

Effect of Plant Growth Regulator and Row Spacing on Mungbean (*Vigna radiata*)

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Abstract: Plant growth regulator play an important role of crops yield especially in mungbean. Row spacing also play vital role in mungbean yield. Therefore, a field experiment was conducted to find out the effect of plant growth regulator (NAA) and row spacing on growth and yield of mungbean. The experiment consists of four levels of NAA viz., 0, 20, 40 and 60 ppm and three different spacing viz., 20 cm × 10 cm, 30 cm × 10 cm and 40 cm × 10 cm. The result indicated significant variations of plant height, number of branches plant⁻¹, leaf dry weight, stem dry weight, root dry weight, 1000 seeds weight, grain yield due to plant growth regulator (NAA) and/or row spacing. The maximum 1000 seeds weights, highest grain yield were found when mungbean was sown with row spacing in 30cm × 10cm when treated with 40 ppm NAA. Therefore, yield of mungbean can be improved by the application of NAA and row spacing.

Key words: Mungbean • Yield • NAA • Plant growth regulator • Row spacing • Vegetative growth

INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the most important pulse crops in Bangladesh. But in Bangladesh the average yield is very low i.e. 0.69 t ha⁻¹ [1]. The yield difference indicates that there has a wide scope for increasing yield of mungbean. The reasons for low yield are manifold; some are varietals, some are agronomic management practices and even for plant growth regulator.

Plant growth regulators (PGRs) are being used as aids to enhance yield of different crops [2, 3, 4, 5]. Naphthalene acetic acid (NAA) is the growth promoting substance, which may play a significant role to change growth characters and yield of mungbean. Foliar application of growth regulator-NAA produces more fertile grain. NAA has a positive effect on growth and higher dry matter production [2]. Foliar spray of NAA (15 ppm) at 15, 30 and 45 days after sowing increased fruit set and productivity [6]. Lee [7] examined the foliar application of NAA and also found to increase plant height, number of leaves plant⁻¹ and fruit size with consequent enhancement in seed yield in different crops and is being advised to use PGRs to get higher

production. Therefore, NAA might have positive effect on higher yield under various plant spacing.

Various experiments and work on spacing of mungbean have been carried out in Bangladesh, as well as in other countries to find out the suitable plant population to get maximum yield [8]. Narrower spacing reduces the yield of mungbean up to 20 to 40% due to competition for light, space, water and nutrition, whereas wider spacing reduces yield by reducing plant population [9]. The optimum spacing favors the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients [10]. Plant spacing directly affects the physiological activities through intra-specific competition. Narrowing of plant spacing by increasing seed rate generally means a more uniform distribution of plants over a given area, thus matching the plant canopy effective in intercepting radiant energy and shading weeds. Though wider space allows individual plants to produce more branches and pods, but it provides smaller number of pods per unit area due to fewer plants per unit area. Although, there are various findings on spacing and fewer on NAA separately, there are no research findings on NAA under different spacing.

Considering the above background, this research program is initiated to evaluate the effect of naphthalene acetic acid (NAA) and row spacing on yield attributes and yield of summer mungbean.

MATERIALS AND METHODS

The experiment was conducted at the Central Experimental farm, Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh during the period from August 2013 to November 2013. The experimental field is located at 23° 41' N latitude and 90° 22' E longitude at a height of 8.6 m above the sea level belonging to the Agro-ecological Zone "AEZ-28" of Madhupur Tract [11, 12].

BARI Mung-6 was the test crop and seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The experiment was laid out in a randomized complete block design (RCBD) with three replications each. The experimental unit was 7.5m² (3.0-m × 2.5-m) plot. The first factor was the four Naphthalene acetic acid (NAA) viz., 0 ppm (G₀), 20 ppm (G₁), 40 ppm (G₂) and 60 ppm (G₃); second factor was the three levels of spacing viz., 20 cm × 10 cm (P₁), 30 cm × 10 cm (P₂) and 40 cm × 10 cm (P₃).

The recommended doses of organic manure and inorganic fertilizer were also used for the present experiment. Cowdung, urea, triple superphosphate, muriate of potash, gypsum, borax and zinc sulphate were applied. The crop was harvested at maturity stage and in the meantime yield and yield contributing data were recorded. Finally, mean data of the experiment of plant height, number of branches plant⁻¹, leaf dry weight, stem dry weight, root dry weight, 1000 seeds weight, grain yield was analyzed using statistical computer software MSTAT-C and the means were separated using least significant different test at 5% level of probability [13].

Preparation of Naphthalene Acetic Acid (NAA) and Control Solution: Naphthalene acetic acid (NAA) in different concentrations viz. 0, 20, 40 and 60 ppm were prepared following the procedure mentioned below. 20 ppm solution of NAA was prepared by dissolving 20 mg of it with distilled water. Then distilled water was added to make the volume 1 liter 20 ppm solution. In a similar way, 40 and 60 ppm concentrations were made. An adhesive Tween-20 @ 0.1% was added to each solution. Control plots were treated with distilled water along with tween-20.

RESULTS AND DISCUSSION

Plant Height

Effect of Plant Growth Regulator: Significant variation of plant height was found due to plant growth regulator in all the studied durations except 10 DAS (Fig. 1). At 10 DAS, numerically highest plant (20.93 cm) was found in 40 ppm NAA treatment and lowest plant (19.19 cm) was 0 ppm NAA treatment. At 20 and 30 DAS, the tallest plant (39.76 and 47.76 cm, respectively) was obtained from 40 ppm NAA (G₄₀) treatment which was statistically similar (35.21 and 45.21 cm, respectively) with 60 ppm NAA (G₆₀) treatment whereas, the shortest plant (31.23 and 38.23 cm, respectively) was obtained from the 0 ppm NAA (G₀) treatment. At 40, 50 and 60 DAS, the tallest plant (58, 57.67 and 56.00 cm, respectively) was obtained from G₄₀ treatment which was statistically similar (55.33, 52.99 and 51.32 cm, respectively) with G₂₀ treatment and (55.23, 52.83 and 51.17 cm, respectively) with G₆₀ treatment whereas, the shortest plant (45.60, 43.32 and 42.66 cm, respectively) was obtained from G₀ treatment.

Effect of Row Spacing: The plant height of mungbean was measured at 10, 20, 30, 40, 50 and 60 DAS. It was evident from Fig. 2 that the height of plant was significantly influenced by row spacing at all the sampling dates. Fig. 1 showed that plant height increased with advancing growing period irrespective of row spacing, the mungbean height increased rapidly at the early stages of growth and rate of progression in height was slow at the later stages except control treatment. At 10 DAS, 30 cm × 10 cm spacing treatment showed the longest plant (22.37 cm) whereas, the shortest plant (17.85 cm) was found from 20 cm × 10 cm spacing treatment. At 20, 30, 40, 50 and 60 DAS, 30 cm × 10 cm spacing gave the highest plant height (39.72, 49.47, 60.01, 56.96 and 54.96 cm, respectively) which was statistically similar with 40 cm × 10 cm spacing (34.22, 43.97, 55.11, 53.52 and 51.52 cm, respectively) whereas, the lowest height was recorded from 20 cm × 10 cm spacing (42.94, 57.59, 55.67 cm, respectively). Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the present experiment since mungbean was grown in the same environment and were given same cultural practices except row spacing. So, the variation of plant height might be due to the effect different level of row spacing.

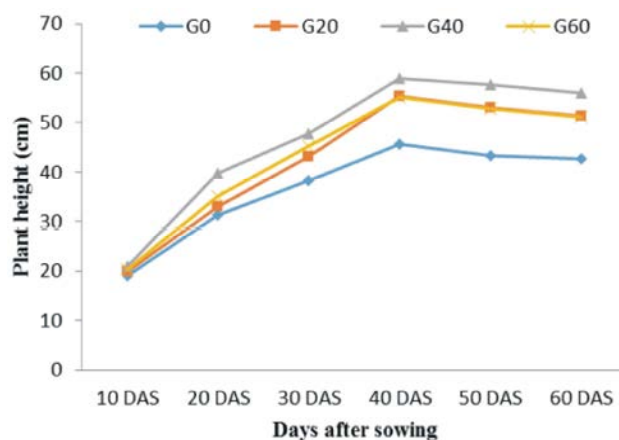


Fig. 1: Effect of plant growth regulator on plant height of mungbean
LED value = NS, 6.56, 4.57, 5.67, 5.85 and 5.58 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: G_0 = 0 ppm NAA, G_{20} = 20 ppm NAA, G_{40} = 40 ppm NAA and G_{60} = 60 ppm NAA

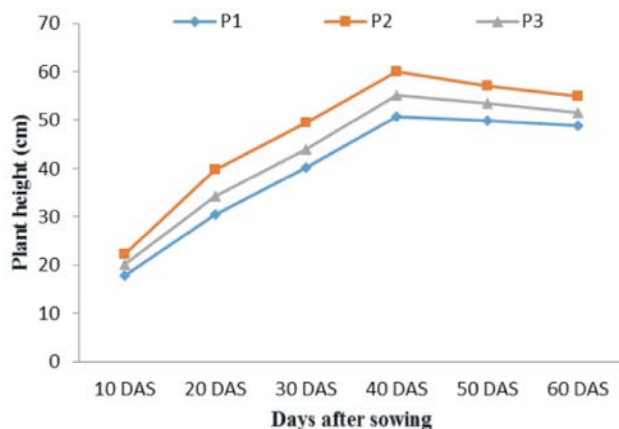


Fig. 2: Effect of row spacing on plant height of mungbean
LED value = 2.04, 5.69, 5.64, 8.88, 5.06 and 5.06 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: P_1 = 20 cm x 10 cm, P_2 = 30 cm x 10 cm and P_3 = 40 cm x 10 cm.

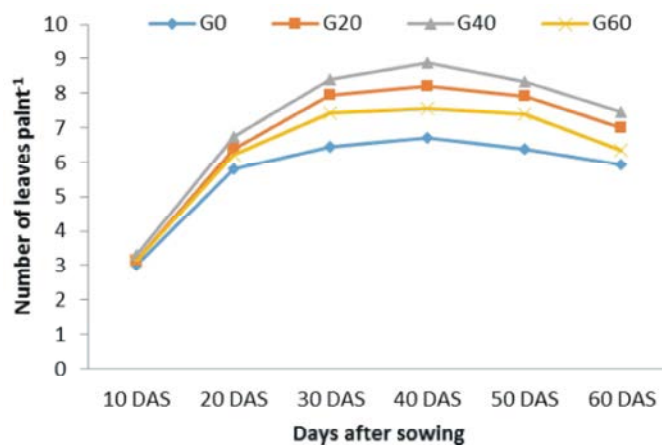


Fig. 3: Effect of plant growth regulator on number of leaves plant⁻¹ of mungbean
LSD value = 0.13, 0.34, 0.44, 0.62, 0.39 and 0.47 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: G_0 = 0 ppm NAA, G_{20} = 20 ppm NAA, G_{40} = 40 ppm NAA and G_{60} = 60 ppm NAA.

Number of Leaves Plant⁻¹

Effect of Plant Growth Regulator: The number of leaves plant⁻¹ was significantly influenced by different plant growth regulator at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 3). The number of leaves plant⁻¹ gradually increased with the advancement of plant age up to 40 DAP and thereafter more/less remain static with advancing growing period, irrespective of different plant growth regulator. At 10, 20, 30, 40, 50 and 60 DAS, the maximum leaves number plant⁻¹ (3.30, 6.76, 8.41, 8.90, 8.35 and 7.47, respectively) was observed from the 40 ppm NAA (G₄₀) treatment and the minimum number (3.01, 5.80, 6.46, 6.71, 6.38 and 5.92, respectively) was observed from the 0 ppm NAA (G₀) treatment.

Effect of Row Spacing: The effect of row spacing on number of leaves plant⁻¹ was insignificant. Results revealed that, the number of leaves plant⁻¹ of mungbean increased gradually with increased the row spacing upto 30 cm × 10 cm (P₂) at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 4). At 10, 20, 30, 40, 50 and 60 DAS, the numerically maximum leaves number plant⁻¹ (3.21, 6.46, 7.67, 8.65, 8.78 and 7.56, respectively) was observed from P₂ treatment and the minimum number (3.03, 6.40, 7.21, 8.09, 8.53 and 7.02, respectively) was observed from P₁ treatment. The present study referred that 30 cm × 10 cm produced maximum number of leaves.

Leaf Dry Weight Plant⁻¹

Effect of Plant Growth Regulator: Leaf dry weight plant⁻¹ varied significantly with different levels of plant growth regulator at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 5). At 10, 20, 30, 40, 50 and 60 DAS, the maximum leaf dry weight (0.84, 2.60, 5.45, 6.79, 7.39 and 8.40 g, respectively) was produced from 40 ppm NAA (G₄₀) treatment while, the minimum (0.24, 1.80, 4.60, 5.83, 6.57 and 6.97 g, respectively) was found from 0 ppm NAA (G₀) treatment. Present study showed that leaf dry weight of mungbean was significantly increased with increasing NAA concentration up to 40 ppm NAA thereafter declined.

Effect of Row Spacing: Leaf dry weight plant⁻¹ significantly influenced by row spacing at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 6). At 10, 20, 30, 40, 50 and 60 DAS, 30 cm × 10 cm spacing produced higher leaf dry weight (0.81, 2.58, 5.91, 6.85, 7.18 and 7.56 g, respectively) whereas, the lowest (0.71, 2.24, 4.53, 5.55, 5.97 and 6.29 g, respectively) was recorded from 20 cm × 10 cm spacing. This might be due to the effect of row spacing.

Stem Dry Weight Plant⁻¹

Effect of Plant Growth Regulator: Stem dry weight plant⁻¹ varied significantly with different levels of plant growth regulator at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 7). At 10, 20, 30, 40, 50 and 60 DAS, the highest stem dry weight (0.79, 1.44, 3.68, 3.86, 4.12 and 4.45 g, respectively) was produced from 40 ppm NAA (G₄₀) treatment while, the lowest (0.19, 0.53, 2.02, 2.34, 2.57 and 2.80 g, respectively) was found from 0 ppm NAA (G₀) treatment.

Effect of Row Spacing: Stem dry weight plant⁻¹ significantly influenced by row spacing at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 8). At 10, 20, 30, 40, 50 and 60 DAS, 30 cm × 10 cm spacing produced maximum stem dry weight (0.45, 1.12, 2.92, 3.85, 3.90 and 3.97 g, respectively) whereas, the minimum (0.35, 0.87, 1.54, 2.55, 2.69 and 2.70 g, respectively) was recorded from 20 cm × 10 cm spacing.

Root Dry Weight Plant⁻¹

Effect of Plant Growth Regulator: Root dry weight plant⁻¹ varied significantly with different levels of plant growth (NAA) regulator at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 9). At 10, 20, 30, 40, 50 and 60 DAS, the maximum root dry weight (0.06, 0.37, 1.34, 1.90, 2.56 and 2.80 g, respectively) was produced from G₄₀ treatment whereas, the minimum (0.03, 0.25, 0.71, 1.31, 1.78 and 2.12 g, respectively) was found from G₀ treatment.

Effect of Row Spacing: Root dry weight plant⁻¹ significantly influenced by row spacing at 10, 20, 30, 40, 50 and 60 days after sowing (DAS) (Fig. 10). At 10, 20, 30, 40, 50 and 60 DAS, 30 cm × 10 cm spacing (P₂) treatment produced highest root dry weight (0.05, 0.34, 0.97, 1.80, 2.34 and 2.57 g, respectively) whereas, the lowest (0.03, 0.26, 0.74, 1.41, 1.73 and 2.10 g, respectively) was found from 20 cm × 10 cm spacing (P₁) treatment.

The 1000 Seeds Weight

Effect of Plant Growth Regulator: The 1000 grains weight of mungbean differed significantly due to plant growth regulator (Table 1). The highest 1000 grains weight (44.50 g) was recorded from the 40 ppm NAA treatment while the lowest (37.14 g) was found in the 0 ppm NAA treatment, which was statistically similar to that of the 60 ppm NAA (40.07 g) treatment. Venkaten et al. [14] also pointed out that 1000 seeds weight of legumes crop increased due to NAA application.

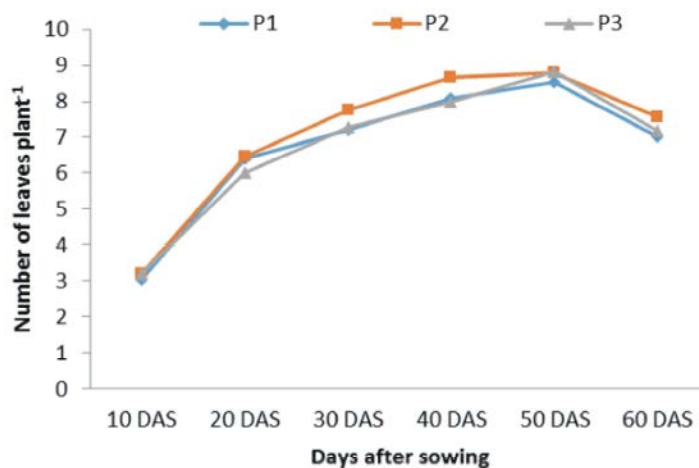


Fig. 4: Effect of row spacing on number of leaves plant⁻¹ of mungbean

LSD value = NS at 20, 40, 60, 80 and 100 DAS, respectively.

Note: P₁ = 20 cm × 10 cm, P₂ = 30 cm × 10 cm and P₃ = 40 cm × 10 cm.

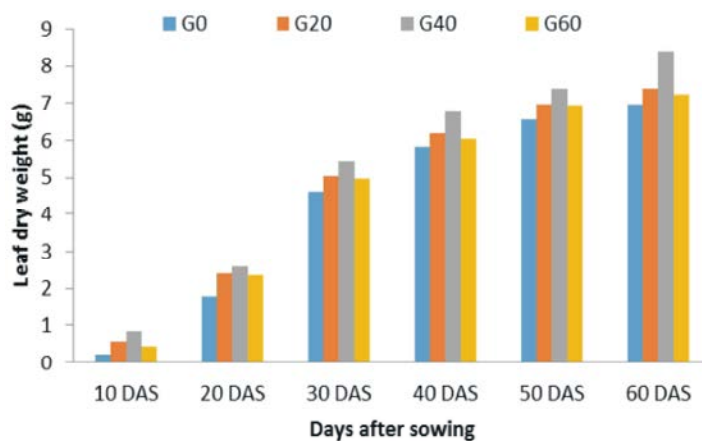


Fig. 5: Effect of plant growth regulator on leaf dry weight plant⁻¹ of mungbean

LSD value = 0.18, 0.14, 0.34, 0.53, 0.29 and 0.65 at 10, 20, 30, 40, 50 and 60 DAS, respectively.

Note: G₀ = 0 ppm NAA, G₂₀ = 20 ppm NAA, G₄₀ = 40 ppm NAA and G₆₀ = 60 ppm NAA

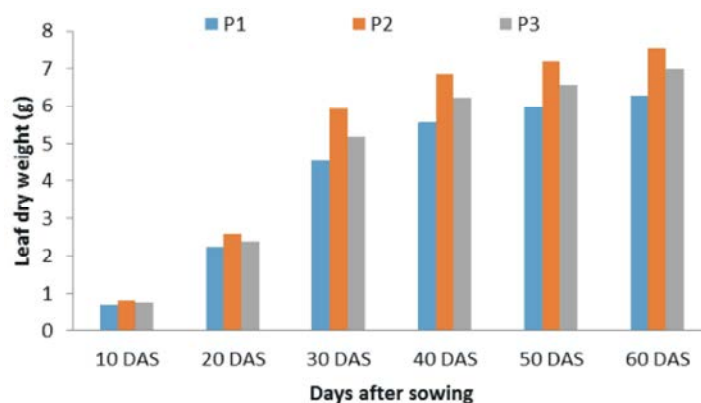


Fig. 6: Effect of row spacing on leaf dry weight plant⁻¹ of mungbean.

LSD value = 0.04, 0.18, 0.49, 0.51, 0.39 and 0.61 at 10, 20, 30, 40, 50 and 60 DAS, respectively.

Note: P₁ = 20 cm × 10 cm, P₂ = 30 cm × 10 cm and P₃ = 40 cm × 10 cm.

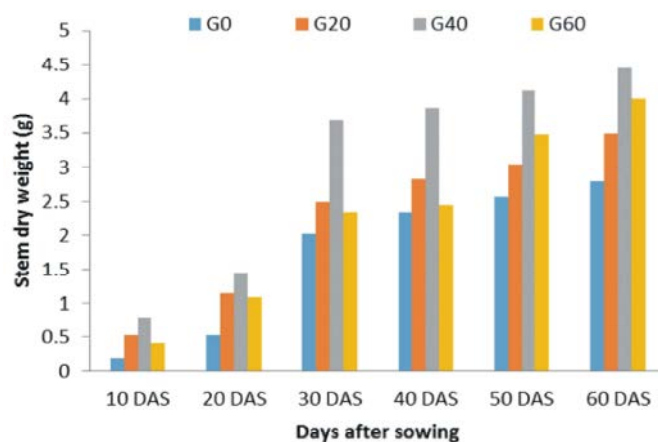


Fig. 7: Effect of plant growth regulator on stem dry weight plant⁻¹ of mungbean
LSD value = 0.23, 0.08, 0.37, 0.48, 0.18 and 0.28 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: G₀ = 0 ppm NAA, G₂₀ = 20 ppm NAA, G₄₀ = 40 ppm NAA and G₆₀ = 60 ppm NAA.

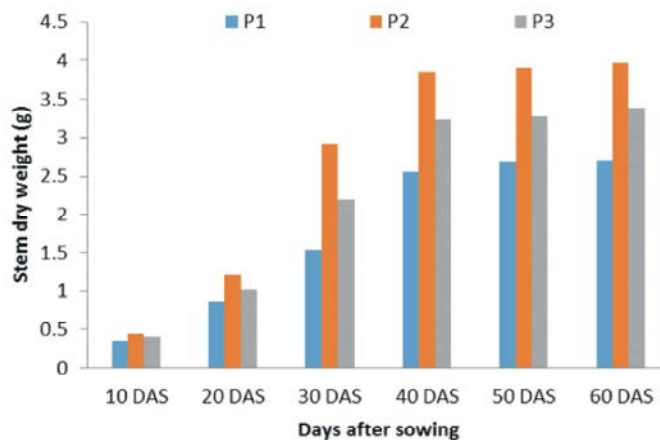


Fig. 8: Effect of row spacing on stem dry weight plant⁻¹ of mungbean.
LSD value = 0.03, 0.14, 0.27, 0.23, 0.45 and 0.38 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: P₁ = 20 cm × 10 cm, P₂ = 30 cm × 10 cm and P₃ = 40 cm × 10 cm.

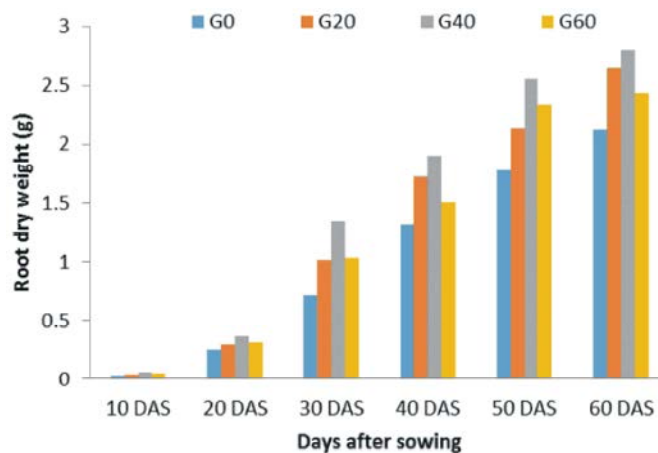


Fig. 9: Effect of plant growth regulator on root dry weight plant⁻¹ of mungbean
LSD value = 0.01, 0.04, 0.29, 0.17, 0.15, 0.11 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: G₀ = 0 ppm NAA, G₂₀ = 20 ppm NAA, G₄₀ = 40 ppm NAA and G₆₀ = 60 ppm NAA.

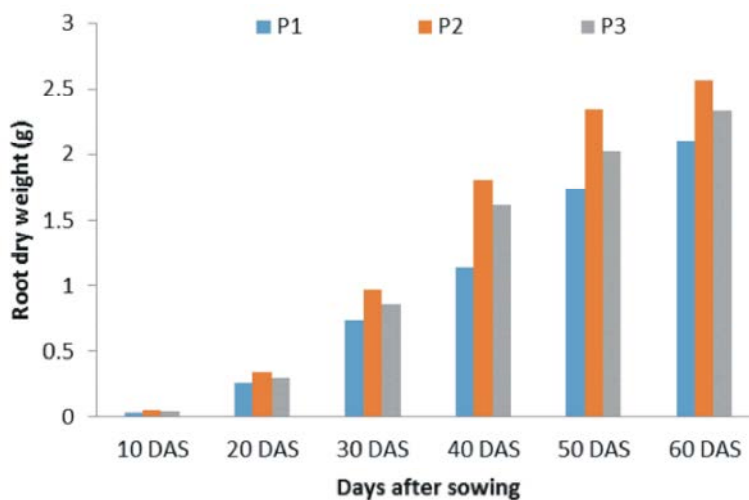


Fig. 10: Effect of row spacing on root dry weight plant⁻¹ of mungbean
LSD value = 0.01, 0.03, 0.10, 0.18, 0.27 and 0.19 at 10, 20, 30, 40, 50 and 60 DAS, respectively.
Note: P₁ = 20 cm × 10 cm, P₂ = 30 cm × 10 cm and P₃ = 40 cm × 10 cm.

Table 1: Effect of plant growth regulator on yield contributing characters of mungbean

Growth regulator	1000 seeds weight (g)	Grain yield (t ha ⁻¹)
G ₀	37.14 c	1.11 c
G ₂₀	40.92 b	1.30 b
G ₄₀	44.50 a	1.68 a
G ₆₀	40.07 bc	1.38 b
LSD _(0.05)	2.933	0.1071
CV (%)	4.26	4.54

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: G₀ = 0 ppm NAA, G₂₀ = 20 ppm NAA, G₄₀ = 40 ppm NAA and G₆₀ = 60 ppm NAA

Table 2: Effect of row spacing on yield contributing characters of mungbean.

Spacing	1000 seeds weight (g)	Grain yield (t ha ⁻¹)
P ₁	37.72 b	1.10 c
P ₂	44.26 a	1.63 a
P ₃	40.00 b	1.38 b
LSD _(0.05)	2.540	0.09275
CV (%)	4.26	4.54

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: P₁ = 20 cm × 10 cm, P₂ = 30 cm × 10 cm and P₃ = 40 cm × 10 cm

Effect of Row Spacing: Statistically significant differences were found for 1000 grains weight of mungbean due to row spacing (Table 2). The maximum 1000 seeds weight (44.26 g) was recorded from the 30 cm × 10 cm spacing (P₂) treatment whereas, the minimum 1000 seeds weight (37.72 g) was observed from the 20 cm × 10 cm spacing (P₁) treatment, which was statistically similar in the 40 cm

× 10 cm spacing i.e., P₃ treatment (40.00 g). Ahmed *et al.*, (2005) reported that row spacing help to get highest 1000 seeds weight of mungbean. Because row spacing significantly affected the seed yield of legumes [15].

Grain Yield

Effect of Plant Growth Regulator: Grain yield of mungbean varied significantly due to plant growth regulator (Table 1). The highest grain yield (1.68 t ha⁻¹) was recorded from the 40 ppm NAA treatment whereas, the lowest (1.11 t ha⁻¹) was found in the 0 ppm NAA treatment. Kalita [16] also reported that yield of mungbean increased with the application of NAA.

Effect of Row Spacing: Grain yield varied significantly due to row spacing (Table 2). The highest grain yield (1.63 t ha⁻¹) was recorded from the 30 cm × 10 cm spacing treatment whereas, the lowest (1.10 t ha⁻¹) was found in the 20 cm × 10 cm spacing treatment. It might be due to row spacing help to get more photosynthetic facility that help to get more yield of mungbean [17]. However, Achakzai and Panizai [18] obtained contrasting results in case of mashbean.

CONCLUSIONS

The present investigation indicated that Naphthalene acetic acid (NAA) and row spacing have a positive effect on the growth attributes of mungbean. Plant height was significantly influenced by row spacing. At 60 DAS, 30 cm × 10 cm spacing gave the highest plant height (54.96 cm).

The number of leaves plant⁻¹ of mungbean increased gradually with increasing the row spacing up to 30 cm × 10 cm (P₂) at 10, 20, 30, 40, 50 and 60 DAS. At 60 DAS, the numerically maximum leaves number plant⁻¹ (7.56) was observed from P₂ treatment. Leaf dry weight plant⁻¹ was significantly influenced by row spacing at different DAS. At 60 DAS, 30 cm × 10 cm spacing produced higher leaf dry weight (7.56 g). Stem dry weight plant⁻¹ was significantly influenced by row spacing. At 60 DAS, 30 cm × 10 cm spacing produced maximum stem dry weight (3.97 g). Root dry weight plant⁻¹ was also significantly influenced by row spacing. At 60 DAS, 30 cm × 10 cm spacing (P₂) treatment produced highest root dry weight (2.57 g). Row spacing significantly influenced leaf area index (%) of mungbean. The highest leaf area index (4.85 %) was found in 30 cm × 10 cm spacing (P₂) treatment. Statistically significant differences were found for number of pod plant⁻¹ of mungbean due to row spacing. The highest 1000 seeds weights (44.26 g), grain yield (1.63 t ha⁻¹) were recorded from 30 cm × 10 cm spacing (P₂). So, it can be concluded that the application of NAA and row spacing helps to increase the yield of mungbean.

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