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| RESEARCH ARTICLE

Effect of Phosphorus Fertilizer and Seed Rates on Growth and Yield of Common Bean *(*Phaseolus Vulgaris L) in Kunduz, Afghanistan

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| ABSTRACT
A field experiment was conducted on the Effect of phosphorus fertilizer and seed rates on the growth and yield of common bean *(*Phaseolus vulgaris L) at the Farm of the agriculture faculty of Kunduz University during the spring season of 2023 to determine the optimum rates of phosphorus fertilizer and seed rates for maximum yield of common bean in the northeast of Afghanistan (Kunduz province). The treatment consists of three phosphorus levels (0kgP_2O_5ha^{-1}, 40kgP_2O_5ha^{-1} and 80kgP_2O_5ha^{-1}) and four combined seed rates (125 kgha^{-1}, 150 kgha^{-1}, 175 kgha^{-}1 and 200 kg ha^{-1}) laid out in randomized complete block design (RCBD) with three replications. The results revealed that phosphorus levels and different seed rates significantly affected on growth, yield attributes and yield of common bean on plant height, Leaf area/plant (cm^2), Brunches/plant, Root dry weight/plant(g), Nodules/pant, No. of notes/plant, Pods/plant, Seeds/pod, 100 seed weight, seed yield/plant(g) and Grain Yield t/ha, the highest plant height (44.10cm), Leaf area/plant (217.18cm^2), Brunches/plant(11.75), Root dry weight/plant (2.282g), Nodules/pant (12.16), Leaves/plant (47.833), No. of notes/plant (7.88), Pods/plant (16.98), Seeds/pod (6.97), 100 seed weight(34.536), seed yield/plant(8.83g) and Grain Yield (2.20t/ha) was in treatments 80kgP_2O_5ha^{-1} respectively. Seed rates were also significantly affected in treatment 200 kg ha^{-1} except for harvest index; all other yield attributes and yield was significant; the highest yield attributes and yield was in seed rate 200 kg ha^{-1}. Thus 80kgP_2O_5ha^{-1}with 200 kg ha^{-1} was found to be the best combination under northeast of Afghanistan agro-ecology as it gave higher values for yield and most yield related traits.

| KEYWORDS

Seed rate, plant height, phosphorus, grain yield, growth and common bean

| ARTICLE INFORMATION

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1. Introduction

The common bean (*Phaseolus vulgaris* L.) is one of the most popular legumes consumed worldwide. The crop is grown for immediate human consumption and has a greater commercial value than all other legume crops combined (*W. J. Broughton et al. 2003*). Common bean is cultivated in almost all continents of the world for utilization of 50% of the grain legume consumed as a source of protein around the world (*Ciat 2008*). In Afghanistan, it is grown for food because it is a good source of protein; Afghanistan farmers favor common beans above other crops because of their early maturing traits, which allow households to meet their food needs and obtain the necessary monetary revenue, while other crops are not yet fully developed and ready for consumption. The crop is the best among pulses and is referred to as “the poor man’s meat” because it makes up for any potential protein deficiencies in low-income households (*D. Legese et al. 2006*). It is also the major staple food supplementing protein source for poor farmers who cannot afford to buy expensive meat. Common bean is high in starch 49%, protein 21.4% and dietary fiber 22.9% and is also a good source of minerals and vitamins, including iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid (*Ferris S.et al.2008*).

Soil Phosphorus deficiency is one of the most significant abiotic factors, along with N, limiting crop productivity. Overall, it is reported that 40% of crop production in the world's arable land is limited by Phosphorus availability, and sub-optimal levels of Phosphorus can result in 5 to 15% yield losses (*Bargaz et al. 2012*). The symbiotic process between legume roots and bacteria, phosphate has received considerable attention due to the dramatic effects observed in low phosphate soils when Phosphorus fertilizer is applied to modulated legumes, including *Phaseolus vulgaris* L. (*Zaman Allah et al. 2006; Abdi et al. 2014*). The contribution of phosphorus in plants inoculated has a significant effect on the nitrogen content, and the increase was more than 48% compared to control plants (*Hmissi et al. 2015*). In comparison with other legumes, (*Vadez et al. 1996; Zaman Allah et al. 2006*) confirm the high sensitivity of symbiotic nitrogen fixation to the type of fertilization in legumes. Under limiting Phosphorus conditions, legumes may lose the distinct advantage of an unlimited source of symbiotic N2, with decreases in N2 fixation leading to decreases in plant growth and nodulation (*Vadez et al. 1996*). However, the mechanism of Phosphorus limitation's effect on the N2 fixation process is not fully understood (*Vance 2001; Hellsten and Huss Danell 2001*). Under limited conditions of Phosphorus, the optimum symbiotic interaction between the host plant and rhizobia would depend on efficient allocation and use of available Phosphorus (*Vance 2001*). The phosphorus level optimal was in order to 4.3 mg P kg−1 (*Bargaz et al. 2012*).

Low phosphorus and nitrogen in the soil often limit the production of common beans (*Singh Y et al. 2006*). Thus the addition of inorganic fertilizers, primary nitrogen and phosphorus to satisfy the nutrient demand of the crop is crucial. In addition, determining the optimum rates of phosphorus and seed rates for higher yield is economically profitable, socially acceptable and environmentally sustainable. Hence this research aims to quantify phosphorus fertilizer and seed rates to be applied under Kunduz conditions and similar agro ecologies. Therefore, this experiment was conducted with the objectives of determining the optimum rates of phosphorus fertilizer and optimum seed rates for maximum yield of common bean and to select the best combination of common bean seed rates and phosphorus for optimum growth and yield of common bean.

2. Materials and Methods

In order to study the role of Phosphorus and seed rates in influencing the growth and yield of common beans, an experiment was conducted at the Farm of Agriculture faculty of Kunduz University during the spring season of 2023. The experimental site was located at 367388884, N latitude and 68.869858 E longitudes, with an elevation of 356 meters from the sea level. The temperature during the cropping period ranged between 23.20oC to 34.2oC, the humidity 25.52% to 65.25% with 9.5-11.0 hours day length and very little rainfall was recorded. The surface (0-15 cm) soil of the experimental site was sandy loamy with pH 7.2; the experiment was laid out in a randomized complete block design with the factorial concept, each plot measuring 2m×3m (6 m^2) with 3 replications. The experiment comprised of 2 factors viz. 3 levels of phosphorus: Phosphorus=0 kg P_2o_5 ha^{-1}, 40 kg P_2o_5 ha^{-1} and 80 kg P_2o_5 ha^{-1} and 4 levels of seed rates: 125 kg ha^{-1},150 kg ha^{-1}, 175 kg ha^{-1} and 200 kg ha^{-1}. Common bean (Baqaye variety) was used as the test crop in this experiment. The adjacent block and neighboring plots were separated by 1.0 m and 0.5 m, respectively common bean seeds were sown in lines with a spacing of 40×10 cm^2 on 1st April 2023. The crop was harvested at maturity on 28th June 2023. All agronomic practices were followed as per recommendations. Growth parameters, yield attributes and yields were recorded using standard procedure. The data recorded on growth, yield attributes, and yield were analyzed statistically by using analysis of variance (ANOVA), and treatment means were compared using the least significance difference at a 5% level of significance.

3. Results and Discussions

3.1 Plant height:

The results of the scientific analysis of variance are presented in Table 1, which shows that phosphorus levels had a significant effect on plant height. The tallest plants were observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(44.10 cm), followed by the treatment with 40 kg P_2O_5 kg ha^{-1} (34.69cm); the control treatment (0 kg P_2O_5 kg ha^{-1}) had the lowest plant height (25.98); however, seed rate did not have a significant effect on plant height. Therefore, it can be concluded that the application of phosphorus fertilizer at a rate of 80 kg P_2O_5 kg ha^{-1} can improve plant growth, while different seed rates do not have a significant effect on plant height. The result is similar to Ranjit Sen et al. and Santosa et al. (2017). Reported Plant height was found to be highest (38.17 cm) at Jamalpur and 38.69 cm at Joydebpur) in the same treatment, and Application of inorganic fertilizers 100 kg N ha-1, 300 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} resulted in plant height, leaf number per plant, leaf area per plant with values 43.85 cm, 26.14 sheets, 3327.84 cm2 and 4.06, respectively. The result revealed that plant height and above ground biomass yield increased as plant density increased. (Kissi Wakweya et al. 2016) also reported the highest plant height (167.6 cm) and biomass yield (105, 27.3 kg/ha) was observed at the highest seed rate of 225 kg/ha. While the lowest value (157 cm) and (9635.4 kg/ha) was recorded at 125 kg/ha seed rate.

3.2 Leaf area/plant:

The results indicate that phosphorus fertilizer application at a rate of 80 kg P_2O_5 kg ha^{-1} can lead to an improvement in leaf area; the highest leave area was in treatment 80 kg P_2O_5 kg ha^{-1} (217.18cm^2), followed by treatment 40 kg P_2O_5 kg ha^{-1} (150.71cm^2) the lowest leave area was in control (140.87 cm^2), while different seed rates do not have a significant effect on leaf area. These findings suggest that plant growth can be enhanced by the proper application of phosphorus fertilizer**; t**his finding is similar to Shubhashree KS et al. and Wondimu W (2017), who reported significant improvement in the leaf area of haricot bean (*P.vulgaris* L) and The highest leaf area (2570 cm^2) and leaf area index (6.421) was recorded for the application of 36 kg N, 92 kg P_2O_5 ha^{-1} while the lowest leaf area (783 cm^2) and leaf area index (1.944) was recorded at no fertilizer plot.

3.3 Brunches/plant:

The results presented in Table 1 shows that phosphorus levels had a significant effect on Brunches/plant. The highest Brunches/plant was observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(11.75), followed by the treatment with 40 kg P_2O_5 kg ha^{-1} (8.042); the control treatment (0 kg P_2O_5 kg ha^{-1}) had the lowest brunches/plant (7.042). However, seed rate did not have a significant effect on brunches/plants. Therefore, it can be concluded that the application of phosphorus fertilizer at a rate of 80 kg P_2O_5 kg ha^{-1} can improve plant growth, while different seed rates do not have a significant effect on brunches/plants. This result, similar to Dhary and Al-Baldawi (2017), showed that the application of NPK fertilizer had the highest number of branches per plant, leaf area, pod numbers per plant and seed number per pod compared to the control treatment.

3.4 Root dry weight per plant:

These findings show that the application of phosphorus fertilizer can have a positive impact on plant growth, particularly on root dry weight per plant. However, the results of this study support the use of phosphorus fertilizer at rates of 80 kg P_2O_5 ha^{-1} to enhance plant growth. Additionally, our analysis did not find a significant effect of seed rate on root dry weight per plant at the tested levels. The highest Root dry weight/plant g was observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(2.282 g), followed by the treatment with 40 kg P_2O_5 kg ha^{-1} (0.875g); the control treatment (0 kg P_2O_5 kg ha^{-1}) had the lowest Root dry weight/plant (0.79 g). However, seed rate did not have a significant effect on Root dry weight/plant g at 125 kg ha^{-1}, 150 kg ha^{-1}, 175 kg ha^{-1} and 200 kg ha^{-1}Overall, these findings provide valuable insights into the factors that influence plant growth and can inform agricultural practices aimed at improving crop yields. Wondimu W, Tana (2017). Reported this could be due to the importance of nitrogen in initiating nodulation and the effect of phosphorus for better root development and nitrogen fixation in common beans.

3.5 Nodules/plant and Leaves/plant:

These findings show that the application of phosphorus fertilizer can have a positive impact on plant growth parameters, particularly on Nodules/plants. However, the highest Nodules/plant were observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(12.15), followed by the treatments with 40 kg P_2O_5 kg ha^{-1} (10.16) and control treatment (0 kg P_2O_5 kg ha^{-1}) (3.167) in same nodules/plant respectively. However, different seed rate also has a significant effect on nodules/plant at 125 kg ha^{-1}, 150 kg ha^{-1}, 175 kg ha^{-1} and 200 kg ha^{-1} was 4.77, 4.88, 4.77 and 7.33, respectively; the results of the scientific analysis of variance are presented in Table 1, which shows that phosphorus levels had a significantly affected on the Leaves/plant. The highest Leaves/plant were observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(47.83), followed by the treatment with 40 kg P_2O_5 kg ha^{-1} (32.28); the control treatment (0 kg P_2O_5 kg ha^{-1}) had the lowest Leaves/plant (20.58); however, seed rate did not have a significant effect Leaves/plant at 125 kg ha^{-1}, 150 kg ha^{-1}, 175 kg ha^{-1} and 200 kg ha^{-1} treatments.

Overall, these findings provide valuable insights into the factors that influence plant growth and can inform agricultural practices aimed at improving crop yields Wondimu W, Tana (2017). Reported There was a highly significant ($P<0.01$) difference in the number of effective nodules due to the interaction effect of variety and NP rates. Accordingly, variety Chercher with 36 kg N, 92 kg P_2O_5 ha^{-1} had the highest (231) number of effective nodules, while Awash Melka at no fertilizer had the lowest (19.50) number of effective nodules per plant.

3.6 No. of notes/plant:

The results are revealed and presented in Table 1, which shows that phosphorus levels had a significantly affected on the No. of notes/plant. The highest No. of notes/plant were observed in the treatment with 80 kg P_2O_5 kg ha^{-1}(7.88), followed by the treatments with 40 kg P_2O_5 kg ha^{-1} (3.75); the control treatment (0 kg P_2O_5 kg ha^{-1}) had the lowest No. of notes/plant(3.30), different seed rates were also significantly affected by treatments at 125 kg ha^{-1}, 150 kg ha^{-1}, 175 kg ha^{-1} and 200 kg ha^{-1} 4.55, 4.66, 5.11 and 5.59, respectively.

Treatments	Plant height (cm)	Leaf area/plant (cm^2)	Brunches/ plant	Root dry weight/plan t g	Nodules/p ant	Leaves/pl ant	No. of notes/plant
						Phosphorus Levels ($kgha^{-1}$)	
0 kg P_2O_5 kg ha^{-1}	25.98	140.87	7.042	0.796	3.167	20.583	3.30
40 kg P_2O_5 kg ha^{-1}	34.69	150.71	8.042	0.875	10.16	32.287	3.75
80 kg P_2O_5 kg ha^{-1}	44.10	217.18	11.75	2.282	12.15	47.833	7.88
SE m±	1.85	13.35	0.36	0.126	0.38	1.48	0.21
CD at 5%	7.46	53.84	1.453	0.51	1.533	6.242	0.847
						Seed Rates ($kgha^{-1}$)	
125 kg ha^{-1}	32.63	260.77	8.722	1.101	4.778	32.889	4.55
150 kg ha^{-1}	33.16	262.18	8.278	1.194	4.889	33.938	4.66
175 kg ha^{-1}	37.70	217.18	9.556	1.367	4.778	32.556	5.11
200 kg ha^{-1}	36.20	243.55	9.222	1.342	7.933	34.889	5.59
SE m±	1.41	26.79	0.499	0.073	0.614	1.53	0.24
CD (P=0.05)	NS	NS	NS	NS	1.837	NS	0.72

Table 1: Effect of phosphorus levels and different seed rates on growth parameters of common bean.

3.7 Effect of phosphorus levels and different seed rates on yield attributes and yield

The results of our study demonstrate that the application of phosphorus fertilizer can have a significant positive impact on the yield attributes and overall yield of common beans. The highest yield attributes and yield of the common bean by phosphorus levels is pods/plant, seeds/pod, 100 seed weight g, seed yield/plant (g), grain yield t/ha in treatment 80 kg P_2O_5 kg ha^{-1}, that is 16.98, 6.974, 34.53g, 8.83g and 2.20 t/ha respectively, followed by treatment 40 kg P_2O_5 kg ha^{-1} the lowest treatment is control plots, pods/plant (7.48), seeds/pod (4.243),100 seed weight (23.94 g), seed yield/plant (7.35g) and grain yield (1.88 t/ha) respectively.

The seed rate is also significantly affected by different seed rates, the highest yield attributes and yield was on pods/plant (13.27), seeds/pod (6.37), 100 seed weight (30.80g), seed yield/plant (8.84g) and grain yield (2.21 t/ha) was in treatment 200 kg ha^{-1} the lowest yield attributes and yield was in seed rate(125 kg ha^{-1}) these are pods/plant (7.48), seeds/pod (4.243), 100 seed weight (23.94g), seed yield/plant(7.35g) and grain yield (1.88t/ha). However, our analysis did not find any significant effects of phosphorus levels or seed rates on the Stover yield and harvest index. Further research is needed to understand the underlying mechanisms and optimize fertilizer application and seed rates for optimal crop growth and yield.

Bonepally et al. (2021) indicated that the significant maximum number of pods per plant (66.30), 100 seed weight (37.33g), higher grain yield (854 kg/ha), higher Stover yield (2072 kg/ha), higher biological yield (2926 kg/ha) and harvest index (29.17 %) was recorded at harvest in those plots which are treated with the spacing 30 × 10 cm2 + 40 kg/ha phosphorus. With spacing 30 × 10 cm2 + 30 kg/ha phosphorus in yield parameters like number of pods per plant (62.00), Stover yield (1735 kg/ha), biological yield (2400 kg/ha) and harvest index (27.52 %),, was found statistically at par with spacing 30 × 10 cm2 + 40 kg/ha phosphorus. In 100 seed weight, however, with spacing 30 × 10 cm2 + 30 kg/ha phosphorus, spacing 40 × 10 cm2 + 40 kg/ha phosphorus, which is statically at par with spacing 30 × 10 cm2 + 40 kg/ha phosphorus. The grain yield was significantly superior with spacing 30 × 10 cm2 + 40 kg/ha phosphorus over all other treatments. The data presented that the number of seeds per pod shows non – significant results. Kissi et al. (2016) similarly reported sowing method at 225 kg/ha seed rate gave the first and the second highest mean seed yield (kg/ha). But, the partial budget analysis result revealed that the first and the second highest net benefit or the highest marginal rate of return was obtained from Gebelcho (large seeded) in row sowing method at 150 kg/ha and 200 kg/ha seed rates, respectively and it was economical to produce faba bean in Bale highlands, but it should be testing under small scale farmers' conditions. Shubhashree K.S (2007) also reported a significantly higher number of pods per plant (48.16) was recorded with P rates of 20 kg ha^{-1} over the rest of the levels. All applied P fertilizer rates significantly increased pods per plant over the control. The lowest pods per plant (24.83) were recorded at control (no application of P fertilizer). Veeresh N.K (2003). Who reported dry matter accumulation increased with the application of phosphorus rates. Similarly, a significant and linear increase in total dry matter production of common bean plants was observed due to increased phosphorus (Veeresh N.K (2003). This is in agreement with the study conducted on soybean indicated that increasing the phosphorus concentration in the soil increased the whole plant dry matter accumulation and total leaf area

The result of the present study was in agreement with the findings of (Shubhashree K.S. et al., who reported that number of seeds per pod increased significantly to levels of phosphorus added. The increment of seeds per pod with increasing P fertilizer application up to the optimum level might be P fertilizer for nodule formation, protein synthesis, fruiting and seed formation.
These findings provide valuable insights into the factors that influence common bean yield and can inform agricultural practices aimed at improving crop productivity and food security. Further research is needed to determine the underlying mechanisms behind these findings and to optimize fertilizer application and seed rates for optimal crop growth and yield.

These results have important implications for agricultural practices aimed at improving crop productivity and food security. By understanding the factors that influence common bean yield, farmers can make informed decisions about fertilizer application and seed rates to maximize crop yields and improve food production.

Treatments	Pods/plant	Seeds/pod	100 seed weight	seed yield/ plant(g)	Grain Yield t/ha	Stover yield t/ha	Harvest Index
Phosphorus Levels (kgha-1)							
0 kg P2O5 kg ha-1	7.48	4.243	23.948	7.35	1.88	3.71	0.51
40 kg P2O5 kg ha-1	7.48	5.637	24.464	7.54	1.86	4.23	0.44
80 kg P2O5 kg ha-1	16.98	6.97	34.536	8.83	2.20	4.59	0.91
SE m±	1.027	0.243	0.547	0.048	12.029	340.46	0.287
CD at 5%	4.14	0.978	2.204	0.195	48.497	NS	NS
Seed Rate (kgha-1)							
125 kg ha-1	10.1	5.286	24.713	7.177	1.79	4.07	0.44
150 kg ha-1	9.059	5.40	29.747	7.726	1.93	4.14	0.47
175 kg ha-1	10.17	5.81	27.999	8.037	2.00	3.80	1.10
200 kg ha-1	13.27	6.37	30.804	8.844	2.21	4.70	0.47
SE m±	0.98	0.282	1.25	0.207	51.679	280.20	0.287
CD (P=0.05)	2.933	0.846	3.744	0.619	154.73	NS	NS

Table 2: Effect of phosphorus and different seed rates on yield attributes and yield

4. Conclusion:

Application of the correct level of phosphorus fertilizer and optimum seed rate is necessary to achieve the maximum yield of common bean crops. The present study was initiated to assess the influence of different levels of phosphorus and different level of seed rates on the growth, yield and yield attributes of common beans.

It can be concluded from the result that the application of 80 kg P^2O_5 ha^{-1} with a seed rate of 200 kg ha^{-1} resulted in significantly higher growth attributes, yield attributes and yield in common beans. Therefore, for Afghanistan conditions above findings may be taken to the level of recommendation in common bean cultivation regions. For future research, the interaction of phosphorus with other nutrients may be taken up for studies in a cropping system mode. Further, diverse nutrient sources, including organic manures, composts and bio-fertilizers, may be tested in conjunction with mineral fertilizers.

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