawassa conditions.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at the Hawassa University, College of Agriculture Research Farm, during the 2020 off-season under irrigation. The site is located in Hawassa city, 273 km south of Addis Ababa, at 7 °04'N latitude and 38 °31'E longitude, with an altitude of 1670 m above sea level. The area receives an annual rainfall ranging from 900 to 1100 mm. The mean minimum and maximum annual temperatures are 12 ℃ and 27 ℃, respectively. (Self-correction: Original text had 200 C, likely a typo for 12 ℃ and 27 ℃ as separate min/max).

2.2. Experimental Design and Treatments

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Four levels of phosphorus fertilizer were used as treatments:

T1: 0 kg P/ha (Control)
T2: 50 kg P/ha
T3: 100 kg P/ha
T4: 150 kg P/ha

2.3. Experimental Procedures and Crop Management

The total experimental area was 37.4m^2. Each plot was 1.6m^2 (e.g., 1.6 m long x 1 m wide, or specify dimensions that give 4 rows). There were four rows per plot. The spacing between rows was 40 cm and between plants within a row was 10 cm. A 1 m space was maintained between blocks and 0.5 m between plots. The experimental field was cleaned, and the land was thoroughly prepared to achieve a fine tilth. (Author: Specify the faba bean variety used). Sowing was done as per the spacing. Irrigation was applied twice a day as needed throughout the crop cycle up to maturity. Other standard agronomic practices, such as weeding, were uniformly applied to all plots as required. Phosphorus fertilizer was applied at sowing as per the treatments

2.4. Data Collection

Data were collected from five randomly selected and tagged plants from the two central rows of each plot, excluding border plants, to avoid edge effects. The following parameters were recorded:

1. Number of pods per plant (NPP): Counted from the five sample plants at maturity and averaged.
2. Number of seeds per pod (SPP): Determined by taking a random sample of 10 pods from the harvested sample plants, counting the total seeds, and dividing by the number of pods, then averaged.

100-seed weight (g): One hundred seeds were randomly taken from the threshed produce of the sample plants from each plot and weighed using a sensitive balance. (Corrected unit to grams, assuming this is standard practice. Please verify.)

(Author: Was grain yield per plot or per hectare measured? This is a critical parameter usually included.)

2.5. Statistical Analysis

The collected data were subjected to Analysis of Variance (ANOVA) appropriate for an RCBD using SAS software (or specify software, e.g., R, GenStat). Treatment means were compared using the Least Significant Difference (LSD) test at the 5% ($\alpha = 0.05$) and/or 1% ($\alpha = 0.01$) levels of significance. The coefficient of variation (CV%) was also calculated.

3. Results

The analysis of variance revealed that phosphorus fertilizer application had a statistically significant effect ($P<0.05$) on the number of seeds per pod (SPP), number of pods per plant (NPP), and 100-seed weight (Table 1; Appendix Tables A1-A3).

Table 1. *Effect of different phosphorus fertilizer rates on yield components of faba bean. Treatment (kg P/ha) | Number of Seeds per Pod (SPP) | Number of Pods per Plant (NPP) | 100-Seed Weight (g)† |.*

NO treatment	Treatments kg/ha	Number of seed per pod	Number of pod per plant	100 seed weight g
1	0	2.83c	9.1d	10.5c
2	50	2.893bc	10.4c	12.39b
3	100	2.973b	11.7b	15.03a
4	150	3.17a	12.3a	15.14a
LSD5%		0.13	0.44	0.02
CV%		2.19%	2.o35%	1.391%

Means within a column followed by the same letter are not significantly different at P<0.05 using LSD test.

3.1. Number of Seeds Per Pod (SPP)

The number of seeds per pod was significantly influenced by P application rates (Table 1). The highest SPP (3.17) was recorded from plants that received 150 kg P/ha (T4), which was statistically superior to all other treatments. The lowest SPP (2.83) was observed in control treatment (T1, 0 kg P/ha). There was a general trend of increasing SPP with increasing P fertilizer rates.

3.2. Number of Pods Per Plant (NPP)

Different rates of P fertilizer significantly affected the number of pods per plant (Table 1). The maximum NPP (12.3) was obtained from the application of 150 kg P/ha (T4). This was significantly higher than all other treatments. The minimum NPP (9.1) was recorded in the control treatment (T1). Similar to SPP, NPP increased with each increment in P fertilizer application.

3.3. 100-seed Weight (g)

The 100-seed weight was also significantly affected by P fertilizer rates (Table 1). The highest 100-seed weight (15.14 g) was recorded for the treatment receiving 150 kg P/ha (T4), which was statistically similar to the 100 kg P/ha treatment (15.03 g) but significantly higher than the 50 kg P/ha and control treatments. The lowest 100-seed weight (10.50 g) was observed in the control plots (T1).

4. Discussion

The results of this study demonstrate that phosphorus fertilization significantly enhanced the yield components of faba bean under the experimental conditions in Hawassa. The observed increases in the number of pods per plant, seeds per pod, and 100-seed weight with increasing P application rates up to 150 kg P/ha are consistent with the known roles of phosphorus in plant growth and development.

Phosphorus is vital for energy transfer (ATP), photosynthesis, respiration, and nucleic acid formation [9]. Adequate P nutrition promotes robust root development, which enhances nutrient and water uptake, leading to overall improved plant vigor [7, 11]. This improved vigor can translate into better flower formation, pod set, and seed development, as observed in this study. The increase in NPP with P application could be attributed to enhanced branching, more flower production, and reduced flower/pod abortion due to improved P supply [12, 13]. Similarly, the increase in SPP and 100-seed weight suggests that P availability influenced assimilate partitioning towards developing seeds, leading to more and heavier seeds [14].

The findings align with previous research. For instance, Salih et al. [15] reported positive effects of P application on faba bean seed yield and quality. Soheir [13] also found that increasing P levels enhanced yield components of faba bean. Getachew and Sommar [7] emphasized the importance of P fertilizer in acidic soils, common in parts of Ethiopia, for improving crop yields. (Author: Find more specific studies from your reference list that show similar trends for NPP, SPP, and 100-seed weight in faba bean or other legumes in response to P and cite them here. E.g., "Similar increases in pods per plant with P application were reported by [Author, Year] and [Author, Year].")

The highest values for yield components were observed at 150 kg P/ha. This suggests that under the conditions of this study (off-season, irrigated, specific soil type of the research farm), faba bean responded positively up to this P level. However, it's important to consider that soil P availability, soil type, and previous cropping history can influence the response to P fertilizer [10, 16]. The soil at the Hawassa University Research Farm might be deficient in P, leading to such a pronounced response.

5. Conclusion and Recommendations

5.1. Conclusion

This study demonstrated that phosphorus fertilizer applica-

tion significantly improved key yield components of faba bean (number of pods per plant, seeds per pod, and 100-seed weight) in the Hawassa area during the off-season under irrigation. Increasing rates of P fertilizer generally led to an increase in these parameters, with the 150 kg P/ha application rate resulting in the highest values for the measured yield components.

5.2. Recommendations

Based on the results for yield components:

For faba bean production under conditions similar to this study (Hawassa area, off-season, irrigated), application of phosphorus fertilizer at a rate of 150 kg P/ha can be considered promising for enhancing yield components. (Author: This recommendation would be stronger if based on actual grain yield and an economic analysis).

It is recommended to repeat this study across different locations in the Sidamo Zone and other faba bean growing regions of Ethiopia, encompassing various soil types and rainfall conditions, to develop more comprehensive and site-specific P fertilizer recommendations.

Future research should include an economic analysis to determine the most profitable P rate for farmers.

Investigating the initial soil P status and its relationship with crop response would further refine P fertilizer recommendations.

Acknowledgments

Above all, I thank to my god adebt of praise for his presence with me in all ups and downs. Next I we would like to express my great thanks to hawassa University College of Agriculture and department of plant and horticultural science for preparing such type of learning activity. My special thanks also go to our advisor instructor Mr Melkamu Dugasa for his unreserved advice and frequent supervision in the entire work of our seiner project proposal writing.

Author Contributions

Adisu Longale: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing

Gobena Tsfaye: Data curation, Funding acquisition, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Table A1. *Analysis of variance (ANOVA), NSP of Faba bean.*

Source of variation	DF	SS	MS	F- test with f-calculated	F –table at 5%
Block	2	0.03647	0.018235		
Treatment	3	0.1896	0.0632	14.929	4.76
Error	6	0.0254	0.00423		
Total	11	0.25147	0.02286		

Table A2. *Analysis of variance (ANOVA), NPP of titicale.*

Source of variation	DF	SS	MS	F- test with f-calculated	F –table
Block	2	0.3466	0.173		
Treatment	3	17.466	5.822	19.111	4.76
Error	6	0.293	0.0488		
Total	11	18.10	1.646		

Table A3. *Analysis of variance (ANOVA) 100 seed weight of faba bean in q/ha.*

Source of variation	DF	SS	MS	F- test with f-calculated	F –table
Block	2	0.0369	0.01846		
Treatment	3	45.3486	15.1162	444.4	4.76
Error	6	0.2041	0.034		
Total	11	45.5896	4.145		

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