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Effect of Sowing Methods and Phosphorus Levels on Growth, Yield and Economic Returns of Summer Mungbean (*Vigna radiata* L.)

Sunidhi Dhiman[1*], Hemraj Meena[2] and Avinash Kumar Bhatia[1]
[1]Faculty of Agriculture and Life Sciences,
Desh Bhagat University Mandi Gobindgarh (Punjab), India.
[2]Assistant Professor, School of Agricultural Sciences and Technology,
RIMT University, Mandi, Gobindgarh (Punjab), India.

(Corresponding author: Sunidhi Dhiman)*
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ABSTRACT: A field experiment was conducted during the Rabi season of 2023–2024 at the Agricultural Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, to assess the effects of different sowing methods and phosphorus levels on the growth, yield, and economic returns of summer mungbean (*Vigna radiata* L.). The experiment was laid out in a Randomized Block Design (RBD) with three replications, comprising nine treatment combinations derived from three phosphorus levels (30, 40, and 50 kg/ha P_2O_5) and three sowing methods (Flat, Ridge, and Bed). The results indicated that both phosphorus application and sowing methods significantly influenced crop growth, yield attributes, and economic performance. Among the various treatments, bed sowing combined with 50 kg/ha P_2O_5 recorded the highest values for growth parameters, yield components, and net economic returns. Based on the outcomes of this one-year study, it can be concluded that the combination of bed sowing with 50 kg/ha P_2O_5 is the most effective practice for enhancing the growth, yield, and profitability of summer mungbean. However, further multi-season trials are recommended to confirm these findings under diverse agro-climatic conditions.

Keywords: Summer Mungbean, Sowing Methods, Growth Characteristics and Yield Attributes.

INTRODUCTION

Pulses play a vital role in daily diets, particularly across the Asian continent (Singh *et al.*, 2018). These crops offer significant nutritional and health benefits, including the ability to mitigate several non-communicable diseases such as cardiovascular conditions and colon cancer. In Indian agriculture, pulses are a cornerstone, traditionally utilized as food, fodder, and feed. High-quality grain derived from pulses is also a valuable feed for livestock (Deva, 2019).

India is the world's largest producer (accounting for 25% of global production), consumer (27% of global consumption), and importer (14%) of pulses. Pulses occupy around 20% of the area under food grains and contribute approximately 7–10% of total food grain production in the country. These crops are cultivated in both Kharif and Rabi seasons, with Rabi pulses accounting for over 60% of the total production. Pulses are grown nationwide in India, covering an area of about 28.90 million hectares, with a total production of 26.05 million tonnes and an average productivity of 902 kg/ha. In Punjab, the area under pulses is around 0.08 lakh hectares, with production matching this area and a slightly higher productivity of 947 kg/ha (Anonymous, 2023).

Mungbean (*Vigna radiata*), known locally as "moong," is the world's largest short-duration pulse crop and is widely grown in northern India. It belongs to the Fabaceae family and the genus *Vigna*. This crop is cultivated extensively across Asia (Choudhary *et al.*, 2015), as well as in Africa, South America, and Australia, serving as a vital source of dietary protein, especially for vegetarians (Gupta and Pratap 2016). Mungbean cultivation also enhances soil health by improving its physical, chemical, and biological properties. Through a symbiotic process involving *Rhizobium* bacteria, mungbean fixes atmospheric nitrogen, thereby boosting soil fertility. In India, mungbean is grown on approximately 5.55 million hectares, with a total production of 3.68 million tonnes and a productivity of 663 kg/ha (Yadav and Singh 2014).

Efficient sowing techniques are essential for optimal root development from the initial stages of crop growth, as they enhance the availability of vital resources such as moisture, sunlight, and nutrients. Among all agricultural practices, the selection of an appropriate sowing method is one of the most crucial for achieving high yields. A key agronomic factor is the adoption of ideal planting geometry, which ensures better utilization of growth resources and improved productivity (Rahim *et al.*, 2014). Various sowing techniques—such as flat, ridge, and bed sowing—have a significant impact on mungbean yield. Flat sowing, which involves planting seeds on level ground, is commonly practiced in many regions (Ram *et al.*, 2018). Ridge sowing, on the other hand, facilitates better root development, enhances nutrient absorption, and results in increased biomass production (FAO, 2020). Bed planting proves especially beneficial during the rainy season, as it helps reduce waterlogging and lowers the incidence of disease in pulse crops, particularly when used alongside the ridge and furrow method.

MATERIALS AND METHODS

Experimental Site. A field experiment was conducted during the Rabi season of 2023–2024 at the Agricultural Research Farm, RIMT University, Mandi Gobindgarh, Punjab. The experimental site is located at 30.6642°N latitude and 76.2914°E longitude, at an elevation of 268 meters above sea level. The region receives an average annual rainfall of approximately 730.2 mm, with about three-fourths of the precipitation occurring during the south-west monsoon period from July to September. The winter months (December to February) experience scanty rainfall. Summers are typically hot, with maximum temperatures ranging between 40°C and 45°C.

Edaphic Conditions. Prior to sowing, composite soil samples were collected from a 0–15 cm depth from randomly selected sites in the experimental field to assess the initial soil physico-chemical properties. The soil was classified as sandy loam in texture, with a pH of 8.4, indicating alkaline conditions. It was moderately fertile, characterized by low organic carbon (0.38%), low available nitrogen (144.6 kg/ha), medium available phosphorus (17.3 kg/ha), and medium available potassium (261.3 kg/ha). Organic carbon content was determined using the rapid titration method proposed by Walkley and Black (1966). Available nitrogen was estimated using the alkaline potassium permanganate method (Subbiah and Asija 1956), available phosphorus by Olsen's method (Olsen *et al.*, 1954), and available potassium using the flame photometer with the ammonium acetate extractable method (Jackson, 1967).

Treatment Details. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatments were allocated randomly in each block. The details of the treatment are as follows:

Table 1: List of the Treatment Combinations.

Notations	Treatment Combinations
T_1	Flat sowing + 30 kg/ha P_2O_5
T_2	Flat sowing + 40 kg/ha P_2O_5
T_3	Flat sowing + 50 kg/ha P_2O_5
T_4	Ridge sowing + 30 kg/ha P_2O_5
T_5	Ridge sowing + 40 kg/ha P_2O_5
T_6	Ridge sowing + 50 kg/ha P_2O_5
T_7	Bed sowing + 30 kg/ha P_2O_5
T_8	Bed sowing + 40 kg/ha P_2O_5
T_9	Bed sowing + 50 kg/ha P_2O_5

Preparation of the Experimental Field and Application of Fertilizers. The experimental field was prepared by ploughing once with a disc harrow, followed by two passes with a cultivator, each succeeded by planking in standing water to achieve a well-puddled and leveled field. Experimental plots were then laid out according to the Randomized Block Design (RBD). The study evaluated three sowing methods, flat, ridge, and bed sowing. Seeds were manually sown in furrows opened using a *kudalat*, maintaining a row spacing of 30 cm and plant spacing of 10 cm. A seed rate of 30 kg/ha was adopted to ensure optimum plant population. Immediately after sowing, seeds were covered with soil. Gap filling and thinning were carried out at one week and again at 20 days after sowing to maintain the desired plant stand. Depending on prevailing climatic and soil conditions, three irrigations were applied during the crop season on March 13, April 6, and May 6, 2024. Care was taken to prevent waterlogging, as it could adversely affect seedling establishment and overall crop health.

A uniform nitrogen dose was applied through urea in two equal splits: half at the time of sowing and the remaining half 45 days after sowing. Phosphorus was applied according to the respective treatment levels (30, 40, and 50 kg/ha P_2O_5) using single super phosphate (SSP) at the time of sowing.

RESULTS AND DISCUSSION

Growth Parameters. Plant height of summer mungbean as influenced by different sowing methods and phosphorus levels is presented in Table 2. The data indicated a progressive increase in plant height with the crop's age. Significant differences were observed at 50 days after sowing and at harvest. Among treatments, the highest plant height was recorded in T9 (Bed sowing + 50 kg/ha P_2O_5) with values of 36.30 cm at 50 DAS and 44.10 cm at harvest, while the lowest plant height was observed in T1 (Flat sowing + 30 kg/ha P_2O_5) with 28.00 cm and 38.00 cm respectively. These findings are consistent with the observations of Ram *et al*. (2001), who reported that bed sowing was significantly superior to ridge and flat sowing in promoting plant growth.

Table 2: Effect of different sowing methods and levels of phosphorus on summer mungbean.

Treatment combination	Plants height (cm)	Number of nodules/plant	Number of branches	Number of pods/plant	Number of seeds/pods	Test Weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	38.00	15.66	14.66	13.03	4.30	31.33	6.69	12.69	34.52
T_2	38.33	16.00	16.00	13.60	4.34	31.68	7.19	13.33	35.04
T_3	39.44	16.33	16.33	13.07	4.49	32.42	7.25	13.86	34.33
T_4	40.33	17.44	17.33	14.10	4.56	32.83	8.49	14.66	36.66
T_5	42.33	17.66	18.33	14.56	4.77	33.23	9.26	15.44	37.41
T_6	42.45	18.33	20.66	15.20	5.01	33.58	10.90	15.88	40.70
T_7	43.22	18.66	22.33	15.17	5.35	34.10	10.84	16.64	39.45
T_8	43.50	20.00	22.33	15.25	6.01	34.44	11.41	17.55	39.41
T_9	38.00	21.50	23.50	15.45	6.02	36.24	12.66	18.76	40.29
SEm (±)	0.19	0.18	0.211	0.03	0.006	0.007	0.08	0.003	0.21
CD at 5%	0.58	0.54	0.63	0.10	0.018	0.021	0.25	0.010	0.63

The number of nodules per plant was significantly influenced by the different treatment combinations (Table 2). Maximum nodules were observed under T9 (Bed sowing + 50 kg/ha P_2O_5) with 27.50 nodules at 50 DAS and 21.50 at harvest, whereas the minimum was recorded in T1 (Flat sowing + 30 kg/ha P_2O_5). These results are supported by Muthu *et al*. (2016), who noted higher nodule formation in green gram under wider spacing. Data in Table 2 revealed that the number of branches per plant was significantly affected by both sowing method and phosphorus level. The maximum number of branches was recorded in T9 (Bed sowing + 50 kg/ha P_2O_5) with 25.00 branches at 50 DAS and 23.50 at harvest. The minimum was recorded in T1 (Flat sowing + 30 kg/ha P_2O_5) with 17.90 and 14.66 branches respectively. The positive effect of higher phosphorus on branching may be attributed to its role in stimulating cell division and plant development. These results align with those of Venkatarao *et al*. (2017).

Yield Parameters. As shown in Table 2, sowing methods and phosphorus levels significantly influenced the number of pods per plant. The maximum number of pods was recorded under T9 (Bed sowing + 50 kg/ha P_2O_5) with 15.45 pods/plant, while the minimum was observed in T1 (Flat sowing + 30 kg/ha P_2O_5) with 13.03 pods/plant. These findings are in agreement with Singh (2007), who found varietal and treatment effects to significantly affect pod number. The data presented in Table 2 shows that the maximum number of seeds per pod (6.02) was recorded under T9 (Bed sowing + 50 kg/ha P_2O_5). The minimum number (4.30 seeds/pod) was recorded in T1. Tigga *et al*. (2017) also reported that bed sowing combined with optimal spacing resulted in higher seed counts due to improved resource use efficiency. Test weight was significantly influenced by the treatments (Table 2). The maximum test weight (36.24 g) was recorded in T9, and the minimum (31.33 g) in T1. Hossain and Hamid (2005), as well as Parihar and Tripathi (1990), reported similar findings, noting increased seed weight with improved sowing techniques and higher phosphorus application.

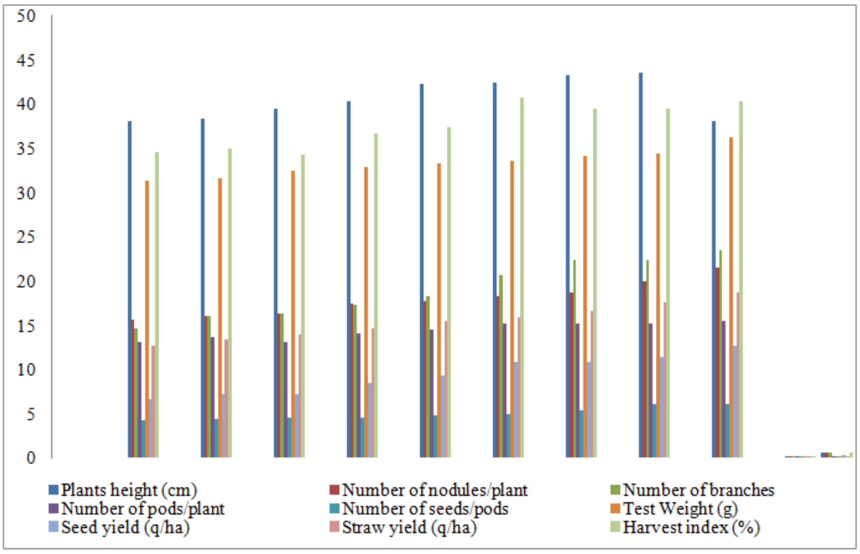

Fig. 1. Various growth and yield parameters of Mungbean in graphical form.

Significant variations were observed in seed and straw yield across treatments (Table 2). The highest seed yield (12.66 q/ha) and straw yield (18.76 q/ha) were recorded under T9, while the lowest yields (6.69 q/ha seed yield and 12.69 q/ha straw yield) were obtained under T1. These results are supported by Rahim *et al*. (2014); Goswami and Jat (2003), who found that bed sowing increased mungbean productivity. The harvest index was significantly influenced by sowing methods and phosphorus levels (Table 2). The highest harvest index (40.29%) was recorded in T9 (Bed sowing + 50 kg/ha P_2O_5), while the lowest (34.33%) was noted in T3 (Flat sowing + 50 kg/ha P_2O_5). Similar trends were observed by Chen *et al.* (2010); Kumar *et al.* (2012), who reported that increasing phosphorus application enhanced the harvest index.

CONCLUSIONS

Based on the findings of the one-year field study on summer mungbean (*Vigna radiata* L.) conducted during the Rabi season of 2023–2024, it can be concluded that the interaction between sowing methods and phosphorus levels had a significant impact on the crop's performance. Among the treatment combinations, bed sowing combined with 50 kg/ha P_2O_5 proved to be the most effective in enhancing growth attributes, yield parameters, and overall productivity. This treatment also exhibited superior economic returns compared to other combinations. Thus, bed sowing with 50 kg/ha P_2O_5 can be recommended as the optimal practice for maximizing the growth and profitability of summer mungbean under the agro-climatic conditions of Mandi Gobindgarh, Punjab. However, to further validate these findings, multi-season and multi-location trials are suggested.

Disclaimer (Artificial Intelligence). The author(s) hereby declare that no generative AI technologies such as large language models (e.g., ChatGPT, Copilot, etc.) or text-to-image generators were used in the writing or editing of this manuscript.

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