

Research Article

The Interaction Effect of Planting Methods with Phosphorus Levels on Mungbean's Growth and Performance

Ramesh Chandra Das^{1,*} , Sultan Ahmed¹ , Sharmina Shamim² , Milon Mia³,
Billal Hossain⁴ 

¹Department of Agronomy, Patuakhali Science and Technology University, Patuakhali, Bangladesh

²Department of Agricultural Extension, Ministry of Agriculture, Dhaka, Bangladesh

³Centre for Higher Studies and Research, Bangladesh University of Professionals, Dhaka, Bangladesh

⁴Research and Training Centre, Patuakhali Science and Technology University, Patuakhali, Bangladesh

Abstract

A study was conducted to assess the effect of planting method and Phosphorus application to BARI Mung 6, a variety suitable for cultivation in Patuakhali, Bangladesh. Significant observations found in interaction effect, where phosphorus at 40 kg ha⁻¹ broadcasting resulting in the tallest plants at 52.19cm. Moreover, phosphorus @40 kg ha⁻¹ in line sowing led to the highest number of branches per plant at 6.60. At 55 days after sowing, total dry matter, average growth rate, relative growth rate, and leaf area index were recorded at 10.86, 0.27, 0.12 g plants⁻¹ day⁻¹ and 0.75. Amongst the profitable features, the sowing of phosphorus @ 40 kg ha⁻¹ yielded maximum seed number of 6.87 pod⁻¹ and 69.85 plants⁻¹, 10.17 podplants⁻¹, weight 1000- seed 35.01 gram. Seed, stover and biological yields were calculated at 1446.74, 1595.31 and 3068.72 kg ha⁻¹, respectively, with a harvest index of 48.01. It was concluded that the sowing of the line in comparison to broadcasting, coupled with the application of 40 kg Pha⁻¹ at other phosphorus levels was more effective for obtaining higher production of mungbeans. Therefore, employing line sowing and 40 kg Pha⁻¹ would be recommended techniques with optimal level of phosphorus, respectively to obtain suitable growth and higher Mungbean yield in the studied area (AEZ-13).

Keywords

Mungbean (BARI Mung 6), Planting Methods, Phosphorus and Crop Yield

1. Introduction

Mungbean, an essential leguminous herb, is an annual pulse crop of significant agricultural importance. In Bangladesh, Mungbean is ranked fourth in the field of assessment, production and is the 1st in market prices [5]. Approximately, 8.23 percent of the total pulse production is attributed to mungbean [5]. Mungbean renowned for its ability to improve

physical, chemical and biological properties of soil. Despite the recommended minimum pulse intake should be 80.0 grams day⁻¹ [8] the actual intake in Bangladesh stands at a mere 19.35 grams per day [4]. It is an important source of protein and several basic micronutrients containing 24.5% protein and 59.9% of carbohydrates. It also contains 75 mg

*Corresponding author: ramesh.pstu@gmail.com (Ramesh Chandra Das)

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calcium, 8.5 mg iron and 49 mg β - carotene per 100 g divided dual [3]. Furthermore, its leaves and stems serve as a good source of feed for livestock and green fertilizer. In beans, mungbean is favored for children and older people due to their simple digestibility and gastric irritation. This crop can be used in broiler diet as a unique feed source [7]. The ideal Agro-climatic conditions prefer mungbean planting at the end of January to early February on earth, where the previous crop is usually wet land rice [1]. Most of the farmers of that region and Bangladesh adopt various techniques to enhance the mungbean yield such as, fertilizers application, planting methods, sowing time, planting densities etc. But they are ignoring how they will apply their techniques. Although most farmers in Bangladesh follow the traditional broadcasting method for seed sowing, but sowing lines is more advantageous because it requires less seeds and more. The space between the lines is maintained and is called sowing lines between plants.

In Bangladesh Mungbean, it usually transmits, though some progressive farmers follow the method of sowing lines. Extent and nutrient size deficiencies has recently deteriorated due to indirect use of intensive agriculture and plant nutrients [2]. However, many farmers grow mungbeans without the use of any artificial fertilizer. While legumes require minimal nitrogen for growth, phosphorus is very important nutrients to obtain high seed yield. Phosphorus requirements vary depending on the content of nutrients in the soil [6]. Insufficient phosphorus levels can hinder plant growth and maturity [11]. However, the mungbean is a short crop period, as it is a simple -fertilizer, as if it should be applied in the field of phosphorus. On the other hand, the availability of nutrients in the soil depends on some factors between them. The best proportion of fertilizer increases crop growth and development and guarantees availability of other basic nutrients for plants [10]. Additionally, the secondary method of interference was the absorption of phosphorus from the soil by luxury consumption, which increases the tissue content without increasing the smooth accumulation of biomass [14]. The new varieties had a short duration maturity of 55 - 65 days, high yield (2 t ha^{-1}) and uniform maturity, fatty seed (5 to 6 gram per 100 seeds) and resistance to diseases like cercospora foliage spots, mold and mung yellow mosaic virus. Mungbean's responsiveness to phosphorus has been well-documented [13]. Consequently, a comprehensive study was conducted to evaluate the impact of planting methods combined with phosphorus application on BARI Mung 6. The aim was to determine the optimal planting method and phosphorus dosage for maximizing the yield of BARI Mung 6, while also observing yield characteristics and contributing factors.

2. Materials and Methods

The study area is predominantly situated on the Ganges tidal floodplains and falls into the agro ecological zone "AEZ - 13" which lies at 0.9 - 2.1 meters above the average sea level [12].

The soil primarily consisted of silty loams or alluvium with a pH of 7.00. In most cases, organic matter found 1.53%. The lack of nitrogen is severe and widespread. The position of replaceable potassium is almost satisfactory. Generally, the Patuakhali field falls under the sub-racial environment, which is characterized by temperature variations and moisture levels, with strong rainfall from April to September, accompanied by strong winds, while the period between October and March sees lower temperatures and reduced precipitation levels. Without the combination of healthy, clean, well mature and other seeds, foreign materials without weed seeds and seeds were collected with the difference of window section in Ghazipur without the window BARI Mung 6. The study consists of two groups of treatment; the first set consisted of two methods of planting such as lines sowing (PM_1), broadcasting (PM_2) and the second set consisting of four different doses of phosphorus such as phosphorus @ 0 kg ha^{-1} (P_0), @ 20 kg ha^{-1} (P_{20}), @ 40 kg ha^{-1} (P_{40}) and @ 80 kg ha^{-1} (P_{80}) including control. These treatments were categorized as follows:

The experiment was placed in two factors, which was done randomly to complete block design with three replications. Practical site land was first opened from a tractor on January 9, 2013. It then came in contact with the sunlight for the first 7 days before the next ploughing. Then, after each ploughing, light and cross-ploughing ensured laddering. All weeds and stubbles were removed from the experimental field. Perfect fertilizers were well included before planting. At the time of final cultivation, the soil was treated with pesticides. According to the plot, all fertilizer quantities were determined and incorporated during the final land preparation. On January 27, 2013, the mungbean seeds were planted in the field of research. The seed was used for another method for another method for 25 kg per hectare and 30 kg per hectare.

Intercultural operations were properly done. After the crop, the data was recorded from five randomly selected plants of a plot. Selected plants were collected before the crop and recorded necessary information accordingly. Plot war was registered on the dry basis of the sun and the yield of seeds and stover. Various parameters were studied, including height of the plant, number of branches, Number of branches per plant, total dry matter, growth characters have been measured, full growth rate, relative growth rate, number of yield and yield contribution characters, number of pod^{-1} , number of seeds pod^{-1} , number of seeds plant^{-1} , thousand-seed weight, seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield and harvest index (%).

Calculated biological yield using the following formula-
Biological yield = seed yield + stover yield

Calculated AGR and RGR values at different growth stages using the following formula-

$$\text{AGR} = \frac{W_2 - W_1}{T_2 - T_1} \text{ g cm}^{-2} \text{ day}^{-1}$$

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \text{ g cm}^{-2} \text{ day}^{-1}$$

Where, W_1 = TDM production at previous sampling date

W_2 = TDM production at current sampling date

T_1 = Previous sampling date

T_2 = Current sampling date

$\log_e$ = Natural logarithm

Leaf area index of 5 plants was measured by dividing leaf area per plant with land area (cm^2) covered by the plant.

$$\text{LAI} = \frac{\text{Leaf area per plant}(\text{cm}^2)}{\text{Ground area covered by per plant}(\text{cm}^2)}$$

Harvest index (%) donates the ratio of seed yield to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological Yield}} \times 100$$

The data on the yield and performance characters were recorded and analyzed statistically using the MSTAT -C program. The average differences between the treatments evaluated by the DMRT test [9].

3. Result and Discussions

3.1. Interaction Effect of Planting Methods and Phosphorus Levels in Plant Height

Significant variation showed by interaction effect in relation to plant height in the crop (Table 1). Notably, the tallest plant reaching a height of (52.91cm) were observed in the broadcasting method combined with a phosphorus application of 40 kg/ha, which vary from other treatment combination in crop. From the observation above, it was found that with

increasing the height of the plants, with micronutrients such as Pasting with Pasting methods. Overall, these results highlight the intricate interplay between planting methods, phosphorus levels, and key growth parameters like plant height and branch numbers. The findings emphasize the significance of nutrient management practices and planting techniques in influencing crop growth and development, offering valuable insights for optimizing agricultural productivity and yield outcomes.

3.2. Interaction Effect of Planting Methods and Phosphorus Levels in Branches Plant⁻¹

Among interaction, highest 6.60 branch plant⁻¹ was found due to application of phosphorus @ 40 kg ha⁻¹ in the line sowing method and it was statistically different from other interactions. The results have shown that the branch number has increased in a significant way with the increasing phosphorus dosage, both planting methods as well as up to 40 kg ha⁻¹ and decreased in the upper dose of phosphorus.

3.3. The Interaction Between Planting Methods and Phosphorus Levels on Total Dry Matter (TDM)

Highest TDM values (3.77, 6.83 and 10.86 g plant⁻¹) were found with line sowing and the application of phosphorus @ 40 kg ha⁻¹ at 25, 40 and 55 DAS, respectively, which was equal to similar phosphorus levels and broadcasting methods (6.79 and 10.83 g plant) (Table 1). These results presented the view that the increase in phosphorus levels increased total TDM with both planting methods. However, line sowing methods performed better than broadcasting to produce TDM comparatively.

Table 1. Interaction effect of planting methods and phosphorus levels at the height of the plant, the number of branches and total dry matter in different days after the planting of BARI Mung 6.

Planting method	Phosphorus level (kg ha ⁻¹)	Plant height (cm)	Number of branch-esplant ⁻¹	Total dry matter (gplant ⁻¹) at		
				25	40	55
Line sowing	0	39.53 g	4.95 f	2.82 f	5.43 f	8.25 f
	20	43.89 e	5.24 e	2.93 e	5.92 d	8.71 d
	40	50.20 b	6.60 a	3.78 a	6.83 a	10.86 a
	80	46.37 d	6.05 c	3.28 c	6.28 b	9.59 c
Broadcasting	0	40.63 f	4.87 f	2.65 g	5.59 e	8.12 g
	20	44.73 e	5.18 e	2.82 f	5.97 d	8.62 e
	40	52.91 a	6.42 b	3.58 b	6.79 a	10.82 a
	80	48.38 c	5.69 d	3.09 d	6.12 c	9.74 b
$S_{\bar{x}}$		0.28	0.03	0.02	0.03	0.03

Planting method	Phosphorus level (kg ha ⁻¹)	Plant height (cm)	Number of branch- esplant ⁻¹	Total dry matter (g plant ⁻¹) at		
				25	40	55
Sig. Level		**	**	**	**	**
CV (%)		1.06	0.98	0.79	0.83	0.48

** = Significant at 1% level of probability and * = 5% of possibility. The figure after the same letter (s) are equal according to DMRT at statistically 5%.

3.4. Interaction Effect of Planting Methods and Phosphorus Levels on Average Growth Rate (AGR) Across Different Growth Stages

Between the two growth stages, all phosphorus levels in both stages recorded statistically uniform AGR without phosphorus in the line sowing method at 25-40 DAS. However, the broadcast method, 40 kg P ha⁻¹ demonstrated varied AGR values, with (0.21 g plant⁻¹ day⁻¹) in 25-40 DAS and the lowest AGR was broadcast in 25-40 DAS (0.174G Plant⁻¹ Day⁻¹) from the untreated phosphorus and in 40-55 DAS (0.168G Plant⁻¹) (Table 4). These findings indicate that phosphorus application at 40 kg/ha resulted in the highest AGR in the line sowing method compared to the broadcast method.

3.5. Interaction Effect of Planting Methods and Phosphorus Levels in RGR in DAS

Maximum RGR (0.093-gram plant⁻¹ day⁻¹) was observed with the interaction effect of 40 kg Pha⁻¹ and broadcasting, which was per 20 kg Pha⁻¹ (0.091 g Plant⁻¹ day⁻¹) and 80 kg Pha⁻¹ (0.088-gram plant⁻¹ day⁻¹) and 40 kg Pha⁻¹ in line with (0.088 g Plant⁻¹ day⁻¹) with broadcasts ha⁻¹ 25-40 DAS (Table 2) was statistically similar at the level. The results have shown that the sowing of the line with 40 kg P ha⁻¹ recorded the high RGR (0.1172 g plant⁻¹ day⁻¹) and the broadcast under control (without) Phosphorus recorded the lowest RGR (0.073g plant⁻¹ day⁻¹) at 40-55 DAS between two development stages.

Table 2. Planting methods on full growth rate, relative growth rate and leaf area index in different days after sowing of mung 6 and phosphorus levels on the leaf area index.

Planting methods	Phosphorus levels (kg ha ⁻¹)	Absolute growth rate (g plant ⁻¹ day ⁻¹) at		Relative growth rate (g plant ⁻¹ day ⁻¹) at		Leaf area index
		25-40	40-55	25-40	40-55	
Line sowing	0	0.17 b	0.19 bc	0.080 d	0.08 cd	0.60 def
	20	0.19 a	0.19 bc	0.098 c	0.08 cd	0.68 bc
	40	0.20 a	0.27 a	0.091 abc	0.12 a	0.75 a
	80	0.19 a	0.22 abc	0.087 bc	0.09 bc	0.67 bcd
Broadcasting	0	0.19 a	0.17 c	0.085 c	0.07 d	0.57 f
	20	0.20 a	0.18 c	0.091 ab	0.08d	0.59 ef
	40	0.21 a	0.27 a	0.093 a	0.12 a	0.70 ab
	80	0.20 a	0.24 ab	0.088 abc	0.11ab	0.64 cde
$S_{\bar{x}}$		0.0058	0.0183	0.0018	0.0058	0.0183
Sig. Level		**	*	*	*	*
CV (%)		2.18	5.07	5.24	4.46	1.36

** = Significant at 1% level of probability and * = 5% of possibility. The figures after the same letter (s) are equal according to DMRT at statistically 5%.

3.6. Interaction Effect of Planting Methods and Phosphorus Levels in Leaf Area Index

The highest LAI value (0.75) was found in the line sowing method at 40 kg Pha⁻¹ which was similar to the same phosphorus dose with statistically broadcast method (0.70). In contrast, in conversation with broadcasts produced the lowest LAI (0.57) without phosphorus. Notably, this value was comparable to broadcasting with 20 kg ha⁻¹ (0.59) was applied and without phosphorus in the sowing of the line (0.60) (Table 3). These results underscore a significant increase in LAI with both planting methods when applying up to 40 kg Pha⁻¹ along with rising levels of phosphorus. It was also indicated that sowing of the line performs better than broadcast in relation to LAI.

3.7. Interaction Effect of Planting Methods and Phosphorus Levels on Number of Seeds Pod⁻¹

Planting methods with phosphorus levels interactively affected the production of seedpod⁻¹ (Table 3). Maximum seedspod⁻¹ (6.87) found from the method of sowing line and the interaction effect of kg Pha⁻¹, statistically different from other interactions. Similarly, minimum seeds were seen in Pod⁻¹ (3.43) broadcast when phosphorus @ 40 kg ha⁻¹ was implemented.

3.8. Interaction Effect of Planting Methods and Phosphorus Levels in the Number of Podsplant⁻¹

Maximum podsplant⁻¹ (10.17) was recorded in the line sowing methods when phosphorus @ 40 kg ha⁻¹ was implemented. In contrast, the lowest number of podsplant⁻¹ (7.27)

was seen in broadcast when phosphorus @ 40 kg ha⁻¹ was implemented (Table 4).

3.9. Interaction Effect of Planting Methods and Phosphorus Levels in the Number of Plantseeds⁻¹

Maximum seed plant⁻¹ (69.85) was found, while phosphorus applied @ 40 kg ha⁻¹ in the line sowing and was statistically important from other interactions. On the other hand, the broadcast method exhibited the lowest seedplant⁻¹ (24.97) with control phosphorus, which was statistically different from other interactions (Table 3). Results showed that seed production plant⁻¹ increased considerably with 40 kg Pha⁻¹ in both planting methods and then reduced in the upper doses of phosphorus. The application of phosphorus @ 40 kg ha⁻¹ recorded the highest seedplant⁻¹ in the line sowed due to proper soil nutrients; A favorable climate status was found under this interaction treatment plot.

Maximum line of 1000-seed (35.01g) obtained by sowing line and the interaction effect of phosphorus @ 40 kg ha⁻¹ which was similarly similar to the broadcast method with the same phosphorus fertilizer application (33.85g). On the other hand, without phosphorus in the broadcast method, the lowest 1000-seed weight (29.79g) was recorded, which was not different with similar sowing methods with 20 kg Pha⁻¹ (30.54 g) (Table 3). These results showed that the application of phosphorus in the line sowing method recorded a maximum yield of 1000-seeds. This was probably due to the fact that the line was more efficient in the line sowing method for the supply of nutrients of adequate plants in the high dose of phosphorus @ 40 kg ha⁻¹ that eventually provided the heaviest seeds of mung bean.

Table 3. Interaction effect of planting methods and phosphorus levels in the number of seeds, pods and thousands of BARI mung 6 weights in harvest.

Planting methods	Phosphorus levels (kg ha ⁻¹)	Number of podsplant ⁻¹	Number of seedpod ⁻¹	Number of seedsplant ⁻¹	Thousand-seed weight (g)
Line sowing	0	7.87 f	4.27 f	33.62 f	31.76 cd
	20	8.87 d	5.30 d	47.03 d	33.12 bc
	40	10.17 a	6.87 a	69.85 a	35.01 a
	80	9.17 c	5.70 c	52.31 c	32.06 c
Broadcasting	0	7.27 g	3.43 g	24.97 g	29.79 e
	20	8.63 e	5.07 e	43.78 e	30.54 de
	40	9.93 b	6.27 b	62.29 b	33.85 ab
	80	8.90 d	5.30 d	47.20 d	33.58 b

Planting methods	Phosphorus levels (kg ha ⁻¹)	Number of pods plant ⁻¹	Number of seed pod ⁻¹	Number of seeds plant ⁻¹	Thousand-seed weight (g)
$S_{\bar{x}}$		0.0658	0.0408	0.6990	0.4389
Sig. Level		*	**	**	*
CV (%)		1.30	1.35	2.54	2.34

** = Significant at 1% level of probability and * = 5% of possibility. The figures after the same letter (s) are equal according to DMRT at statistically 5%.

3.10. Interaction Effect of Planting Methods and Phosphorus Levels in Seed Performance

Planting methods and interaction effects of phosphorus application greatly affected the production of seeds (Table 4). In the interaction, the line sowing method with 40 kg P ha⁻¹ recorded the highest seed yield (1446.74 kg ha⁻¹), while, the lowest (908.43 kg ha⁻¹) was in the crop without a transmission method of phosphorus.

3.11. Interaction Effect of Planting Methods and Phosphorus Levels on Stover Yield

Regarding stover yield (1595 kg ha⁻¹) was achieved in the

line sowing method when phosphorus was applied @ 40 kg ha⁻¹ showing statistical significance compared to other interactions. On the other hand, the lowest stover yield (1109.32 kg ha⁻¹) (Table 4) was recorded with untreated or control phosphorus by broadcasting methods.

3.12. Interaction Effect of Planting Methods and Phosphorus Levels on Biological Performance

Phosphorus @ 40 kg ha⁻¹ recorded the highest organic yield (3068.72 kg ha⁻¹) in the line sowing method, while it was the lowest (2017.75 kg ha⁻¹) (Table 4) in broadcasting method under untreated phosphorus, where all interaction treatments were native to each other.

3.13. Interaction Effect of Planting Methods and Phosphorus Levels in the Harvest Index (%)

Table 4. Planting methods on various produce characters and the interaction effect of the level of phosphorus and the crop index of Mung 6 in harvest.

Planting methods	Phosphorus levels (kg ha ⁻¹)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)
Line sowing	0	953.81 g	1186.42 g	2140.23 g	44.56 f
	20	1120.53 e	1341.66 e	2462.18 e	45.51 d
	40	1446.74 a	1595.31 a	3068.72 a	48.01 a
	80	1263.25 c	1517.21 c	2813.80 c	46.08 c
Broadcasting	0	908.43 h	1109.32 h	2017.75 h	45.02 e
	20	1095.79 f	1274.51 f	2370.30 f	46.23 c
	40	1401.91 b	1542.55 b	2944.45 b	47.61 a
	80	1227.01 d	1395.05 d	2622.07 d	46.86 b
$S_{\bar{x}}$		2.2410	3.6920	28.7800	0.1483
Sig. Level		**	**	*	**
CV (%)		0.33	0.47	1.95	0.56

** = Significant at 1% level of probability and * = 5% of possibility. The figures after the same letter (s) are equal according to DMRT at statistically 5%.

Phosphorus @ 40 kg ha⁻¹ showed maximum harvest index (48.01%) in line sowing methods, while statistically similar harvest index (47.61%) was seen in the broadcast method with the same phosphorus level. On the other hand, minimum harvest index (45.02%) was seen in the broadcast method, while phosphorus was absent (Table 4).

4. Conclusion

On the basis of the results of the experiment stated above, following conclusion could be drawn that various sowing methods and phosphorus doses significantly affected most of the morphological, development and yield, where interaction of line sowing method with phosphorus @ 40 kg ha⁻¹ alone or combination performed better over other treatments. Therefore, the optimal approach for achieving high mungbean yield in the studied area (AEZ -13) will be the suitable sowing method and optimal Phosphorus level for high yield of mung 6. However, it is suggested that further research be conducted to explore additional sowing techniques and phosphorus levels to maximize yield potential.

Abbreviations

AEZ	Agro Ecological Zone
TDM	Total Dry Matter
DMRT	Duncan's Multiple Range Test
LAI	Leaf Area Index
AGR	Average Growth Rate
RGR	Relative Growth Rate
DAS	Days After Sowing
CV	Coefficient of Variation
HI	Harvest Index
BP	Biological Performance
BARI	Bangladesh Agricultural Research Institute

Author Contributions

Billal Hossain: Conceptualization, Software, Writing – original draft

Ramesh Chandra Das: Formal Analysis, Investigation, Writing – original draft

Sultan Ahmed: Data curation, Methodology, Supervision, Writing – review & editing

Sharmina Shamim: Formal Analysis, Investigation, Software, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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