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Effect of Plant Growth Regulator and Row Spacing on Yield of Mungbean (*Vigna radiate* L.)

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Abstract: Plant growth regulator plays 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 results indicated significant variations in number of pod plant^{-1}, pod length, number of seed pods^{-1}, 1000 seeds weight, seed yield, stover yield, biological yield and harvest index due to plant growth regulator (NAA) and/or row spacing. The maximum 1000 seeds weights, seed yield and harvest index were found when mungbean was sown with row spacing in 30cm × 10cm in combination with 40 ppm NAA. Therefore, yield of mungbean can be improved by applying NAA and row spacing.

Key words: Mungbean · Yield · NAA · Plant growth regulator · Row spacing

INTRODUCTION

Mungbean [*Vigna radiata* L.] is one of the most important pulse crops in Bangladesh. But in Bangladesh the average yield is very low. The average yield of mungbean is 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 [2-5]. Naphthalene acetic acid 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}, fruit size with consequent enhancement in seed yield in different crops and are 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

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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 filed 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 with three replications. The experimental unit was 7.5m^2 (3.0-m × 2.5-m) plot. The first factor was the four Naphthalene acetic acid (NAA) *viz*., 0 ppm (G_0), 20 ppm (G_1), 40 ppm (G_2) and 60 ppm (G_3); second factor was the three levels of spacing *viz*., 20 cm × 10 cm (P_1), 30 cm × 10 cm (P_2) and 40 cm × 10 cm (P_3).

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 number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 1000 seeds weight, seed yield, stover yield, biological yield, harvest index were 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

Number of Pod Plant^{-1}

Effect of Plant Growth Regulator: Number of pods plant^{-1} of mungbean differed significantly due to plant growth regulator (Table 1). The highest number of pod plant^{-1} (24.89) was obtained from 40 ppm NAA (G_{40}) treatment whereas, the lowest (16.56) was found 0 ppm NAA (G_0) treatment. It might be due to foliar application of NAA increased the number of pods per plant and eventually the pod yield of legumes [14].

Effect of Row Spacing: Statistically significant differences were found for number of pod plant^{-1} of mungbean due to row spacing (Table 2). The highest number of pods plant^{-1} (22.08) was obtained from 30 cm × 10 cm spacing (P_2) treatment, which was statistically similar to that of P_3 (20.58) treatment whereas, the lowest (18.83) was observed from 20 cm × 10 cm spacing (P_1) treatment. It might be due to row spacing helps to get more sunlight and food for photosynthesis as a result pods plant^{-1} is higher [15].

Pod Length

Effect of Plant Growth Regulator: Length of pod of mungbean differed significantly due to plant growth regulator (Table 1). The maximum pod length (9.68 cm) was obtained from 40 ppm NAA treatment, while the minimum (7.09 cm) was found in 0 ppm NAA treatment. Because pod length of mungbean increased due to NAA application [16].

Effect of Row Spacing: Statistically significant differences were found for pod length of mungbean due to row spacing (Table 2). The maximum pod length (10.18 cm) was obtained from 30 cm × 10 cm spacing whereas, the minimum (6.38 cm) was observed from 20 cm × 10 cm spacing. The present finding consisted with the findings of Agasimani *et al.* [17].

Number of Seeds Pod^{-1}

Effect of Plant Growth Regulator: Number of seeds pod^{-1} of mungbean differed significantly due to plant growth regulator (Table 1). The highest number of seeds pod^{-1} (14.67) was obtained from G_{40} treatment,while the lowest

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

Growth regulator	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	1000 seeds weight (g)
G_0	16.56 c	7.09 c	10.67 d	37.14 c
G_{20}	21.00 b	8.42 b	12.67 c	40.92 b
G_{40}	24.89 a	9.68 a	14.67 a	44.50 a
G_{60}	19.56 b	8.21 b	12.73 b	40.07 bc
$LSD_{(0.05)}$	1.978	0.4113	0.05355	2.933
CV (%)	5.70	2.90	0.23	4.26

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: G_0 =0 ppm NAA, G_{20} = 20 ppm NAA, G_{40} = 40 ppm NAA and G_{60} = 60 ppm NAA

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

Spacing	Number of pods plant^{-1}	Pod length (cm)	Number of seeds pod^{-1}	1000 seeds weight (g)
P_1	18.83 b	6.38 c	9.83 c	37.72 b
P_2	22.08 a	10.18 a	15.47 a	44.26 a
P_3	20.58 a	8.47 b	12.75 b	40.00 b
$LSD_{(0.05)}$	1.713	0.3562	0.04637	2.540
CV (%)	5.70	2.90	0.23	4.26

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: P_1 = 20 cm × 10 cm, P_2 = 30 cm × 10 cm and P_3 = 40 cm × 10 cm

number of seeds pod^{-1} (01.67) was found G_0 treatment. Because pod length of mungbean increased due to NAA application [16].

Effect of Row Spacing: Statistically significant differences were found for number of seeds pod^{-1} of mungbean due to row spacing (Table 2). The maximum number of seeds pod^{-1} (15.47) was obtained from P_2 treatment, while the minimum (9.83) was observed from P_1 treatment. Because mungbean grown at very high density failed to produce yield because of high rate of mortality [18].

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 obtained from the 40 ppm NAA treatment and 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.* [19] also pointed out that 1000 seeds weight of legumes crop increased due to NAA application.

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 obtained from the 30 cm × 10 cm spacing (P_2) treatment whereas, the minimum 1000 seeds weight (37.72 g) was observed from the 20 cm × 10 cm spacing (P_1) treatment, which was statistically similar in the 40 cm × 10 cm spacing i.e., P_3 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 [20].

Grain Yield

Effect of Plant Growth Regulator: Grain yield of mungbean varied significantly due to plant growth regulator (Table 3). The highest grain yield (1.68 t ha^{-1}) was obtained from the 40 ppm NAA treatment whereas, the lowest (1.11 t ha^{-1}) was found in the 0 ppm NAA treatment. Kalita [21] also reported that yield of mungbean was increased with applying NAA.

Effect of Row Spacing: Grain yield varied significantly due to row spacing (Table 4). The highest grain yield (1.63 t ha^{-1}) was obtained 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 [22].

Stover Yield

Effect of Plant Growth Regulator: Stover yield of mungbean were significantly influenced by plant growth regulator (Table 3). The maximum stover yield (2.13 t ha^{-1}) was obtained from the G_0 treatment whereas, the minimum (1.30 ha^{-1}) was found in the G_{40} treatment. Kelaiya *et al.* [23] also stated that NAA help to increase the plant dry weight.

Table 3: Effect of plant growth regulator on yields and harvest index of mungbean

Growth regulator	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
G_0	1.11 c	2.13 a	3.24 a	34.64 c
G_{20}	1.30 b	1.70 b	3.00 b	43.59 b
G_{40}	1.68 a	1.30 c	2.98 c	56.42 a
G_{60}	1.38 b	1.64 b	3.02 b	46.35 b
$LSD_{(0.05)}$	0.1071	0.2623	0.2208	5.690
CV (%)	4.54	9.12	4.24	7.34

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: G_0 = 0 ppm NAA, G_{20} =20 ppm NAA, G_{40} = 40 ppm NAA and G_{60} = 60 ppm NAA

Table 4: Effect of row spacing on yields and harvest index of mungbean

Spacing	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
P_1	1.10 c	2.03 a	3.13 a	35.39 c
P_2	1.63 a	1.75 b	2.93 b	55.71 a
P_3	1.38 b	1.31 c	3.12 ab	44.65 b
$LSD_{(0.05)}$	0.09275	0.2272	0.1912	4.928
CV (%)	4.54	9.12	4.24	7.43

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: P_1 = 20 cm × 10 cm, P_2 = 30 cm × 10 cm and P_3 = 40 cm × 10 cm

Effect of Row Spacing: Stover yield of mungbean were significantly influenced by row spacing (Table 4). The maximum stover yield (2.03 t ha^{-1}) was obtained from the P_1 treatment whereas, the minimum (1.31 t ha^{-1}) was found in the P_3 treatment. It might be due to row spacing helps to get more stover yield [24].

Biological Yield

Effect of Plant Growth Regulator: Plant growth regulator a significant in producing biological yield (Table 3). The highest biological yield (3.24 t ha^{-1}) was obtained from G_0 treatment,while the lowest (2.98 t ha^{-1}) was found in G_{40} treatment. Kandagal *et al.* [25] also observed that NAA helps to get more yield.

Effect of Row Spacing: Row spacing differed a significantly in producing biological yield (Table 4). The maximum biological yield (3.13 t ha^{-1}) was obtained from P_1 treatment which was statistically similar (3.12 t ha^{-1}) to P_3 treatment whereas, the minimum (2.93 t ha^{-1}) was found in P_2 treatment. Khan *et al.* [26] also stated that row spacing helps to get more biological yield of mungbean.

Harvest Index

Effect of Plant Growth Regulator: A significant difference was found in harvest index due to plant growth regulator (Table 3). The maximum harvest index (56.42 %) was obtained from 40 ppm NAA (G_{40}) treatment whereas, the minimum (34.64 %) was found from 0 ppm NAA (G_0) treatment.

Effect of Row Spacing: A significant difference was found in harvest index due to row spacing (Table 4). The maximum harvest index (55.71 %) was obtained from 30 cm × 10 cm spacing (P_2) treatment whereas, the minimum (35.39 %) was found in 20 cm × 10 cm spacing (P_1) treatment. Because row spacing helps to get highest harvest index yield of mungbean [26].

CONCLUSION

The present investigation indicated that Naphthalene acetic acid (NAA) and row spacing have a positive effect on mungbean yield. The highest number of pod $plant^{-1}$ (22.08), pod length (10.18 cm), number of seeds pod^{-1} (15.47), 1000 seeds weight (44.26 g), seed yield (1.63 t ha^{-1}) and harvest index (55.71 %) were obtained from 30 cm × 10 cm spacing (P_2) treatment where the maximum stover yield (2.03 t ha^{-1}) and biological yield (3.13 t ha^{-1}) was obtained from P_1 treatment (20cm × 10cm). The highest number of pod $plant^{-1}$ (24.89), pod length (9.68 cm), number of seeds pod^{-1} (14.67), 1000 seeds weight (44.50 g), seed yield (1.68 t ha^{-1}) and harvest index (56.42 %) were obtained from the 40 ppm NAA treatment (G_2), while, stover yield (2.13 t ha^{-1}) and biological yield (3.24 t ha^{-1}) were obtained from control (G_0) treatment. Therefore, it can be concluded that the application of NAA and row spacing increased the yield of mungbean.

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