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INTERACTIVE EFFECTS OF ROW SPACING AND GIBBERELLIC ACID ON GROWTH AND YIELD ATTRIBUTES OF MUNG BEAN

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ABSTRACT

Research was undertaken to examine the comparative effects of row spacings and gibberellic acid (GA_3) applications at various days after sowing (DAS) on mung bean growth and yield. The study was carried out at the Agricultural Research Institute (ARI) in Dera Ismail Khan during the cropping season from April to July 2024. The study was conducted in a randomized complete block design (split-plot arrangement) with various row spacings (15, 30, 45 and 60 cm) in the main plot. The sub-plots comprised GA_3 application at various times, namely control (T_1), 15 DAS GA_3 (T_2), 30 DAS GA_3 (T_3), 45 DAS GA_3 (T_4), and 60 DAS GA_3 (T_5). The study found that 30 cm row spacings significantly improved all growth attributes, including leaf area index, crop growth rate, chlorophyll content, and yield components such as seeds per pod, pod length, and 1000-seed weight, resulting in increased seed yield and harvest index, demonstrating its superiority over other row spacings. Furthermore, GA_3 at 30 DAS outperformed all other treatments in terms of total plant growth and mung bean seed yield. Nonetheless, GA_3 application at 45 DAS increased crop growth. The combination of 30 cm row spacings with GA_3 application at 30 DAS improved mung bean growth and yield. The current study concluded that adopting 30 cm row spacing, particularly with GA_3 application at 30 DAS, is an effective strategy to increase mung bean yield.

Key words: Row Spacing, Gibberellic Acid, Productivity, Mung bean.

Introduction

Mung bean is cultivated in Pakistan over a total area of 217.8 thousand hectares, resulting in an annual production of 134.9 thousand tons. The agricultural area in KPK was 5.7 thousand hectares, with an output of 3.88 thousand tons. The cultivated area of mung bean in Dera Ismail Khan was 0.83 thousand hectares, with a harvested area of 0.55 thousand tons (Anonymous, 2023).

Elevated temperature stress can cause a shortage of water in plant tissues, resulting in damage to cell membranes and a decrease in the rate of transpiration, protein synthesis, enzyme activity, and ion absorption and transportation (Khalil et al., 2009). The application of GA_3 to black gram plants resulted in an increase in grain output (Manjari et al., 2018). This was attributed to the combined impact of various factors, including the positive influence of yield attributing features and improved photosynthetic efficiency.

The optimal spacing promotes the growth of plants in both their aboveground and belowground sections by maximizing the use of solar radiation and nutrients. The arrangement of plants at specified distances from each other has a direct impact on their physiological processes due to competition within the same species (Foysalkabir et al., 2016). Due to uneven or high planting density, crop growth is highly affected. Due to high planting density, competition between the plants increases for different resources such as water, nutrients and light which ultimately resulted in low production of mung bean in Pakistan. As a result, we have to depend on other countries to meet our

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consumption which is recorded to be 315 thousand tones (USDA, 2023). To facilitate the production of mung bean and to become self-sufficient in mung bean production, Gibberellic acid will be sprayed at different days after sowing (DAS) to optimize canopy development, photosynthetic efficiency and light interception at different row spacings.

The significance of this study lies in its innovative approach to addressing the challenges of uneven or high planting density in mung bean cultivation, which currently hinders production levels in Pakistan. Mung bean crops often face various stresses, including high planting density and diverse growing conditions. Investigating the effects of gibberellic acid on stress tolerance and resilience under different planting geometries can provide valuable insights into mitigating yield losses and ensuring crop stability. The main objective of this study is to assess the effect of planting geometry for achieving optimum yield, evaluate the influence of gibberellic acid applied at different days after sowing (DAS) to enhance production, and determine the optimum planting geometry and appropriate timing of gibberellic acid application to improve light interception, photosynthetic efficiency, and overall yield performance. By strategically timing the application of gibberellic acid at various stages after sowing and exploring its effects across different row spacings, this research will contribute to understanding the ideal combination of planting geometry and gibberellic acid application for optimizing growth and productivity of mung bean under local agro-ecological conditions.

Materials and Methods

Study Location

The present experiment was conducted during the 2024 cropping season (April to July) at the Agricultural Research Institute, Dera Ismail Khan, Pakistan. The experimental site is located at an elevation of 139.10 meters above sea level. All experimental materials and facilities were provided at the research station.

Experimental Materials

The experiment was performed using Inqalab, a profitable and well-adopted mung bean (Vigna radiata L.) variety. The recommended seed rate of 20 kg ha^{-1} was used. Sowing was done manually using a single-row hand drill, maintaining a plant-to-plant distance of 10 cm. The net plot size was 5.4 m^2 (3 m × 1.8 m). The soil was well-prepared, leveled, and fertilized according to standard agronomic recommendations before sowing.

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with a split-plot arrangement and three replications. The main plots consisted of different row spacings, whereas the subplots contained gibberellic acid (GA_3) applications at different days after sowing (DAS).

Main plot: Row Spacing	Sub-plots: Gibberellic Acid at different times

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M_1: 15 cm R × R apart	S_1: 15 DAS GA_3
M_2: 30 cm R × R apart	S_2: 30 DAS GA_3
M_3: 45 cm R × R apart	S_3: 45 DAS GA_3
M_4: 60 cm R × R apart	S_4: 60 DAS GA_3

Preparation and Application of Gibberellic Acid

Gibberellic acid (GA_3), a plant growth regulator, was used at a concentration of 200 ppm. The GA_3 solution was prepared by dissolving 0.2 g of GA_3 in 200 ml of distilled water. The prepared solution was applied to the designated subplots using a hand sprayer at 15, 30, 45, and 60 days after sowing according to the treatment schedule. The purpose of GA_3 application was to assess its effect on the growth, physiological, and yield attributes of mung bean under different planting geometries.

Irrigation and Crop Management

Irrigation was applied as per crop requirements throughout the growing season to maintain optimum soil moisture levels. Standard agronomic and plant protection practices were uniformly followed for all treatments to ensure proper growth and development of the crop.

Parameters Studied

The data on various physiological and morphological parameters were recorded during the experiment as follows:

Physiological Parameters:

SPAD values at 35 and 70 days after sowing, Leaf area index (LAI) at 35 and 70 days after sowing, Photosynthetic rate (µmol m^{-2} s^{-1}) at 35 and 70 days after sowing, Crop growth rate (CGR; g m^{-2} day^{-1}), Net assimilation rate (NAR; g m^{-2} day^{-1})

Morphological Parameters:

Plant height (cm), Number of branches per plant, Pod length (cm), Number of pods per plant Number of seeds per pod, 1000-seed weight (g), Seed yield (kg ha^{-1})

Statistical Analysis

All recorded data were statistically analyzed using STATISTIX 8.1 software. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% probability level to determine significant differences among treatments.

Results and Discussion

SPAD Values at 35 and 70 Days After Sowing

The results for SPAD values at 35 and 70 days after sowing (DAS) are presented in Table 1. At 35 DAS, variations among row spacings, gibberellic acid (GA_3) application times, and their interaction were statistically non-significant, indicating that planting geometry and GA_3 timing had no measurable effect on chlorophyll content at the early growth stage.

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At 70 DAS, SPAD values differed significantly among row spacings. The highest value (48.89) was recorded at 30 cm spacing, followed by 45 cm (44.32), while the lowest (36.18) occurred at 60 cm spacing. Improved spacing likely enhanced light interception and photosynthetic activity, promoting chlorophyll synthesis (Ling et al., 2011) GA_3 application times also showed significant differences, with the highest SPAD value (45.70) observed at 30 DAS, followed by 45 DAS (45.09), whereas the control and 60 DAS treatments recorded the lowest (39.11 and 39.69). These results agree with findings by Gomathinayagan et al. (2009), Kumar et al. (2018), and Chaudhary et al. (2023), confirming that GA_3 enhances chlorophyll content and photosynthetic efficiency. The interaction between both factors was statistically non-significant.

Leaf Area Index at 35 and 70 Days After Sowing

At 35 DAS, LAI showed significant variation among row spacings (Table 1). The highest LAI (0.39) was recorded at 30 cm spacing, while the lowest (0.11) was noted at 60 cm. Closer spacing promoted greater leaf expansion and canopy development. GA_3 application times and their interaction with spacing were non-significant at this stage.

At 70 DAS, both row spacing and GA_3 application significantly affected LAI. The 30 cm spacing again produced the highest LAI (5.21), whereas the lowest (1.37) was recorded at 60 cm spacing. Enhanced LAI at closer spacing may result from improved microclimate and efficient resource utilization (Foysalkabir et al., 2016). Among GA_3 treatments, application at 30 DAS recorded the maximum LAI (3.26), followed by 45 DAS (3.10), while the control and 60 DAS treatments produced the lowest (2.63). Timely GA_3 application promotes organ elongation and increases leaf surface area (Madavi et al., 2023).

The interaction between both factors was significant, with 30 cm spacing + 30 DAS GA_3 yielding the highest LAI (6.65), followed by 30 cm + 45 DAS GA_3 (5.63). The lowest LAI values (1.23 and 1.31) were observed under 60 cm spacing with control and 60 DAS GA_3 treatments, respectively. The improved LAI under closer spacing and timely GA_3 application may be attributed to optimum plant population and enhanced leaf elongation (Masa et al., 2017).

Photosynthetic Rate at 35 and 70 Days After Sowing (µmol m^{-2} s^{-1})

At 35 DAS, photosynthetic rate differed significantly among row spacings (Table 1). The highest rate (41.19 µmol m^{-2} s^{-1}) was recorded at 30 cm spacing, whereas the lowest (27.52 µmol m^{-2} s^{-1}) occurred at 60 cm spacing. Optimal spacing (30 cm) likely improved air circulation and CO_2 exchange, enhancing photosynthetic efficiency (Mansoor et al., 2010). GA_3 application times and their interaction with spacing were non-significant, though slightly higher values were observed when GA_3 was applied at 15 DAS.

At 70 DAS, row spacing and GA_3 timing both showed significant effects. The 30 cm spacing again recorded the highest photosynthetic rate (34.82 µmol m^{-2} s^{-1}), while 60 cm spacing showed the lowest (27.83 µmol m^{-2} s^{-1}). Optimal spacing ensured better light interception and reduced mutual shading (Priyadharshini et al., 2021). Among

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GA_3 timings, 30 DAS application gave the maximum rate (34.61 µmol m^{-2} s^{-1}), followed by 45 DAS (33.52 µmol m^{-2} s^{-1}), while the control and 60 DAS treatments showed minimum values. GA_3 enhanced photosynthesis by promoting leaf expansion and chlorophyll development (Dawar et al., 2020; Islam et al., 2021).
The interaction was significant, with 30 cm spacing + 30 DAS GA_3 producing the highest rate (41.50 µmol m^{-2} s^{-1}), while 60 cm spacing without GA_3 recorded the lowest (21.96 µmol m^{-2} s^{-1}). These results agree with Dar et al. (2015) and Foysalkabir et al. (2016).

Crop growth rate (g m^{-2} day^{-1})

The data for crop growth rate (CGR) of mung bean are presented in Table 1. Analysis of variance revealed highly significant differences among row spacings. The highest CGR (24.02 g m^{-2} day^{-1}) was recorded at 30 cm spacing, followed by 45 cm (15.14 g m^{-2} day^{-1}), while the lowest and statistically similar values were observed at 15 cm and 60 cm spacings (9.15 and 9.09 g m^{-2} day^{-1}, respectively). Enhanced CGR at 30 cm spacing may be attributed to optimal plant population and efficient utilization of growth resources, resulting in greater dry matter accumulation (Khalil and Muhammad, 2018).
Significant variations were also observed among gibberellic acid (GA_3) application times. The highest CGR (21.68 g m^{-2} day^{-1}) was obtained when GA_3 was applied at 30 DAS, whereas the lowest values (8.59 and 9.06 g m^{-2} day^{-1}) were noted in the control and 60 DAS treatments, respectively. These findings align with Chaudhary et al. (2023), who reported that timely GA_3 application enhances dry matter accumulation and growth rate in mung bean.
The interaction between row spacing and GA_3 application time was also significant. The combination of 30 cm spacing with GA_3 applied at 30 DAS produced the highest CGR (38.06 g m^{-2} day^{-1}), followed by 45 cm + 30 DAS (28.52 g m^{-2} day^{-1}) and 30 cm + 45 DAS (28.22 g m^{-2} day^{-1}). The lowest CGR (4.55 g m^{-2} day^{-1}) was recorded in 60 cm spacing under control conditions. The superior performance at 30 cm spacing with 30 DAS GA_3 application may be due to balanced plant density and enhanced leaf expansion, which improved photosynthetic efficiency and dry matter production (Bunkar et al., 2013; Islam et al., 2021).

Net assimilation rate (g m^{-2} day^{-1})

Data on net assimilation rate (NAR) of mung bean are presented in Table 2. Analysis of variance revealed significant effects of row spacing, with the highest NAR (1.48 g m^{-2} day^{-1}) recorded at 30 cm spacing. The lowest and statistically similar values (0.50 and 0.53 g m^{-2} day^{-1}) were observed at 60 cm and 15 cm spacing, respectively. The superior performance at 30 cm spacing may be attributed to a favorable microclimate that enhances photosynthesis and growth, consistent with the findings of Singh (2013).
Gibberellic acid (GA_3) application timing also showed significant variation. The highest NAR (0.97 g m^{-2} day^{-1}) was recorded when GA_3 was applied at 30 DAS, statistically comparable with 45 DAS (0.93 g m^{-2} day^{-1}) and 15 DAS (0.88 g m^{-2} day^{-1}). The lowest NAR (0.55 g m^{-2} day^{-1}) occurred in the control. These results align with Madavi et al. (2023), who reported enhanced metabolic and photosynthetic activity in

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mung bean following GA_3 (200 ppm) application at 30 DAS.

Interaction between row spacing and GA_3 timing was also significant. The combination of 30 cm spacing with GA_3 at 30 DAS produced the highest NAR (1.81 g m^{-2} day^{-1}), followed by 30 cm spacing with GA_3 at 15 and 45 DAS (1.74 g m^{-2} day^{-1} each). The lowest NAR (0.30 g m^{-2} day^{-1}) occurred in 60 cm spacing without GA_3. The superior NAR under 30 cm spacing and 30 DAS GA_3 may result from efficient light interception, resource utilization, and enhanced metabolic activity, corroborating the findings of Noor et al. (2017).

Number of branches (plant^{-1})

Data on the number of branches per plant are presented in Table 2. Analysis of variance showed significant effects of row spacing. The highest number of branches (38.04 $plant^{-1}$) was recorded at 30 cm spacing, followed by 45 cm spacing (36.35 $plant^{-1}$). The lowest and statistically similar values (26.26 and 30.86 $plant^{-1}$) were observed at 60 cm and 15 cm spacing, respectively. These findings agree with Khan et al. (2017), who also reported more branches at 30 cm spacing.

Significant variation was also observed for GA_3 application timing. The maximum number of branches (35.46 $plant^{-1}$) was produced when GA_3 was applied at 15 DAS, statistically comparable with 30 and 45 DAS applications (33.56 and 35.01 $plant^{-1}$, respectively). The minimum values (29.79 and 30.55 $plant^{-1}$) were recorded in the control and 60 DAS treatments. Similar results were reported by Tasnim et al. (2019), who found that GA_3 application around 30 DAS enhanced branching.

The interaction between row spacing and GA_3 application was non-significant. However, the combination of 30 cm spacing with GA_3 at 30 DAS yielded the highest branch count (41.90 $plant^{-1}$), while the fewest branches (24.66 $plant^{-1}$) occurred at 60 cm spacing without GA_3.

Pod length (cm)

Data on pod length are presented in Table 2. Analysis of variance revealed significant differences among row spacings. The longest pods (8.30 cm) were recorded at 30 cm spacing, followed by 45 cm (7.80 cm), while the shortest and statistically similar pod lengths (7.05 and 7.51 cm) were observed at 60 cm and 15 cm spacing, respectively. Optimum spacing (30 cm) likely enhanced resource utilization and plant vigor, resulting in longer pods, as also reported by Prasad et al. (2005), Zaher et al. (2014), and Khan et al. (2017).

Significant effects of GA_3 application timing were also observed. The maximum pod length (8.10 cm) occurred when GA_3 was applied at 30 DAS, statistically comparable with 45 and 15 DAS applications (7.98 and 7.68 cm, respectively). The shortest pods (7.07 cm) were recorded in the control, followed by 60 DAS treatment (7.49 cm). Enhanced pod elongation due to GA_3 may be attributed to its role in promoting cell division and elongation, consistent with Islam et al. (2021).

The interaction between row spacing and GA_3 timing was non-significant. However, the combination of 30 cm spacing with GA_3 at 30 DAS produced the longest pods (9.16 cm), whereas the shortest (6.03 cm) were obtained at 60 cm spacing without GA_3.

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Number of pods (plant^{-1})

Data on the number of pods per plant are presented in Table 2. Analysis of variance revealed significant differences among row spacings. The highest and statistically similar pod numbers (43.35 and 39.94 plant^{-1}) were recorded at 30 cm and 45 cm spacing, whereas the lowest values (35.50 and 36.50 plant^{-1}) were observed at 60 cm and 15 cm spacing, respectively. Optimum spacing (30 cm) likely enhanced light interception and nutrient utilization, resulting in vigorous growth and higher pod formation, consistent with Khan et al. (2017).

Significant variations were also observed for GA_3 application times. The maximum pod numbers (42.46 and 42.41 plant^{-1}) were recorded at 30 and 45 DAS GA_3 applications, while the control and 60 DAS treatments produced the fewest pods (34.45 and 36.45 plant^{-1}). GA_3 application likely enhanced vegetative growth and delayed pod abscission by promoting hormonal activity, as reported by Madavi et al. (2023) and Islam et al. (2021).

The interaction between row spacing and GA_3 timing was also significant. The combination of 30 cm spacing with GA_3 at 30 DAS produced the highest pod number (49.00 plant^{-1}), followed by 30 cm + 45 DAS (47.90 plant^{-1}). The fewest pods (28.80 plant^{-1}) occurred at 60 cm spacing without GA_3. The superior performance at 30 cm spacing with timely GA_3 application may be attributed to optimal plant population and efficient use of growth resources (Rasul et al., 2012; Varshitha, 2022; Singh et al., 2015; Islam et al., 2023).

No of seeds (pod^{-1})

Data on the number of seeds per pod are presented in Table 2. Analysis of variance revealed non-significant differences among row spacings; however, the highest seed number (11.76 pod^{-1}) was recorded at 30 cm spacing, while the lowest (8.38 pod^{-1}) was noted at 60 cm spacing. Longer pods obtained at closer spacing likely contributed to higher seed count, as also reported by Zaher et al. (2014) and Khan et al. (2017).

Significant differences were observed among GA_3 application times. The maximum and statistically similar seed numbers (10.50, 10.10, and 10.02 pod^{-1}) were recorded when GA_3 was applied at 30, 45, and 15 DAS, respectively, whereas the control and 60 DAS treatments produced fewer seeds (9.03 and 9.31 pod^{-1}). These findings agree with Islam et al. (2021), who noted that GA_3 application during flowering increases seed formation.

A significant interaction was also observed between row spacing and GA_3 application time. The combination of 30 cm spacing with GA_3 at 30 DAS yielded the highest seed number (13.03 pod^{-1}), followed by 30 cm + 45 DAS (11.74 pod^{-1}) and 45 cm + 30 DAS (11.66 pod^{-1}). The fewest seeds (7.42 pod^{-1}) were produced at 60 cm spacing under control conditions. The superior results at closer spacing with timely GA_3 application may be due to enhanced assimilate translocation and effective pollination, as reported by Varshitha et al. (2022) and Islam et al. (2023).

1000 seed weight (g)

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Table 2 presents the data for 1000-seed weight of mung bean. Analysis of variance revealed significant differences among row spacings. The highest seed weight (47.33 g) was recorded at 30 cm spacing, while the lowest and statistically similar weights (40.20–42.86 g) were observed at 60, 15, and 45 cm spacings. The superior performance at 30 cm spacing may be attributed to improved physiological efficiency and resource utilization, as also reported by Foysalkabir et al. (2016).

Significant variations were also observed among GA_3 application times. The heaviest seeds (46.75 g) were obtained from 30 DAS application, followed by 45 DAS (45.33 g). The control (39.41 g) and 60 DAS (41.83 g) treatments produced lighter seeds, statistically similar to 15 DAS (42.75 g). GA_3 application likely enhanced the grain-filling period and assimilate translocation, resulting in increased seed weight (Wang et al., 2006).

The interaction between row spacing and GA_3 application was statistically non-significant. However, the combination of 30 cm spacing with GA_3 applied at 30 DAS produced the heaviest seeds (50.00 g), whereas the lowest weight (32.66 g) was observed under 60 cm spacing without GA_3.

Seed yield (kg ha^{-1})

Table 2 presents the seed yield data of mung bean. Analysis of variance showed significant effects of row spacing. The highest yield (838.1 kg ha^{-1}) was obtained at 30 cm spacing, followed by 45 cm (750.2 kg ha^{-1}), while the lowest and statistically similar yields (690.2 and 712.3 kg ha^{-1}) were recorded at 60 and 15 cm spacings, respectively. The increased yield at 30 cm spacing may be attributed to better light interception, improved canopy photosynthesis, and efficient utilization of resources (Tickoo et al., 2006; Khan et al., 2017).

Significant differences were also observed among GA_3 application times. The highest seed yield (847.1 kg ha^{-1}) was achieved with GA_3 applied at 30 DAS, followed by 45 and 15 DAS applications (775.7 and 759.4 kg ha^{-1}). The lowest yield (666.9 kg ha^{-1}) occurred in the control. GA_3 likely enhanced vascular development and assimilate transport, resulting in improved seed filling and higher yield (Dawar et al., 2020; Madavi et al., 2023).

The interaction between row spacing and GA_3 application was significant. The combination of 30 cm spacing with GA_3 applied at 30 DAS produced the maximum yield (1000.1 kg ha^{-1}), whereas the lowest yield (601.2 kg ha^{-1}) was recorded under 60 cm spacing without GA_3. Similar findings were reported by Singh et al. (2003) and Islam et al. (2023), who noted that optimal spacing and timely GA_3 application enhance photosynthate translocation and seed productivity

Conclusion

The study revealed that both row spacing and GA_3 application timing significantly influenced the growth and yield of mung bean. Among the treatments, 30 cm row spacing markedly enhanced plant development and yield components compared to wider or narrower spacings. Likewise, GA_3 application at 30 DAS produced the highest improvements in growth attributes (LAI, CGR, photosynthetic rate, SPAD value) and

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yield parameters (pods per plant, seed weight, and seed yield). The interaction of 30 cm spacing with GA_3 applied at 30 DAS achieved the maximum seed yield (1000.1 kg ha^{-1}), demonstrating its superior effectiveness under the agro-ecological conditions of Dera Ismail Khan.

Recommendations

For optimal mung bean performance, farmers are advised to maintain 30 cm row spacing and apply GA_3 at 30 DAS as a foliar spray. This combination ensures better light interception, air circulation, and assimilate translocation, leading to higher yield and improved crop quality. Alternatively, GA_3 at 45 DAS can also be used for favorable results under similar field conditions

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Table 1 Influence of row spacing and gibberellic acid (GA_3) application on SPAD values (35 and 70 DAS), leaf area index (30 and 70 DAS), photosynthetic rate (35 and 70 DAS), and crop growth rate (g m^{-2} day^{-1}) of mung bean

Treatments	SPAD values (35 DAS)	SPAD values (70 DAS)	Leaf area index (35 DAS)	Leaf area index (70 DAS)	Photosynthetic rate (35 DAS)	Photosynthetic rate (70 DAS)	Crop growth rate (g m^{-2} day^{-1})
Row spacings							
M_1	44.04	41.64 ab	0.19 c	1.93 c	33.52 b	29.78 bc	9.15 c
M_2	45.68	48.89 a	0.39 a	5.21 a	41.19 a	34.82 a	24.02 a
M_3	44.62	44.32 a	0.29 b	2.97 b	33.86 b	30.98 b	15.14 b
M_4	41.24	36.18 b	0.11 d	1.37 d	27.52 b	27.83 c	9.09 c
$LSD_{0.05}$	NS	7.61	0.04	0.06	6.98	2.01	2.50
Gibberellic acid application							
S_1	42.05	39.11 b	0.24	2.63 d	33.67	27.13 c	8.59 c
S_2	45.51	44.20 ab	0.26	2.74 c	34.67	31.66 b	15.19 b
S_3	44.20	45.70 a	0.23	3.26 a	33.89	34.61 a	21.68 a
S_4	44.98	45.09 a	0.25	3.10 b	34.01	33.52 ab	17.22 b
S_5	42.73	39.69 b	0.26	2.63 d	33.85	27.33 c	9.06 c
$LSD_{0.05}$	NS	5.14	NS	0.09	NS	2.40	2.15
Row spacings × Gibberellic acid application							
M_1 S_1	42.20	38.00	0.18	1.87 h	32.93	28.06 eg	7.08 fh
M_1 S_2	46	43.60	0.21	1.91 h	34.13	31.66 c-f	10.77 df
M_1 S_3	43.93	42.63	0.16	1.88 h	33.40	28.66 d-g	8.46 eh
M_1 S_4	45.50	46.26	0.18	2.19 g	33.83	33.16 cd	13.80 cd
M_1S_5	42.56	37.70	0.21	1.82 h	33.30	27.33 fg	5.64 gh
M_2 S_1	43.56	47.30	0.39	4.54 c	40.86	30.40 c-f	12.25 ce
M_2 S_2	46.53	48.63	0.41	4.63 c	41.86	33.43 bc	25.74 b
M_2 S_3	46.16	51.06	0.38	6.65 a	41.06	41.50 a	38.06 a
M_2 S_4	46.63	49.40	0.40	5.63 b	40.73	38.06 ab	28.22 b
M_2 S_5	45.53	48.06	0.40	4.59 c	41.43	30.73 cf	15.81 c
M_3S_1	41.93	41.83	0.27	2.87 ef	33.70	28.10 eg	10.49 df
M_3S_2	46.93	46.93	0.31	3.07 d	34.66	33 cd	13.29 cd
M_3S_3	45.46	48.93	0.28	3.08 d	33.66	39.10 a	28.52 b
M_3S_4	46.03	42.66	0.29	3.05 de	33.73	30.43 cf	13.84 cd
M_3S_5	42.73	41.26	0.31	2.81 f	33.53	24.26 gh	9.56 dg
M_4S_1	40.50	29.33	0.10	1.23 j	27.20	21.96 h	4.55 h
M_4S_2	42.60	37.66	0.13	1.36 ij	28.03	28.56 dg	10.97 df
M_4S_3	41.23	40.16	0.10	1.41 ij	27.43	29.20 cf	11.67 ce
M_4S_4	41.76	42.03	0.12	1.53 i	27.76	32.43 ce	13.04 ce
M_4S_5	40.10	31.73	0.12	1.31 j	27.16	27 fg	5.24 gh
$LSD_{0.05}$	NS	NS	NS	0.18	NS	4.74	4.58

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Table 2. Influence of row spacing and gibberellic acid (GA_3) application on net assimilation rate (g m^{-2} day^{-1}), number of branches $plant^{-1}$, pod length (cm), number of pods $plant^{-1}$, number of seeds pod^{-1}, 1000-seed weight (g), and seed yield (kg ha^{-1}) of mung bean.

Treatments	Net assimilation rate (g m^{-2} day^{-1})	Number of branches ($plant^{-1}$)	Pod length (cm)	Number of pods ($plant^{-1}$)	Number of seeds (pod^{-1})	1000 seed weight (g)	Seed yield (kg ha^{-1})
Row spacings							
M_1	0.53 c	30.86 bc	7.51 bc	36.50 bc	8.83	42.46 b	712.3 c
M_2	1.48 a	38.04 a	8.30 a	43.35 a	11.76	47.33 a	838.1 a
M_3	0.66 b	36.35 ab	7.80 ab	39.94 ab	10.19	42.86 b	750.2 b
M_4	0.50 c	26.26 c	7.05 c	35.50 c	8.38	40.20 b	690.2 c
$LSD_{0.05}$	0.04	6.23	0.53	3.82	NS	3.67	23.56
Gibberellic acid application							
S_1	0.55 d	29.79 b	7.07 c	34.45 c	9.03 b	39.41 c	666.9 d
S_2	0.88 b	33.56 a	7.68 ab	38.35 b	10.02 a	42.75 bc	759.4 b
S_3	0.97 a	35.46 a	8.10 a	42.46 a	10.50 a	46.75 a	847.1 a
S_4	0.93 ab	35.01 a	7.98 ab	42.41 a	10.10 a	45.33 ab	775.7 b
S_5	0.63 c	30.55 b	7.49 bc	36.45 bc	9.31 b	41.83 c	689.5 c
$LSD_{0.05}$	0.05	2.55	0.53	2.53	0.59	3.48	21.22
Row spacing × Gibberellic acid application							
M_1 S_1	0.35 hi	26.30	7.16	33.56 hk	8.67 e	39.33	661.7 jl
M_1 S_2	0.65 eg	32.80	7.70	39.20 ch	8.85 e	38.00	742.0 dg
M_1 S_3	0.62 eg	32.53	7.63	37.13 di	8.78 e	44.00	735.8 eh
M_1 S_4	0.71 de	36.76	7.93	40 c-h	9.26 de	45.66	767.9 df
M_1S_5	0.34 hi	25.93	7.13	32.63 ik	8.63 e	45.33	654.3 kl
M_2 S_1	0.94 c	36.43	7.53	36.76 di	11.03 bc	45.33	711.5 gi
M_2 S_2	1.74 a	37.13	8.26	42.66 bd	11.59 b	48.66	829.6 c
M_2 S_3	1.81 a	41.90	9.16	49 a	13.03 a	50.00	1000.1 a
M_2 S_4	1.74 a	37.96	8.36	47.90 ab	11.74 b	49.33	867.9 c
M_2S_5	1.16 b	36.76	8.16	40.43 cg	11.41 bc	43.33	781.7 d
M_3S_1	0.61 eg	31.76	7.56	38.66 c-h	9.00 e	40.33	693.2 hk
M_3S_2	0.70 e	38.33	7.90	34.96 gj	11.18 bc	44.66	762.4 df
M_3S_3	0.81 d	39.76	8.30	43.23 abc	11.66 b	48.66	923.5 b
M_3S_4	0.58 g	37.56	7.80	40.56 cg	10.29 cd	44.66	693.8 hk
M_3S_5	0.59 fg	34.33	7.46	42.30 be	8.81 e	36.00	678.4 il
M_4S_1	0.30 i	24.66	6.03	28.80 k	7.42 f	32.66	601.2 m
M_4S_2	0.43 h	26	6.86	36.60 ei	8.48 ef	39.66	703.7 gj
M_4S_3	0.64 eg	27.66	.33	40.50 cg	8.52 ef	44.33	729.2 fh
M_4S_4	0.70 ef	27.76	7.83	41.20 bf	9.11 de	41.66	773.4 de
M_4S_5	0.43 h	25.20	7.20	30.43 jk	8.40 ef	42.66	643.5 lm
$LSD_{0.05}$	0.10	NS	NS	5.91	4.49	NS	44.55

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