Influence of sowing methods and phosphorus levels on Growth, Yield and Economic returns of Summer Mungbean (*Vigna radiata* L.)

ABSTRACT: A field experiment was conducted during the *Rabi* season of 2023-24 at the Agricultural Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab to study the "Effect of sowing methods and phosphorus levels on growth, yield and economic returns of summer mungbean (*Vigna radiata* L.)". The experiment consisted of nine treatment combinations with methods of sowing (Flat, Ridge and Bed sowing) and three phosphorus levels (30, 40 and 50 kg/ha P_2O_5) were tested in Randomized Block Design (RBD) with three replications. The results indicated that the crop responded significantly to sowing methods and phosphorus in respect of growth, yield and economics such as plant height (cm), number of nodules/plant, number of branches, dry matter accumulation/plant (g/m²) and yield characteristics *viz.,* number of pods/plant, number of seeds/pod, test weight (g), seed yield (q/ha), straw yield (q/ha), harvest index (%), net return (Rs/ha) and B:C ratio. In the combination of sowing methods and phosphorus, all the parameters were significant by influence. The combination of Bed sowing + 50 kg/ha P_2O_5 treatment had the highest values for growth characteristics, yield characteristics and also performed economically well as compared to other treatments.

Keywords: *Summer mungbean, sowing methods, phosphorus levels, growth parameters, yield attributes and yield.*

1. INTRODUCTION

Pulses play a significant role in everyday diets, especially on the Asian continent [1]. Pulses offer noteworthy nutritional and health advantages and have been shown to mitigate several non-communicable illnesses, including cardiovascular and colon cancer.Pulses are the main stay of Indian agriculture and have been used as food, fodder and feed. Animals can also be fed high-quality grain made from pulses[2].India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 percent of the area under food grains and contribute around 7-10 percent of the total food grains production in the country. Pulses are grown in both*Kharif* and *Rabi*seasons; Rabi pulsescontribute more than 60 percent of the total production [3].Pulses are grown across the country,in India, the area under pulses is about 28.90 million ha, with production of 26.05 million tonnes and productivity about 902 kg/ha. In Punjab, the area under pulses is about 0.08 lakh ha, with production of 0.08 lakh tonnes and productivity about 947 kg/ha [4].

Mungbean (*Vigna radiata*) world's largestshort-duration pulse crop grown in northern India which belongs to Fabaceae family of the genus *Vigna*. It has been known as "moong." It is widely cultivated throughout the Asia [5].Mungbean grown in Southeast Asia, Africa, South America and Australia and serves as a major source of dietary protein for the vast majority of vegetarian people [6].Cultivation of mungbean can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through nitrogen fixation from atmosphere by symbiotic process with the help of micro-symbionts (Rhizobium). In India, area of mungbean is 5.55 million hectares, with the total production of 3.68 million tonnes with a productivity of 663 kg/ha [7].

To ensure optimal root system development from the outset of crop growth, efficient sowing techniques maximize the availability of resources, including moisture, sunshine, and nutrients.A good yield can only be achieved by using the sowing methods, which is one of the most important agricultural activities. Among other agronomic practices, proper method of planting may considerably increase the production of green gram. Ideal planting geometry is precious and important for better and efficient utilization of available plant growth resources in order to get maximum productivity [8].Among different sowing methods such as flat sowing, ridge sowing and bed sowing methods by using the right techniques can significantly boost mungbean yields. Flat sowing involves sowing seeds or transplanting seedlings on a surface level [9]. The ridge seeding approach improved the conditions for plant root development, increased nutrient absorption, and increased biomass output [10]. Bed planting is one of the more successful agronomic interventions when it comes to minimizing the damage caused by waterlogging, especially during the rainy season, especially in places with significant rainfall and irrigation in the ridge and furrow planting technique decreased the incidence of illness in pulses.

Mungbean is highly responsive to fertilizers and has a considerable response to phosphorus. The conventional approach to treating phosphorus shortage in the soil has been to apply phosphorus fertilizers. Every year, 52.3 billion tons of fertilizers are sprayed on soil and plant systems to maintain constant phosphorus levels [11]. The organic matter composition of the soil decreases under these circumstances, but the immobilization of nutrients like phosphorus increases [12, 13].Considering the above facts the present study is aimed at following objectives to determine the effects of methods of sowing and phosphorus levels on the growth, yields attributes and yield of summer mungbean.

2. MATERIALS AND METHODS

2.1 ***Experimental site:*** A fieldexperimentwas laid out during *Rabi* 2023-24 at the Agriculture Research Farm, RIMT University, Mandi Gobindgarh, Punjab.The experimental site (Mandi Gobindgarh) is situated in Punjab at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters.The annual rainfall of Mandi Gobindgarh is 730.2 mm, about three-fourth of which is contributed by the south-west monsoon during July to September. Scanty rainfall is received during winter months of December, January to February.With highs between 40 and 45 °C (104 and 113 °F), summers are quite hot.

2.2 ***Edaphic condition:*** The composite soil samples from 0-15 cm profile layers were collected before planting from randomly selected sites and analysed for initial soil reaction, electrical conductivity and fertility status. The soil of the experimental field was sandy loam in texture with pH 8.4. It was moderately fertile, being low in available organic carbon (0.38%), available nitrogen (144.6 kg/ha) and medium in available phosphorus (17.3 kg/ha) and medium in available potassium (168 kg/ha). Organic carbon in the soil was 0.38% which was estimated by rapid titration method given by Walkley and Black [14]. The available Nitrogen in soil was 144.6 kg/ha, which was estimated by the Alkaline potassium permanganate method given by Subbiah and Asija [15]. The available Phosphorus was 17.3 kg/ha estimated by Olsen's method given by Olsen [16]. The available K was 261.3 kg/ha which was estimated by the Flame photometer Ammonium extractable method given by Jackson [17].

2.3 ***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

2.4 *Preparation of the experimental field and application of fertilizers:* The experimental field was ploughed once with disc harrow and twice with cultivators each followed by planking in standing water to bring the field to a good puddle. Plots were prepared according to the layout of the experiment. There are three methods of sowing *viz*., flat, ridge and bed sowing. Seeds were sown manually in the furrow opened by *kudal*at a row distance of 30 cm and plant distance of 10 cm with the seed rate of 30 kg/ha was used for optimum maintenance of plant population. Immediately after sowing seeds were covered with soil. Gap filling and thinning of the plants were done after one week & 20 days after sowing to get optimum yield. Depending upon the climatic situation and soil factors there was a requirement of three irrigations (March 13,2024, April 6,2024 and May 6,2024). Water logging in the field should be avoided to ensure healthy seeds. A uniform dose of nitrogen through urea was applied in two splits *viz.,* the half dose of nitrogen applied at the time of sowing and rest of the dose was applied at 45 days after sowing. The Phosphorus was applied as per the treatments at the time of sowing through single super phosphate.

3. RESULTS AND DISCUSSION

3.1 *Growth parameters*

3.1.1 Plant height as influenced by given treatments: Plant height of summer mungbean recorded at growth stages as affected by methods of sowing and phosphorus levels have been presented in (Table2). Plant height increased successively with age of crop. It is evident from the data that different methods of sowing and phosphorus levels influenced plant height significantly at 50 days after sowing and at harvest. It was quite evident from the data that higher plant height was obtained in T_9 (Bed sowing + 50 kg/ha P_2O_5) at 50 days after sowing (36.30 cm) and at harvest (44.10 cm) while the lowest plant height was recorded in T_1 (Flat sowing + 30 kg/ha P_2O_5) at 50 days after sowing (28.00 cm) and at harvest (38.00 cm). The result obtained from the present study was similar with the findings, Ram *et al.,* [18] reported that bed sowing technique was significantly superior over ridge and flat methods in term of growth.

3.1.2 Number of nodules/plant as influenced by different days: Perusal of the data in (Table 2), revealed that number of nodules/plant of summer mungbean recorded at growth stages and has significant effect on summer mungbean. Among different treatments combination of different methods of sowing and phosphorus levels the maximum treatment with Bed sowing + 50 kg/ha P_2O_5 number of nodules/plant was recorded at 50 days after sowing (27.50) and at harvest (21.50) in summer mungbean and minimum number of nodules/plants was found in treatment withFlat sowing + 30 kg/ha P_2O_5 at 50 days after sowing (27.50) and at harvest (21.50). The result obtained from the present study was similar with the findings by Muthu *et al*., [19] who observed significantly higher number of nodules in green gram at wider spacing than at narrow spacing.

3.1.3 Number of branches: Data presented in (Table 2), depicted those treatments of number of branches of summer mungbean recorded at growth stages and has significant effect on summer mungbean. The effect of sowing methods and phosphorus levels was observed significantly maximum number of branches on summer mungbean with T_9 (Bed sowing + 50 kg/ha P_2O_5) (25.00 and 23.50) and minimum number of branches was found with T_1 (Flat sowing + 30 kg/ha P_2O_5) at 50 days after sowing and at harvest (17.90 and 14.66). The result indicated that the higher branches/plant with higher phosphorus levels might be due the reason that phosphorus played an important role in better development of plant. Similar results were found by Venkatarao *et al.*, [20].

3.1.4 Dry matter accumulation (g/m²): Dry matter accumulation as influenced by different methods of sowing and phosphorus levels have been presented in (Table 2). It is quite obvious from the data that dry matter accumulation varied significantly due to different methods of sowing and phosphorus levels at all the stages of summer mungbean. Higher dry matter accumulation was recorded on summer mungbean with Bed sowing + 50 kg/ha P_2O_5 (13.33 and 17.93 g/m²) and minimum dry matter accumulationwas found with Flat sowing + 30 kg/ha P_2O_5 at 40, 50 days after sowing and at harvest (9.00 and 13.33 g/m²). Rahman *et al.,* 2015 [21] found similar results in dry matter accumulation was significantly influenced by the interaction of sowing methods and variety. Phosphorus application had a significant effect on the dry matter accumulation results reported by Erman *et al.,* [22].

3.2 *Yield parameters*

3.2.1 Number of pods/plant: The data on the effect of different sowing methods and levels of phosphorus on number of pods/plant have been presented in (Table 3). They showed that the effect of sowing methods and phosphorus levels was observed significantly highest the number of pods/plants on summer mungbean with Bed sowing + 50 kg/ha P_2O_5 (15.45) and lowest number of pods/plants was found in treatment T_1 (13.03). The result obtained from the present study was similar with the findings of Singh[23] also reported that varieties had a significant effect on number of pods/plants of mungbean.

3.2.2 Number of seeds/pod: It is evident from the data presented in Table 3, on the effect of different sowing methods and levels of phosphorus on number of seeds/pod. It has been noticed that the maximum number of seeds/pods on summer mungbean treatment combinations with (Bed sowing + 50 kg/ha P_2O_5) (6.02) and found minimum number of seeds/pods in T_1 (Flat sowing + 30 kg/ha P_2O_5) (4.30). Similar findings were made by Tigga *et al.*, [24] reported that the bed sowing method have maximum seed/pod with narrow spacing. This could be due to different variability and adaptability to the environment of green gram. The result is agreed with the findings of Kumar *et al.,* [25] in phosphorus levels.

3.2.3 Test weight (g): Test weight as affected by different sowing methods and levels of phosphorus has been presented in (Table 3). They showed that the effect of sowing methods and phosphorus levels was observed significantly maximum test weight on summer mungbean in T_9 (36.24g) and recorded minimum test weight in T_1 (31.33g). Hossain and Hamid [26] also reported that test weight under bed sowing as compare to flat sowing of summer mungbean. Parihar and Tripathi [27] also revealed that test weight increased significantly with increasing phosphorus levels up to 50 kg/ha P_2O_5.

3.2.4 Seed and Straw yield (q/ha) as influenced by given treatment: Significant variation was observed on the seed yield and straw yield of mungbean when different methods of sowing and phosphorus levels were applied (Table 3). The highest seed yield and straw yield was recorded in Bed sowing + 50 kg/ha P_2O_5 (12.66 q/ha and 18.76q/ha) and lowest seed yield was recorded in treatment combination with Flat sowing + 30 kg/ha P_2O_5 (6.69 q/ha and 12.69 q/ha). Rahim *et al.,* [28] was found similar results in sowing methods of seed yield. Goswami and Jat [29] also reported that bed planted mungbean gave significantly more straw yield as compare to flat sowing.

3.2.5 Harvest index (%): Harvest index exhibited significant effects ondifferent methods of sowing and phosphorus levels have been presented in (Table 3). They observed that the effect of sowing methods and phosphorus levels was observed significantly maximum on summer mungbean harvest index in T_9- Bed sowing + 50 kg/ha P_2O_5 (40.29 %) and minimum harvest index in T_3- Flat sowing + 50 kg/ha P_2O_5 (34.33 %). Harvest index was significantly influenced by different planting methods. The similar results observed by Chen *et al.,* [30] and Kumar *et al*., [31] also reported that, the increasing rate of phosphorus application significantly increased harvest index over the control plots.

4. ECONOMICS

4.1 Net return and benefit cost ratio (Rs/ha): Economic analysis showed that the combined application of Bed sowing + 50 kg/ha P_2O_5resulted in significantly maximum net return (Rs 64,650.00) and benefit cost ratio (3.38) than the other methods of sowing and phosphorus levels treatment. The minimum net return (Rs 28,148.00) and benefit-cost ratio (2.38) was recorded under Flat sowing + 30 kg/ha P_2O_5 (Table 3). This might be owing to more seed yield in Bed sowing + 50 kg/ha P_2O_5levels treatment. These findings are in agreement by Patel *et al*., [32].

Table: 2 Effect of different sowing methods and levels of phosphorus on plant height, number of nodules/plants and number of branches of the summer mungbean at 50 days after sowing and at harvest

Treatment combination	Plants height (cm)		Number of nodules/plant		Number of branches		Dry matter accumulation (g/m²)	
	50 DAS	At harvest	50 DAS	At harvest	50 DAS	At harvest	50 DAS	At harvest
T1: Flat sowing + 30 kg/ha P_2O_5	28.00	38.00	21.66	15.66	17.90	14.66	9.00	13.33
T2: Flat sowing + 40 kg/ha P_2O_5	28.33	38.33	22.00	16.00	19.26	16.00	9.50	13.88
T3: Flat sowing + 50 kg/ha P_2O_5	29.44	39.44	22.33	16.33	23.33	16.33	9.70	14.10
T4: Ridge sowing + 30 kg/ha P_2O_5	30.33	40.33	23.44	17.44	24.00	17.33	10.20	14.59
T5: Ridge sowing + 40 kg/ha P_2O_5	32.66	42.33	23.66	17.66	23.33	18.33	11.20	15.57
T6: Ridge sowing + 50 kg/ha P_2O_5	34.33	42.45	24.33	18.33	21.66	20.66	11.78	16.20
T7: Bed sowing + 30 kg/ha P_2O_5	34.45	43.22	24.66	18.66	24.00	22.33	12.33	16.88
T8: Bed sowing + 40 kg/ha P_2O_5	35.50	43.50	26.00	20.00	25.00	22.33	12.66	16.98
T9: Bed sowing + 50 kg/ha P_2O_5	36.30	44.10	27.50	21.50	25.00	23.50	13.33	17.93
SEm (±)	0.21	0.19	0.14	0.18	0.28	0.211	0.03	0.03
CD at 5%	0.65	0.58	0.41	0.54	0.84	0.63	0.10	0.09

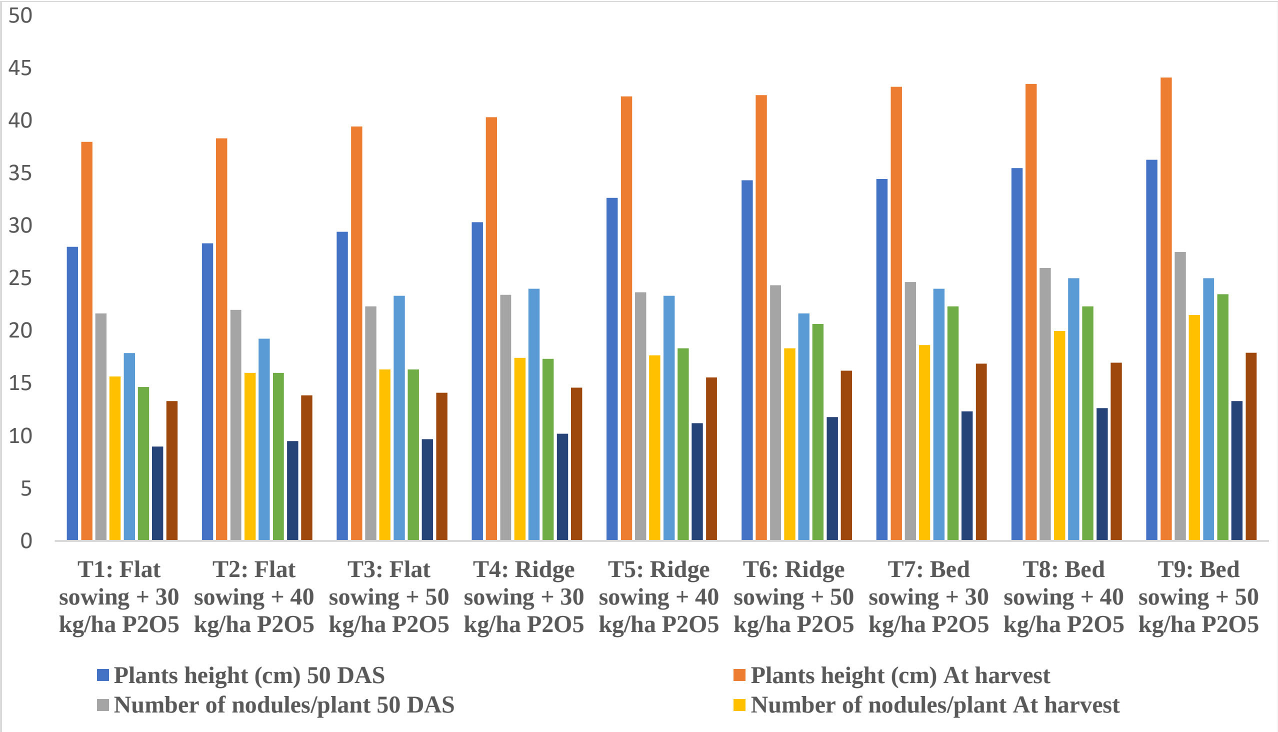

Fig.1. Effect of different sowing methods and levels of phosphorus on plant height, number of nodules/plants and number of branches of the summer mungbean (*Vigna radiata* L.) at 50 days after sowing and at harvest.

Table: 3 Effect of different sowing methods and levels of phosphorus on number of pods/plant, number of seeds/ pod, test weight (g), seed yield (q/ha), straw yield (q/ha), harvest index (%), net return (Rs/ha) and Benefit-cost ratio (B:C)of the summer mungbean

Treatment combination	Number of pods/plant	Number of seeds/pod	Test weight (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net return (Rs/ha)	Benefit-cost ratio (B:C)
T1: Flat sowing + 30 kg/ha P_2O_5	13.03	4.30	31.33	6.69	12.69	34.52	28,148.00	2.38
T2: Flat sowing + 40 kg/ha P_2O_5	13.60	4.34	31.68	7.19	13.33	35.04	31,609.00	2.54
T3: Flat sowing + 50 kg/ha P_2O_5	13.07	4.49	32.42	7.25	13.86	34.33	31,002.67	2.44
T4: Ridge sowing + 30 kg/ha P_2O_5	14.10	4.56	32.83	8.49	14.66	36.66	37,567.67	2.57
T5: Ridge sowing + 40 kg/ha P_2O_5	14.56	4.77	33.23	9.26	15.44	37.41	41,707.67	2.64
T6: Ridge sowing + 50 kg/ha P_2O_5	15.20	5.01	33.58	10.90	15.88	40.70	52,990.33	3.03
T7: Bed sowing + 30 kg/ha P_2O_5	15.17	5.35	34.10	10.84	16.64	39.45	52,270.33	2.98
T8: Bed sowing + 40 kg/ha P_2O_5	15.25	6.01	34.44	11.41	17.55	39.41	56,195.33	3.11
T9: Bed sowing + 50 kg/ha P_2O_5	15.45	6.02	36.24	12.66	18.76	40.29	64,650.00	3.38
SEm (±)	0.03	0.006	0.007	0.08	0.003	0.21	607.49	0.03
CD at 5%	0.10	0.018	0.021	0.25	0.010	0.63	1,836.95	0.07

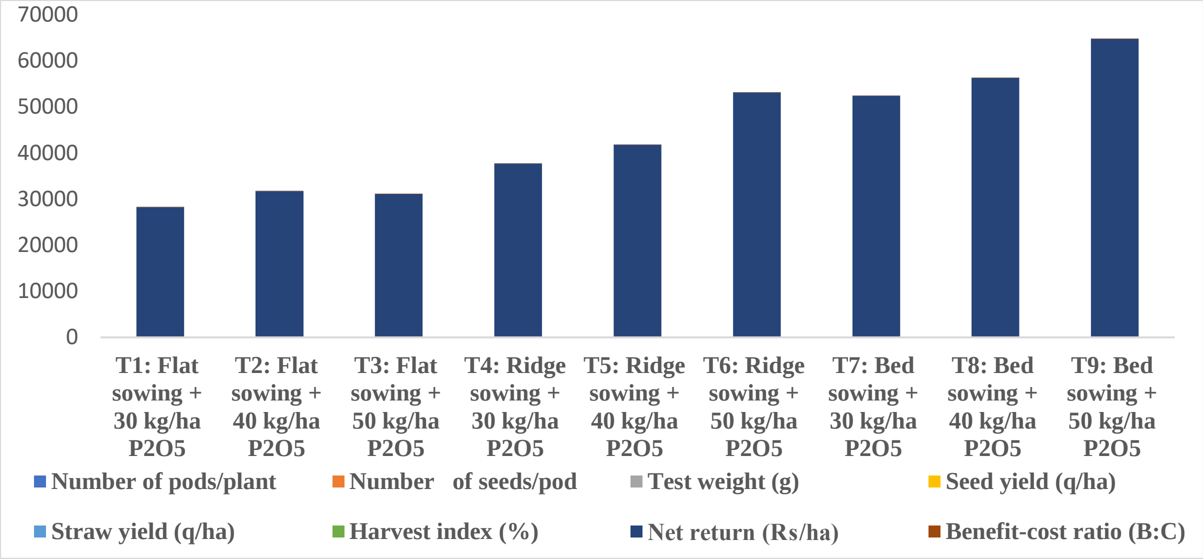

Fig. 2.Effect of different sowing methods and levels of phosphorus on number of pods/plant, number of seeds/ pod, test weight (g), seed yield (q/ha), straw yield (q/ha), harvest index (%), net return (Rs/ha) and Benefit-cost ratio (B:C)of the summer mungbean (*Vigna radiata* L.).

5. CONCLUSION

Based on the one-year study on summer mungbean (*Vigna radiata* L.), it may be concluded that, effect of sowing methods and phosphorus levels was significantly better with treatment combination, Bed sowing + 50 kg/ha P_2O_5, in terms of growth attributes, yield attributes, yield and also performed economically well as compared to other treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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