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EFFECT OF SOWING TIME AND SPACING ON GROWTH, YIELD AND YIELD CONTRIBUTING CHARACTERS OF MUNGBEAN MUTANTS IN THREE LOCATIONS OF BANGLADESH

M.S. Islam[1], M.I. Ali[1], M.M. Islam[1], M.H. Rahman[1], A. Mahmud[1] and N. Aktar[1]

Abstract

Field experiments were conducted with mungbean mutants to evaluate their yield performance as affected by time of sowing and spacing. The mutant lines were MBM-656-51-2 and MBM-427-87-3, and the check varieties were BARI Mung8 and Binamung-8. Total four experiments were conducted of which two experiments were executed at Bangladesh Institute of Nuclear Agriculture (BINA) substations, Barishal and Ishurdi during 2018 and other two experiments at BINA substations, Ishurdi and Magura during 2019. Four different sowing times were Jan. 15, Feb. 1, Feb. 15, and Mar. 1 during 2018 and Feb. 15, Feb. 28, Mar. 15 and Mar. 30 during 2019. Three levels of row spacing were 20 cm, 25 cm and 30 cm. During 2018, the interaction effect of sowing time, variety and row spacing showed that Binamung-8 produced the maximum seed yield (1157 kg ha^{-1}) at 20 cm row spacing when the sowing date was Feb 15; followed by MBM-656-51-2 with the same sowing date and spacing. The advanced mutant line MBM-656-51-2 required the least average crop duration of 72 days) and BARI Mung8 required the maximum average duration of 79 days) during 2018; which required 75 days and 78 days during 2019, respectively. During 2019, the interaction effect of sowing date, variety and row spacing showed that MBM-656-51-2 produced the maximum seed yield (843.3 kg ha^{-1}) followed by BARI Mung-8 (828.6 kg ha^{-1}) at 25 cm row spacing when the sowing time was Feb 18. Overall results suggest that to ensure satisfactory yield of mungbean, Feb. 15 to Feb. 28 sowing at 20-25 cm row spacing is needed for all the studied locations.

Key words: Mungbean, spacing, mutant, sowing time, optimum yield

Introduction

Mungbean (*Vigna radiate* L.*)* is an important grain legume in Bangladesh. Pulses are central to many culinary traditions in many countries, and they are a cornerstone of food and nutritional security. With rapid increase in global food needs on the horizon, the role of pulses will become even more significant, especially with regard to dietary protein and micronutrients. It holds the 4th in both acreage (24%) and production in Bangladesh (Alam, 2015). Mungbean play an important role in solving the protein malnutrition in Bangladesh. The country is facing an acute shortage of mungbean due to low yield per unit area and less production. Mungbean cultivated almost throughout the year in the diverse agro-climatic condition of Bangladesh. Its edible seed is characterized by higher digestibility, flavour, high protein content and absence of any flatulence effects (Ahmad *et al.*, 2008). The total

[1]Agronomy division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh-2202

production of pulses in Bangladesh is only 0.65 million tons against the requirement 2.7 million tons (MoA, 2013). This means the shortage is almost 76% of the total requirement and this is mostly due to low yield (MoA, 2013). Mungbean seed contains about 1-3% fat, 5.4% carbohydrates, 25.67% protein, 3.5-4.5% fibers and 4.5-5.5% ash while calcium and phosphorus are 132 and 367 mg per 100 grams of seed, respectively *(*Haider *et al., 2018*). Mungbean, in particular, is rich in easily digestible form of protein. It contains a high degree of proteins, minerals and vitamins. Genetic potential of legume is not obtained at farmer's field due to poor soil nutrient status, mineral deficiency etc. (Crews *et al*., 2004). Farmers cultivated mungbean by one ploughing and hardly use minimum fertilizers and irrigation. There is a huge scope to increase the mungbean yield through proper fertilizers management practices. The practical implications of packaging mutant line/varieties with optimal management practices are better understood. Climate change is an important new driver for genetic improvement that anticipates future shift of temperature and precipitation. Therefore, the present study was undertaken to find out the optimum sowing date and spacing of advanced mutant line of mungbean for better growth and yield.

Materials and methods

The experiment was carried out at the Field Laboratory of the Department of Agronomy, Bangladesh Institute of Nuclear Agriculture, BINA sub-station Ishurdi and Barishal during Rabi season of 2018 and at BINA substation, Ishurdi and Magura during 2019. The climatic parameters during the growing period of mungbean in different time and location are presented in Fig. 1. The experiment was laid out in a split-split design with three replications. The unit plot size was 3m x 4m. The treatments were two advance mutant lines MBM-656-51-2 and MBM-427-87-3, and the check varieties were BARI Mung8 and Binamung-8 randomly distributed to the plots within a block. A drain of one meter wide provided for watering around the whole experimental plot and between the blocks.

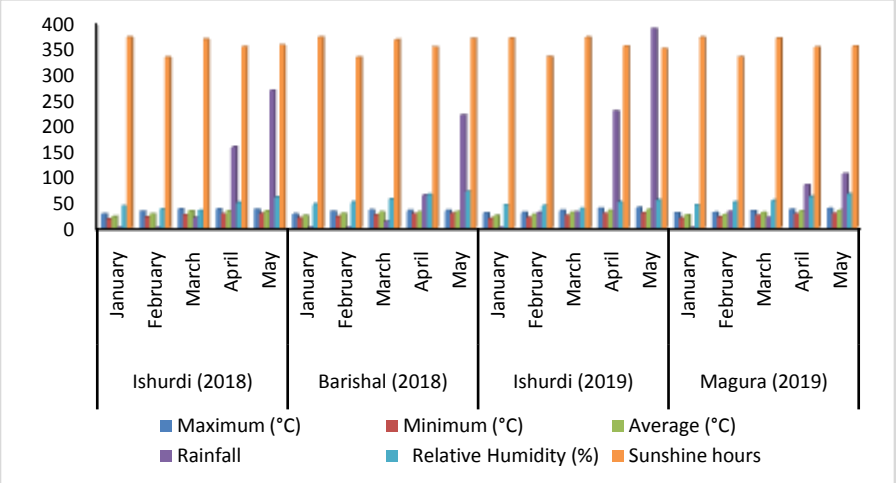

Fig. 1. The climatic parameters during the growing period of mungbean during 2018 and 2019 in different locations.

The plots of Mungbean were fertilized with N, P, K, Zn and Boron respectively according to the recommendation of BARC (2012). The whole amount at triple super phosphate, muriatic of potash, gypsum, Boron and zinc sulphate (separately) were applied to the soil at the time of final land preparation. Mungbean bio-fertilizer was used during sowing of seeds. The maturity of crops was determined when about 70% of the seeds attain their characters color. Seed yields plot were recorded after threshing and sun drying properly. Data recorded for different parameters were subjected to analysis of variance (ANOVA) using statistix-10 software and the treatment means were compared using the least significant different test.

Results and discussions

Results of 1st year (2018)

Mean effects

The results of first year (2018) showed that in case of mean effect of sowing date on seed yield (irrespective of cultivar and spacing), the highest seed yield was produced at February 15 sowing (988 kg ha^{-1}) whereas March 1 sowing produced the lowest seed yield (503 kg ha^{-1}) (Table 1). A substantial higher number of branches per plant and good number of pod per plant contributed to the highest seed yield at Feb. 15 sowing. In early sowing at Jan. 15, there was low soil temperature which caused less germination of seeds and less crop stand. In case of late sowing, due to continuous rainfall overall growth was not up to the mark and higher weed competition was occurred. The mean seed yield of 25 cm row spacing was the highest (792.6 kg ha^{-1}) whereas 30 cm row spacing produced the lowest seed yield (720 kg ha^{-1}). The results are in par with the finding of Miah *et al.,* (2009). Soomro (2003) also reported that delay in sowing caused a substantial decrease in all the growth and development parameters of mungbean.

Table 1. Mean effects of locations, sowing date, mutants/variety and spacing on yield and yield contributing characters during 2018

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed wt. (g)	Seed yield (t ha^{-1})
Location(s)								
Barishal	22.3	44.3	0.4	20.8	8.6	10.6	48.2	664.0
Ishurdi	52.9	55.9	2.6	33.5	8.0	10.1	41.1	853.3
Level of sig.	*	*	*	*	*	*	*	*
Date of Sowing								
Jan. 15 (D_1)	30.3	37.6	1.0	12.6	8.1	10.3	46.2	647.1
Feb. 01 (D_2)	35.4	44.8	0.7	14.6	8.4	10.4	45.3	896.4
Feb. 15 (D_3)	38.6	54.4	4.4	37.5	8.2	10.1	44.8	988.0
Mar. 01 (D_4)	46.0	63.6	0.1	43.8	8.5	10.4	42.4	503.3
$LSD_{0.05}$	2.4	2.0	1.1	4.7	0.2	0.2	1.1	117.1
MBM-656-51-2 (V_1)	37.4	49.9	1.7	25.9	8.8	10.3	43.1	794.0
MBM-427-87-3 (V_2)	37.4	48.0	1.3	27.8	8.5	10.3	48.2	710.9
BARI Mung8 (V_3)	37.8	51.7	1.4	26.4	8.4	10.3	43.4	752.0
Binamung-8 (V_4)	37.8	50.8	1.7	28.4	8.5	10.4	43.9	762.8
$LSD_{0.05}$	NS	1.7	NS	NS	0.2	NS	0.9	NS

Table 1. Continued

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed wt. (g)	Seed yield (t ha^{-1})
Row spacing								
20 cm (S_1)	44.3	50.2	1.5	27.9	8.3	10.3	44.8	763.1
25 cm (S_2)	37.6	50.5	1.6	26.9	8.3	10.2	44.6	792.6
30 cm (S_3)	31.0	49.6	1.6	26.7	8.3	10.4	44.5	720.4
$LSD_{0.05}$	1.8	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.3	9.3	7.6	11.3	7.0	4.2	5.6	13.4

Among the mutant lines and varieties, MBM-656-51-2 produced the highest seed yield (794 kg ha^{-1}) followed by Binamung-8 and BARI Mung8 (Table 1). The canopy coverage, growth and development of mutant line MBM-656-51-2 were good at 25 cm row spacing. These findings closely resembles to those obtained by BINA (2007), BINA (2006), Siddique *et al.*, (2006), Mondal (2004) and Patil *et al.*, (2003).

Interaction effects (2 factors)

In case of sowing date × mutants/variety, the mutant MBM-656-51-2 produced the maximum seed yield (1002 kg ha^{-1}) followed by BARI Mung8 (953 kg ha^{-1}) at same sowing date of Feb. 15 (Table 2). For sowing date × row spacing, sowing at Feb. 15 with 20 cm row spacing produced the maximum seed yield (1066 kg ha^{-1}) followed by sowing at Feb. 15 with 20 cm row spacing (993 kg ha^{-1}). For variety × row spacing, Binamung-8 produced maximum seed yield at 25 cm row spacing (850 kg ha^{-1}) followed by BARI Mung8 at 20cm row spacing (850 kg ha^{-1}) (Table 2). In case of early sowing, less germination and less crop establishment were resulted and ultimately less seed yield was found. Tomar *et al*., (1994) and Miah *et al*., (2009) also reported the similar findings. They found that the interactions of Binamung-5 × 2 March sowing, Binamung-6 × 20 February sowing, Binamung-6 × 2 March sowing and Binamung-7 × 22 March sowing produced similar and the second highest seed yield.

Table 2. Interaction effects of two factors on yield and yield contributing characters during 2018

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
Date of Sowing × Mutant/variety								
D_1V_1	29.7	36.1	1.0	12.6	7.8	10.2	46.3	518.9
D_1V_2	29.7	36.4	1.0	10.7	7.9	10.2	47.5	585.5
D_1V_3	31.6	37.7	1.1	13.7	8.4	10.4	44.5	678.9
D_1V_4	30.2	40.3	1.0	13.3	8.5	10.6	46.5	805.2
D_2V_1	35.9	44.6	0.6	14.2	7.9	10.3	43.9	966.2
D_2V_2	34.6	44.0	0.7	14.5	8.6	10.6	46.6	870.5
D_2V_3	35.6	45.8	0.6	14.7	8.6	10.4	45.0	889.9
D_2V_4	35.7	45.0	0.8	15.1	8.5	10.5	45.5	859.0
D_3V_1	39.2	52.9	5.0	38.0	7.4	10.2	42.1	1002.1
D_3V_2	37.7	52.0	4.3	37.4	8.7	10.1	50.1	909.3
D_3V_3	38.2	57.9	4.7	36.3	8.4	10.4	43.6	953.5

Table 2. Continued

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
D_3V_4	39.4	54.7	3.4	38.5	8.4	9.9	43.2	947.0
D_4V_1	44.7	66.1	0.3	38.8	8.1	10.3	40.0	509.0
D_4V_2	47.6	59.6	0.9	48.7	8.8	10.4	48.7	478.5
D_4V_3	45.9	65.4	0.7	41.0	8.4	10.1	40.5	515.8
D_4V_4	45.9	63.3	1.7	46.8	8.6	10.5	40.2	509.9
$LSD_{0.05}$	5.4	4.3	2.4	10.4	0.5	0.4	2.3	256.6
Date of Sowing × Row spacing								
D_1S_1	34.8	37.7	0.9	11.5	8.1	10.3	46.0	560.2
D_1S_2	30.5	38.2	1.0	12.6	8.1	10.4	46.6	698.8
D_1S_3	25.5	37.0	1.1	13.6	8.2	10.3	45.9	682.3
D_2S_1	41.4	43.8	0.6	13.2	8.4	10.4	45.6	921.3
D_2S_2	35.0	45.0	0.7	15.5	8.4	10.4	44.7	906.8
D_2S_3	30.0	45.7	0.7	15.2	8.3	10.5	45.6	861.0
D_3S_1	44.8	54.7	4.9	40.2	8.3	10.1	45.0	1066.9
D_3S_2	38.9	53.3	3.9	35.2	8.1	9.9	44.9	993.4
D_3S_3	32.2	55.1	4.2	37.3	8.3	10.4	44.3	903.6
D_4S_1	56.0	64.6	-0.6	46.5	8.3	10.3	42.7	503.9
D_4S_2	45.8	65.7	0.7	44.3	8.7	10.2	41.9	571.1
D_4S_3	36.3	60.6	0.3	40.8	8.4	10.6	42.5	434.8
$LSD_{0.05}$	4.6	3.8	2.1	9.0	0.5	0.3	2.0	222.2
Mutant/variety × Row spacing								
V_1S_1	42.9	48.8	1.4	24.7	7.7	10.4	42.6	771.4
V_1S_2	37.9	50.9	1.5	25.7	7.8	10.1	43.1	777.8
V_1S_3	31.2	50.0	2.3	27.3	7.9	10.3	43.6	697.9
V_2S_1	43.3	50.2	1.3	32.2	8.5	10.2	49.0	700.1
V_2S_2	37.3	47.7	1.1	24.7	8.5	10.3	47.5	778.1
V_2S_3	31.6	46.0	1.4	26.6	8.5	10.4	48.2	654.6
V_3S_1	44.7	50.2	1.2	24.6	8.5	10.3	43.7	806.8
V_3S_2	37.8	53.9	1.4	28.3	8.5	10.2	43.7	763.6
V_3S_3	30.9	50.9	1.7	26.4	8.4	10.5	42.8	775.7
V_4S_1	46.1	51.4	1.9	29.9	8.5	10.3	43.9	774.0
V_4S_2	37.1	49.6	2.3	28.8	8.6	10.3	43.9	850.8
V_4S_3	30.2	51.4	0.9	26.6	8.4	10.5	43.8	753.5
$LSD_{0.05}$	3.7	3.0	NS	7.1	0.4	0.3	1.5	175.7
CV (%)	12.3	9.3	7.6	11.3	7.0	4.2	5.6	13.4

Interaction effects (3 factors)

From the interaction effect of sowing date, cultivar and row spacing (Table 3), the highest seed yield was recorded for Binamung 8 with 20 cm row spacing sown in Feb.15 followed by MBM 656-51-2 with same spacing and sowing date. The result complies with the findings of Ahmad *et al.,* (2021). The seed yield is the interplay of yield components. The maximum seed yield in the early sown at the end of January crop can be due to maximum emergence count, longer pods with more seeds and seed weight as compared to the other SD (Khattak *et al.,* 2006; Ahmad *et al.,* 2008).

Table 3. Interaction effect of three factors on yield and yield contributing characters of mungbean during 2018

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $Plant^{-1}$ (no)	Pods $Plant^{-1}$ (no)	Pod Length (cm)	Seeds Pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
Sowing date × Mutant/variety × Row spacing								
$D_1V_1S_1$	34.2	35.0	0.8	11.2	7.3	10.3	45.1	423.6
$D_1V_1S_2$	29.3	37.8	1.0	12.1	8.0	10.1	47.6	536.8
$D_1V_1S_3$	25.5	35.6	1.2	14.5	8.2	10.2	46.2	596.2
$D_1V_2S_1$	34.5	37.5	1.0	10.9	8.3	10.2	47.3	508.3
$D_1V_2S_2$	28.8	37.1	0.9	10.4	7.5	10.4	46.6	635.0
$D_1V_2S_3$	25.7	34.5	1.0	10.8	7.9	9.8	48.5	613.1
$D_1V_3S_1$	35.8	36.4	0.9	11.7	8.1	10.2	45.2	600.8
$D_1V_3S_2$	33.2	37.9	1.1	14.4	8.4	10.6	44.8	693.7
$D_1V_3S_3$	25.7	38.7	1.2	15.0	8.5	10.4	43.5	742.1
$D_1V_4S_1$	34.8	41.7	1.0	12.4	8.6	10.6	46.4	708.2
$D_1V_4S_2$	30.8	39.9	1.1	13.6	8.6	10.7	47.5	929.9
$D_1V_4S_3$	25.0	39.2	1.1	14.0	8.2	10.6	45.5	777.5
$D_2V_1S_1$	41.5	44.3	0.5	12.8	7.8	10.2	43.6	1023.3
$D_2V_1S_2$	37.0	43.4	0.6	15.4	7.8	10.5	43.1	966.9
$D_2V_1S_3$	29.2	46.1	0.6	14.4	8.1	10.3	45.0	908.2
$D_2V_2S_1$	40.8	43.1	0.6	13.1	8.6	10.5	46.6	921.3
$D_2V_2S_2$	34.8	45.1	0.6	15.5	8.7	10.5	46.1	904.0
$D_2V_2S_3$	28.2	43.7	0.8	15.0	8.5	10.7	47.2	786.1
$D_2V_3S_1$	40.3	45.0	0.6	13.0	8.6	10.4	45.9	839.1
$D_2V_3S_2$	34.2	45.9	0.7	15.8	8.8	10.4	44.4	932.9
$D_2V_3S_3$	32.3	46.4	0.7	15.3	8.2	10.4	44.8	897.8
$D_2V_4S_1$	42.8	42.8	0.7	14.1	8.5	10.4	46.1	901.4
$D_2V_4S_2$	33.8	45.6	1.0	15.2	8.3	10.4	45.1	823.6
$D_2V_4S_3$	30.3	46.6	0.7	16.1	8.6	10.6	45.3	852.1
$D_3V_1S_1$	43.7	54.0	4.9	39.9	7.6	10.1	42.0	1055.5
$D_3V_1S_2$	40.0	52.3	4.5	35.7	7.3	10.0	42.2	1010.4
$D_3V_1S_3$	33.8	52.2	5.6	38.5	7.4	10.5	42.1	940.2
$D_3V_2S_1$	41.3	53.0	4.5	43.0	8.7	9.8	51.8	940.6
$D_3V_2S_2$	39.3	48.7	3.4	34.1	8.7	10.2	50.0	956.9
$D_3V_2S_3$	32.3	54.4	4.9	35.2	8.7	10.4	48.5	830.5
$D_3V_3S_1$	45.0	58.4	4.7	34.3	8.4	10.6	43.6	1157.1
$D_3V_3S_2$	39.0	58.0	4.8	35.5	8.3	10.2	44.4	953.4
$D_3V_3S_3$	30.7	57.4	4.7	39.1	8.5	10.3	42.8	920.1
$D_3V_4S_1$	49.2	53.3	5.5	43.7	8.5	9.9	42.6	1014.6
$D_3V_4S_2$	37.3	54.3	2.9	35.5	8.3	9.4	43.1	1052.7
$D_3V_4S_3$	31.8	56.4	1.7	36.3	8.5	10.3	44.0	923.6
$D_4V_1S_1$	52.4	62.0	0.8	35.0	8.0	10.8	39.8	583.1
$D_4V_1S_2$	45.4	70.2	0.1	39.6	8.3	10.0	39.3	596.9
$D_4V_1S_3$	36.4	66.2	1.9	42.0	8.0	10.2	41.0	346.9
$D_4V_2S_1$	56.4	67.4	1.1	62.0	8.3	10.2	50.4	430.3
$D_4V_2S_2$	46.4	60.0	0.4	39.0	9.1	10.2	47.2	616.4
$D_4V_2S_3$	40.0	51.5	1.1	45.3	9.0	10.9	48.5	388.6
$D_4V_3S_1$	57.7	61.2	1.1	39.3	8.6	10.0	40.2	530.3
$D_4V_3S_2$	45.0	73.8	1.1	47.6	8.3	9.7	41.4	474.2
$D_4V_3S_3$	35.0	61.2	0.2	36.0	8.3	10.7	40.0	542.8
$D_4V_4S_1$	57.7	67.8	0.6	49.6	8.3	10.2	40.4	472.0
$D_4V_4S_2$	46.4	58.8	4.2	51.0	9.1	10.8	39.7	596.9
$D_4V_4S_3$	33.7	63.4	0.2	40.0	8.3	10.5	40.5	460.8
$LSD_{0.05}$	9.2	7.5	4.2	18.0	0.9	0.7	4.0	444.4
CV (%)	12.3	9.3	7.6	11.3	7.0	4.2	5.6	13.4

Interaction effects (4 factors)

From the interaction effect of location, date of sowing, mutant/variety, and row spacing (Table 4), the highest seed yield (1198.6 kg ha^{-1}) was found in Barishal at Feb. 15 sowing for the variety BARI Mung8 with 20 cm spacing; which is followed by the mutant line MBM-656-51-2 (1173.6 kg ha^{-1}) at same sowing date and spacing in Ishurdi.

Table 4. Interaction effects of locations, sowing dates, cultivars and spacing on yield and yield contributing characters of mungbean during 2018

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $plant^{-1}$ (no)	Pods $plant^{-1}$ (no)	Pod length (cm)	Seeds pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
Location × Sowing time × Mutant/variety × Row spacing								
$L_1D_1V_1S_1$	9.7	25.0	1.2	11.2	7.3	10.4	46.9	202.8
$L_1D_1V_1S_2$	9.7	27.8	1.3	12.9	8.2	10.4	49.6	257.5
$L_1D_1V_1S_3$	8.7	27.5	1.6	16.4	8.0	10.3	47.4	243.9
$L_1D_1V_2S_1$	8.7	30.3	1.4	10.9	8.5	10.5	48.3	245.8
$L_1D_1V_2S_2$	7.7	29.6	1.3	8.8	7.9	10.4	47.2	236.7
$L_1D_1V_2S_3$	10.0	25.5	1.2	9.0	8.4	10.4	49.9	161.1
$L_1D_1V_3S_1$	11.3	29.4	1.1	11.2	8.6	10.8	49.2	323.6
$L_1D_1V_3S_2$	13.7	29.6	1.5	15.7	8.4	10.6	48.6	314.4
$L_1D_1V_3S_3$	10.7	32.2	1.5	16.3	9.1	10.6	47.8	403.7
$L_1D_1V_4S_1$	14.0	32.3	1.5	13.4	8.8	10.8	49.9	534.6
$L_1D_1V_4S_2$	15.3	30.1	1.3	15.0	8.9	10.8	50.0	661.2
$L_1D_1V_4S_3$	12.3	30.2	1.4	15.4	8.8	10.6	49.1	637.1
$L_1D_2V_1S_1$	24.7	38.0	0.7	13.0	7.9	10.5	46.9	988.9
$L_1D_2V_1S_2$	23.3	36.3	0.6	16.8	8.3	10.5	47.4	864.4
$L_1D_2V_1S_3$	18.7	39.9	0.8	14.9	8.5	10.5	50.8	761.1
$L_1D_2V_2S_1$	22.7	37.6	0.5	13.4	8.8	10.5	50.2	787.3
$L_1D_2V_2S_2$	18.3	39.4	0.7	15.7	8.7	10.8	51.1	697.2
$L_1D_2V_2S_3$	17.7	35.8	0.8	14.9	8.6	10.7	52.9	641.6
$L_1D_2V_3S_1$	24.0	37.7	0.7	13.3	9.1	10.5	48.6	618.5
$L_1D_2V_3S_2$	18.3	39.7	0.8	18.9	9.0	10.7	45.0	671.3
$L_1D_2V_3S_3$	21.7	39.3	0.8	16.2	8.6	10.5	47.1	587.5
$L_1D_2V_4S_1$	25.7	37.9	0.8	15.4	8.7	10.4	49.8	913.9
$L_1D_2V_4S_2$	17.0	41.0	1.1	17.3	8.7	10.4	48.1	787.5
$L_1D_2V_4S_3$	21.3	41.0	0.8	18.5	8.8	10.6	48.3	787.5
$L_1D_3V_1S_1$	29.7	51.1	0.5	15.1	8.6	10.7	48.9	1152.7
$L_1D_3V_1S_2$	26.7	45.7	0.7	16.7	8.0	10.7	49.3	1173.6
$L_1D_3V_1S_3$	24.0	49.2	0.8	16.3	7.6	10.5	49.2	930.5
$L_1D_3V_2S_1$	23.0	49.7	0.7	17.6	9.3	10.5	54.9	1047.2
$L_1D_3V_2S_2$	27.7	47.3	0.7	17.1	9.2	10.5	52.5	1191.6
$L_1D_3V_2S_3$	23.7	48.9	0.5	16.8	8.8	10.4	51.6	1036.1
$L_1D_3V_3S_1$	28.3	54.7	0.7	14.5	8.6	10.4	46.4	1115.3
$L_1D_3V_3S_2$	27.0	57.7	0.7	17.0	8.6	10.6	47.5	1073.6
$L_1D_3V_3S_3$	21.7	53.7	0.8	17.2	8.9	10.6	45.8	1076.4
$L_1D_3V_4S_1$	35.0	50.8	0.4	17.7	8.7	10.5	48.4	1126.4
$L_1D_3V_4S_2$	26.3	53.4	0.5	19.0	8.6	10.7	49.0	1118.1
$L_1D_3V_4S_3$	23.3	54.9	0.8	18.6	8.6	10.6	50.0	1013.8
$L_1D_4V_1S_1$	67.7	67.8	0.3	41.3	7.7	10.6	36.2	677.7
$L_1D_4V_1S_2$	60.7	76.0	1.0	46.0	8.0	10.0	35.7	691.6
$L_1D_4V_1S_3$	51.7	72.0	3.0	48.3	7.7	9.7	37.4	441.6
$L_1D_4V_2S_1$	71.7	73.2	0.0	68.3	8.0	10.6	46.8	525.0
$L_1D_4V_2S_2$	61.7	65.8	0.7	45.3	8.8	10.0	43.6	711.1
$L_1D_4V_2S_3$	55.3	57.3	0.0	51.7	8.7	9.9	44.9	483.3
$L_1D_4V_3S_1$	73.0	67.0	0.0	45.7	8.3	10.5	36.6	625.0
$L_1D_4V_3S_2$	60.3	79.6	0.0	54.0	8.0	9.8	37.8	568.9

Table 4. Continued

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $plant^{-1}$ (no)	Pods $plant^{-1}$ (no)	Pod length (cm)	Seeds pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
$L_1D_4V_3\ S_3$	50.3	67.0	1.3	42.3	8.0	9.5	36.4	637.5
$L_1D_4V_4\ S_1$	73.0	73.6	1.7	56.0	8.0	10.5	36.9	566.6
$L_1D_4V_4\ S_2$	61.7	64.6	5.3	57.3	8.8	10.3	36.1	691.6
$L_1D_4V_4\ S_3$	49.0	69.2	1.3	46.3	8.0	9.9	36.9	555.5
$L_2D_1V_1S_1$	58.7	45.0	0.5	11.3	7.3	10.2	43.2	644.4
$L_2D_1V_1\ S_2$	49.0	47.8	0.7	11.3	7.7	10.2	45.6	816.1
$L_2D_1V_1\ S_3$	42.3	43.5	0.8	12.6	8.3	9.8	44.9	948.6
$L_2D_1V_2\ S_1$	60.3	45.4	0.6	10.9	8.0	9.9	46.3	770.8
$L_2D_1V_2\ S_2$	50.0	43.7	0.6	12.0	7.0	9.3	45.9	1033.3
$L_2D_1V_2\ S_3$	41.3	43.5	0.8	12.6	7.3	10.4	47.2	1065.2
$L_2D_1V_3\ S_1$	60.3	43.4	0.6	12.1	7.7	10.0	41.2	878.0
$L_2D_1V_3\ S_2$	52.7	46.1	0.7	13.1	8.3	9.8	41.0	1073.0
$L_2D_1V_3\ S_3$	40.7	45.2	0.9	13.8	8.0	10.5	39.2	1080.5
$L_2D_1V_4\ S_1$	55.7	51.0	0.5	11.3	8.3	10.6	45.1	881.9
$L_2\ D_1V_4\ S_2$	46.3	49.7	0.8	12.1	8.3	10.6	43.0	1198.6
$L_2D_1V_4\ S_3$	37.7	48.0	0.7	12.7	7.7	10.3	41.8	918.0
$L_2D_2V_1S_1$	58.3	50.5	0.4	12.6	7.7	10.0	40.2	1057.7
$L_2D_2V_1\ S_2$	50.7	50.4	0.5	14.0	7.3	9.8	38.8	1069.4
$L_2D_2V_1\ S_3$	39.7	52.3	0.5	14.0	7.7	10.5	39.3	1055.4
$L_2D_2V_2\ S_1$	59.0	48.5	0.7	12.7	8.3	10.6	43.0	1055.3
$L_2D_2V_2\ S_2$	51.3	50.8	0.6	15.3	8.7	10.5	41.0	1110.9
$L_2D_2V_2\ S_3$	38.7	51.6	0.8	15.1	8.5	10.3	41.4	930.5
$L_2D_2V_3\ S_1$	56.7	52.2	0.4	12.7	8.2	10.2	43.3	1059.7
$L_2D_2V_3\ S_2$	50.0	52.0	0.6	12.7	8.7	10.2	43.8	1194.4
$L_2D_2V_3\ S_3$	43.0	53.5	0.6	14.5	7.8	10.1	42.6	1108.1
$L_2D_2V_4\ S_1$	60.0	47.6	0.7	12.8	8.3	10.7	42.4	888.8
$L_2D_2V_4\ S_2$	50.7	50.1	0.8	13.1	7.8	10.4	42.1	859.7
$L_2D_2V_4\ S_3$	39.3	52.3	0.6	13.8	8.3	10.4	42.3	916.6
$L_2D_3V_1S_1$	57.7	56.8	9.3	64.7	6.7	9.5	35.1	958.3
$L_2D_3V_1\ S_2$	53.3	58.8	8.3	54.7	6.6	9.4	35.2	847.2
$L_2D_3V_1\ S_3$	43.7	55.2	10.3	60.7	7.2	10.4	34.9	950.0
$L_2D_3V_2\ S_1$	59.7	56.2	8.3	68.3	8.2	10.3	48.6	834.0
$L_2D_3V_2\ S_2$	51.0	50.1	6.0	51.0	8.2	9.9	47.5	722.2
$L_2D_3V_2\ S_3$	41.0	59.8	9.3	53.7	8.6	9.0	45.5	625.0
$L_2D_3V_3\ S_1$	61.7	62.0	8.7	54.0	8.2	10.6	40.8	998.9
$L_2D_3V_3\ S_2$	51.0	58.2	9.0	54.0	8.0	10.1	41.3	833.3
$L_2D_3V_3\ S_3$	39.7	61.0	8.7	61.0	8.0	9.9	39.8	763.8
$L_2D_3V_4\ S_1$	63.3	55.8	10.7	69.7	8.3	9.9	36.9	902.8
$L_2D_3V_4\ S_2$	48.3	55.0	5.3	52.0	8.0	9.3	37.2	801.3
$L_2D_3V_4\ S_3$	40.3	57.9	2.7	54.0	8.3	8.3	37.9	833.3
$L_2D_4V_1S_1$	67.7	67.8	0.3	41.3	7.7	10.6	36.2	677.7
$L_2D_4V_1\ S_2$	60.7	76.0	1.0	46.0	8.0	10.0	35.7	691.6
$L_2D_4V_1\ S_3$	51.7	72.0	3.0	48.3	7.7	9.7	37.4	441.6
$L_2D_4V_2\ S_1$	71.7	73.2	0.0	68.3	8.0	10.6	46.8	525.0
$L_2D_4V_2\ S_2$	61.7	65.8	0.7	45.3	8.8	10.0	43.6	711.1
$L_2D_4V_2\ S_3$	55.3	57.3	0.0	51.7	8.7	9.9	44.9	483.3
$L_2D_4V_3\ S_1$	73.0	67.0	0.0	45.7	8.3	9.8	36.6	625.0
$L_2D_4V_3\ S_2$	60.3	79.6	0.0	54.0	8.0	9.5	37.8	568.9
$L_2D_4V_3\ S_3$	50.3	67.0	1.3	42.3	8.0	10.5	36.4	637.5
$L_2D_4V_4\ S_1$	73.0	73.6	1.7	56.0	8.0	10.5	36.9	566.6
$L_2D_4V_4\ S_2$	61.7	64.6	5.3	57.3	8.8	10.3	36.1	691.6
$L_2D_4V_4\ S_3$	49.0	69.2	1.3	46.3	8.0	9.9	36.9	555.5
$LSD_{0.05}$	9.9	11.2	0.5	5.8	2.78	1.5	5.5	111.7
CV (%)	12.3	9.3	7.6	11.3	7.0	4.2	5.6	13.4

Results of 2nd year (2019)

Mean effects

The mean effect of sowing date on seed yield showed that the highest seed yield (752.8 kg ha^{-1}) was produced at Feb. 28 sowing while March 30 sowing produced the lowest (658.3 kg ha^{-1}) (Table 5). The seed yield of 25 cm row spacing was the highest (764.7 kg ha^{-1}) whereas 30 cm row spacing produced the lowest (705 kg ha^{-1}). Singh *et al.,* (2010) and Singh *et al.,* (2013) also reported similar results.

Among the mutant lines/varieties, MBM-656-51-2 produced the highest seed yield (794.5 kg ha^{-1}) followed by MBM-427-87-3 and BARI Mung8. The potential yield was not found due to the reason that second picking could not be done for early rainfall which caused germination of seed in pod and rotten thereafter. So, lower yield was found in second year compared to first year experiments. These results are in line with those of Sarkar *et al.,* (2004) and Khan and Malik (2001).

Table 5. Mean effects of location, dates of sowing, cultivars and spacing on yield and yield contributing characters of mungbean during 2019

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed yield (t ha^{-1})
Location(s)								
Ishurdi (L_1)	39.6	44.3	0.8	10.8	7.4	10.2	47.1	740.2
Magura (L_2)	40.6	51.4	0.8	10.5	7.4	10.3	41.4	739.7
T value	NS	*	NS	NS	NS	NS	*	NS
Sowing date								
Feb. 15 (D_1)	38.9	26.8	0.8	8.6	7.4	9.7	45.1	679.6
Feb. 28 (D_2)	40.1	40.6	0.5	12.0	8.1	10.1	44.2	752.8
Mar. 15 (D_3)	41.7	54.3	1.1	9.7	7.0	10.2	43.7	709.2
Mar. 30 (D_4)	39.7	69.6	0.7	12.2	7.3	10.9	42.4	658.3
$LSD_{0.05}$	NS	21.9	NS	NS	NS	NS	1.3	42.5
Mutant/varieties								
MBM-656-51-2 (V_1)	39.5	46.1	0.7	10.2	7.4	10.3	43.2	794.5
MBM-427-87-3 (V_2)	40.7	48.6	0.8	10.7	7.3	10.3	48.1	763.8
BARI Mung-8 (V_3)	40.5	48.4	0.8	11.0	7.4	10.2	43.2	705.6
Binamung-8 (V_4)	39.6	48.3	0.8	10.6	7.5	10.3	43.6	696.0
$LSD_{0.05}$	NS	3.1	NS	NS	NS	NS	0.6	20.6
Row spacing								
20 cm (S_1)	41.1	47.4	0.7	10.0	7.4	10.2	43.7	729.3
25 cm (S_2)	40.0	49.1	0.8	10.7	7.4	10.3	44.2	764.7
30 cm (S_3)	39.2	47.0	0.8	11.1	7.5	10.2	43.4	705.8
$LSD_{0.05}$	1.1	1.7	NS	0.9	NS	NS	NS	15.6
CV (%)	10.1	12.3	17.4	10.0	14.4	11.2	8.1	7.2

Interaction effect (2 factors)

The interaction effect of sowing date and mutants/variety showed that MBM-656-51-2 produced the maximum seed yield (817.8 kg ha^{-1}) followed by BARI Mung8 (799.3 kg ha^{-1}) at same sowing date of Feb 28 (Table 6). The sowing date × row spacing showed maximum seed yield (783.9 kg ha^{-1}) at Feb. 28 sowing with 25 cm row spacing followed by Feb 15 sowing with 25 cm row spacing (756.7 kg ha^{-1}). The cultivar × row spacing showed that Binamung-8 produced maximum seed yield (809 kg ha^{-1}) at 25 cm row spacing followed by BARI Mung-8 (791.8 kg ha^{-1}) at 25cm row spacing. Sadeghipour, (2008) also found similar results.

Table 6. Mean effects of two factors on yield and yield contributing characters of mungbean during 2019

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed yield (t ha^{-1})
Sowing date × Mutant/varieties								
D_1V_1	39.2	26.3	0.7	8.3	7.2	9.5	46.4	784.4
D_1V_2	39.9	25.6	0.8	8.5	7.3	9.9	47.5	755.0
D_1V_3	38.1	26.5	0.8	9.4	7.5	9.6	44.3	711.1
D_1V_4	38.3	28.9	0.9	8.4	7.7	10.0	46.5	700.0
D_2V_1	37.8	37.4	0.4	12.1	8.3	10.0	43.4	817.8
D_2V_2	40.7	41.5	0.4	11.3	8.1	10.2	46.1	763.0
D_2V_3	41.5	41.8	0.6	11.8	7.9	10.2	45.3	799.7
D_2V_4	40.4	41.9	0.6	12.8	8.0	10.1	45.5	699.4
D_3V_1	40.1	50.4	0.9	8.7	6.9	10.6	42.1	764.1
D_3V_2	42.6	56.7	1.2	10.7	6.9	10.2	50.1	775.6
D_3V_3	42.6	55.7	1.2	9.5	6.9	9.9	43.4	708.9
D_3V_4	41.6	54.5	1.0	9.8	7.2	10.0	43.2	694.4
D_4V_1	40.9	70.4	0.7	11.6	7.3	11.0	40.2	776.1
D_4V_2	39.8	70.5	0.6	12.2	7.1	10.7	48.7	761.7
D_4V_3	40.0	69.5	0.6	13.4	7.4	11.0	40.1	693.3
D_4V_4	38.2	67.9	0.8	11.5	7.3	11.0	40.1	690.0
$LSD_{0.05}$	3.5	2.8	0.3	1.9	NS	NS	2.1	41.2
Sowing date × Row spacing								
D_1S_1	39.5	25.6	0.8	8.4	7.0	9.9	46.3	750.4
D_1S_2	38.1	29.0	0.9	8.3	7.7	10.0	46.1	756.7
D_1S_3	38.9	25.9	0.8	9.3	7.6	9.3	45.9	705.8
D_2S_1	41.5	41.7	0.5	11.1	8.6	10.0	45.2	753.1
D_2S_2	40.5	40.6	0.5	12.7	7.7	10.2	44.7	783.9
D_2S_3	38.4	39.6	0.5	12.2	7.9	10.2	45.5	711.3
D_3S_1	43.0	53.1	1.0	9.4	7.0	10.0	45.5	755.8
D_3S_2	41.6	56.9	1.0	9.3	6.8	10.2	44.4	742.5
D_3S_3	40.6	53.1	1.2	10.2	7.1	10.4	44.3	719.2
D_4S_1	40.4	69.3	0.7	11.2	7.2	11.0	42.5	739.6
D_4S_2	39.9	70.1	0.6	12.6	7.3	10.9	41.4	734.2
D_4S_3	38.8	69.3	0.7	12.7	7.2	10.9	42.1	687.1
$LSD_{0.05}$	2.3	1.7	NS	NS	0.6	0.5	1.6	31.3

Table 6. Continued

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed wt. (g)	Seed yield (t ha^{-1})
Mutant/variety × Row spacing								
V_1S_1	39.8	46.6	0.7	9.9	7.5	10.2	42.7	775.7
V_1S_2	39.2	46.4	0.6	10.0	7.2	10.3	43.2	809.4
V_1S_3	39.6	45.5	0.7	10.6	7.6	10.3	43.5	760.8
V_2S_1	42.0	47.8	0.8	10.4	7.2	10.3	49.1	770.8
V_2S_2	40.8	49.0	0.8	10.3	7.4	10.3	47.5	777.7
V_2S_3	39.5	49.0	0.7	11.3	7.4	10.2	48.2	712.9
V_3S_1	42.0	48.7	0.8	10.4	7.5	10.2	43.4	735.8
V_3S_2	40.4	49.1	0.8	11.3	7.5	10.5	43.7	791.8
V_3S_3	39.2	47.3	0.8	11.3	7.2	9.8	42.9	660.0
V_4S_1	40.7	46.7	0.7	9.4	7.5	10.3	43.9	719.6
V_4S_2	39.7	52.1	0.8	11.3	7.5	10.1	43.7	703.8
V_4S_3	38.5	46.1	0.9	11.2	7.6	10.5	43.2	664.6
$LSD_{0.05}$	2.3	3.4	NS	1.8	0.6	0.5	1.3	31.3
CV (%)	10.1	12.3	17.4	10.0	14.4	11.2	8.1	7.2

Interaction effects (3 factors)

The interaction effect of date of sowing, mutant/variety and row spacing showed that the highest seed yield (843.3 kg ha^{-1}) was found for the mutant line MBM-656-51-2 sowing at Feb. 28 with 25 cm row spacing; which is followed by the BARI Mung-8 (828 kg ha^{-1}) at same sowing date and spacing (Table 7). This result agrees with the findings of Yoldas and Esiyok (2007) and Corokalo *et al.*, (1992).

Table 7. Mean effects of different dates of sowing and spacing on yield and yield contributing characters of mungbean mutants/variety during 2019

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed weight (g)	Seed yield (t ha^{-1})
Sowing date× Mutant/variety × Row spacing								
$D_1V_1S_1$	38.7	25.8	0.7	7.8	6.3	9.7	45.1	776.7
$D_1V_1S_2$	36.7	25.9	0.7	8.2	7.5	9.8	47.6	783.3
$D_1V_1S_3$	42.1	27.2	0.8	9.0	7.7	9.1	46.2	773.3
$D_1V_2S_1$	41.4	25.9	0.9	9.3	6.6	10.1	47.3	781.7
$D_1V_2S_2$	39.3	26.5	0.9	8.5	7.8	10.0	46.6	773.3
$D_1V_2S_3$	38.9	24.5	0.6	7.7	7.5	9.5	48.5	710.0
$D_1V_3S_1$	38.8	26.1	0.7	9.0	7.7	10.0	45.2	726.7
$D_1V_3S_2$	38.5	25.6	0.8	7.8	7.7	9.8	44.8	730.0
$D_1V_3S_3$	36.9	27.8	0.9	11.4	7.2	8.9	43.3	676.7
$D_1V_4S_1$	39.2	24.6	0.9	7.6	7.3	9.9	46.4	716.7
$D_1V_4S_2$	38.0	37.8	1.0	8.6	7.8	10.5	47.5	720.0
$D_1V_4S_3$	37.8	24.3	0.8	9.0	7.8	9.7	45.2	663.3
$D_2V_1S_1$	38.9	38.1	0.3	11.1	9.6	9.7	43.6	805.8

Table 7. Continued

Treatment	Populations m^{-2} (no.)	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seed weight (g)	Seed yield (t ha^{-1})
$D_2V_1S_2$	39.7	36.3	0.4	12.6	7.5	10.1	43.1	843.3
$D_2V_1S_3$	34.9	37.7	0.6	12.4	7.8	10.2	45.3	790.0
$D_2V_2S_1$	41.5	43.4	0.6	11.0	8.1	10.4	46.6	783.3
$D_2V_2S_2$	42.0	40.8	0.5	11.7	8.0	10.2	46.1	790.7
$D_2V_2S_3$	38.7	40.4	0.2	11.2	8.2	10.0	47.1	715.0
$D_2V_3S_1$	43.2	43.1	0.5	11.1	8.3	10.0	45.9	726.7
$D_2V_3S_2$	40.4	40.8	0.6	12.2	7.8	10.7	44.3	828.6
$D_2V_3S_3$	41.0	41.3	0.6	12.3	7.7	10.0	44.8	660.0
$D_2V_4S_1$	42.3	42.2	0.4	11.2	8.4	10.1	46.1	696.7
$D_2V_4S_2$	40.0	44.4	0.6	14.3	7.7	9.7	45.1	721.7
$D_2V_4S_3$	39.0	38.9	0.6	13.0	8.0	10.6	45.3	680.0
$D_3V_1S_1$	41.0	52.4	0.8	9.2	6.9	10.2	42.2	806.7
$D_3V_1S_2$	40.0	54.0	0.7	7.9	6.6	10.7	42.2	821.3
$D_3V_1S_3$	39.4	44.9	1.0	9.0	7.3	11.0	42.1	817.3
$D_3V_2S_1$	42.3	54.9	1.0	9.6	6.9	10.0	51.8	803.3
$D_3V_2S_2$	43.2	58.4	1.3	9.3	6.5	10.1	50.0	773.3
$D_3V_2S_3$	42.4	56.8	1.4	13.1	7.2	10.6	48.5	730.0
$D_3V_3S_1$	44.8	53.0	1.3	9.6	6.8	9.6	43.6	760.0
$D_3V_3S_2$	42.2	59.2	1.3	10.2	7.1	10.3	44.4	706.7
$D_3V_3S_3$	40.8	54.9	1.2	8.8	6.7	9.7	42.8	660.0
$D_3V_4S_1$	44.0	52.0	1.0	9.3	7.3	10.2	42.6	733.3
$D_3V_4S_2$	41.0	55.9	0.8	10.0	7.0	9.6	43.1	686.7
$D_3V_4S_3$	39.7	55.7	1.2	10.0	7.3	10.2	44.0	663.3
$D_4V_1S_1$	40.4	69.8	0.9	11.3	7.1	11.1	39.8	801.7
$D_4V_1S_2$	40.5	69.2	0.6	11.5	7.2	10.7	39.3	770.0
$D_4V_1S_3$	41.8	72.2	0.5	12.0	7.4	11.2	41.3	756.7
$D_4V_2S_1$	42.6	66.9	0.6	11.7	7.1	10.7	50.4	815.0
$D_4V_2S_2$	38.7	70.3	0.5	11.7	7.4	11.0	47.2	773.3
$D_4V_2S_3$	37.9	74.3	0.6	13.2	6.9	10.6	48.5	696.7
$D_4V_3S_1$	41.4	72.7	0.5	12.0	7.3	11.0	40.4	730.0
$D_4V_3S_2$	40.6	70.6	0.5	15.2	7.5	11.3	41.4	706.7
$D_4V_3S_3$	38.0	65.2	0.7	12.9	7.3	10.6	40.0	643.3
$D_4V_4S_1$	37.3	67.8	0.6	9.7	7.2	11.0	40.4	731.7
$D_4V_4S_2$	39.9	70.4	0.8	12.1	7.3	10.6	39.7	686.7
$D_4V_4S_3$	37.5	65.4	0.9	12.7	7.4	11.4	40.4	651.7
$LSD_{0.05}$	4.5	6.9	0.5	3.6	1.3	1.1	3.2	62.5
CV (%)	10.1	12.3	17.4	10.0	14.4	11.2	8.1	7.2

Interaction effects (4 factors)

The interaction effects of location, date of sowing, mutant/variety and row spacing showed that the highest seed yield (841.3 kg ha^{-1}) was produced in Ishurdi at Feb. 28 sowing, for the mutant line MBM-656-51-2 at 25 cm spacing; which is followed by the mutant line MBM-656-51-2 (829.7 kg ha^{-1}) at same sowing date and at 20cm row spacing in Magura (Table 8).

Table 8. Interaction effects of location, cultivar, sowing date and spacing on yield and yield contributing characters of during 2019

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $plant^{-1}$ (no)	Pods $plant^{-1}$ (no)	Pod length (cm)	Seeds pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
Location × Sowing time × Mutant/variety × Row spacing								
$L_1D_1V_1S_1$	34.3	20.7	1.1	7.2	6.8	9.6	37.5	726.7
$L_1D_1V_1S_2$	33.8	20.7	1.1	7.5	6.8	9.0	34.5	803.3
$L_1D_1V_1S_3$	42.5	20.8	1.3	8.9	6.7	9.5	39.9	723.3
$L_1D_1V_2S_1$	41.8	21.1	1.5	9.0	6.8	9.7	40.0	740.0
$L_1D_1V_2S_2$	43.0	20.8	1.2	7.8	6.9	9.3	41.2	773.3
$L_1D_1V_2S_3$	42.0	21.1	0.9	9.0	6.9	9.0	37.2	690.0
$L_1D_1V_3S_1$	44.0	21.3	1.1	8.7	7.0	9.5	41.3	693.3
$L_1D_1V_3S_2$	38.3	19.9	0.9	6.1	7.0	9.7	37.8	753.3
$L_1D_1V_3S_3$	37.0	21.6	1.1	8.4	7.0	9.0	34.7	693.3
$L_1D_1V_4S_1$	44.0	20.9	1.1	6.2	6.7	10.1	37.5	700.0
$L_1D_1V_4S_2$	39.3	45.4	1.3	8.7	7.1	9.7	36.3	753.3
$L_1D_1V_4S_3$	30.5	19.1	1.2	8.3	7.1	10.0	34.4	663.3
$L_1D_2V_1S_1$	45.2	31.3	0.5	11.0	7.3	8.9	39.3	785.0
$L_1D_2V_1S_2$	38.0	28.0	1.2	14.5	8.1	10.0	46.7	841.3
$L_1D_2V_1S_3$	39.3	31.8	0.7	12.6	7.5	9.3	33.2	756.7
$L_1D_2V_2S_1$	42.3	36.1	0.8	10.7	7.7	10.4	40.6	743.3
$L_1D_2V_2S_2$	45.0	34.6	0.7	11.0	8.0	10.4	41.8	808.0
$L_1D_2V_2S_3$	33.3	34.3	0.3	12.3	8.2	10.5	36.0	700.0
$L_1D_2V_3S_1$	42.5	37.3	0.8	13.3	8.1	9.8	44.0	693.3
$L_1D_2V_3S_2$	38.5	36.5	0.6	14.7	7.3	10.2	40.5	773.3
$L_1D_2V_3S_3$	34.8	38.1	0.7	10.9	7.6	9.7	38.3	660.0
$L_1D_2V_4S_1$	35.3	36.3	0.6	11.1	8.2	10.0	39.4	660.0
$L_1D_2V_4S_2$	38.3	38.5	0.7	13.3	7.2	9.4	36.7	756.7
$L_1D_2V_4S_3$	33.5	34.3	0.6	13.3	7.5	10.2	39.2	696.7
$L_1D_3V_1S_1$	33.0	47.1	0.5	10.7	7.6	10.0	44.2	826.7
$L_1D_3V_1S_2$	31.8	46.8	0.6	12.2	7.4	10.7	43.3	803.3
$L_1D_3V_1S_3$	38.0	44.2	0.8	11.4	8.0	11.3	40.3	823.3
$L_1D_3V_2S_1$	36.0	45.8	0.9	11.1	7.7	10.7	41.6	821.2
$L_1D_3V_2S_2$	35.7	47.3	0.8	12.3	7.2	10.7	40.8	773.3
$L_1D_3V_2S_3$	36.2	42.5	1.1	14.9	7.7	10.5	44.2	730.0
$L_1D_3V_3S_1$	37.5	45.9	0.8	11.6	7.6	10.8	45.0	760.0
$L_1D_3V_3S_2$	36.8	50.6	0.5	11.7	8.0	11.2	42.5	706.7
$L_1D_3V_3S_3$	32.3	47.1	1.1	12.3	7.5	10.7	43.3	660.0
$L_1D_3V_4S_1$	33.3	47.7	0.7	9.8	7.8	10.5	44.2	733.3
$L_1D_3V_4S_2$	31.3	47.3	0.8	13.4	7.9	9.9	42.5	686.7
$L_1D_3V_4S_3$	39.3	46.0	0.9	13.6	7.5	9.8	41.7	663.3
$L_1D_4V_1S_1$	35.0	72.9	0.3	9.6	7.5	10.9	44.1	816.9
$L_1D_4V_1S_2$	30.0	74.8	0.2	11.1	7.6	10.9	41.1	803.3
$L_1D_4V_1S_3$	30.0	74.6	0.9	11.4	7.6	11.3	42.2	812.3
$L_1D_4V_2S_1$	35.0	71.1	0.6	12.1	7.2	11.1	42.8	825.3
$L_1D_4V_2S_2$	42.5	72.7	0.5	10.0	7.8	11.1	37.9	773.3
$L_1D_4V_2S_3$	32.5	75.7	0.3	11.2	7.6	10.9	35.7	730.0
$L_1D_4V_3S_1$	44.5	76.5	0.5	12.2	7.7	11.4	38.6	760.0
$L_1D_4V_3S_2$	36.5	72.9	0.4	12.2	7.8	10.9	39.5	706.7
$L_1D_4V_3S_3$	30.0	68.4	0.7	10.4	8.0	10.7	40.4	660.0
$L_1D_4V_4S_1$	35.8	73.0	0.2	8.7	7.3	11.3	35.8	733.3
$L_1D_4V_4S_2$	30.0	75.5	0.7	12.1	7.6	10.5	36.2	686.7
$L_1D_4V_4S_3$	27.5	67.1	0.5	11.3	7.4	10.5	35.8	663.3

Table 8. Continued

Treatment	Populations m^{-2} (no)	Plant height (cm)	Branches $plant^{-1}$ (no)	Pods $plant^{-1}$ (no)	Pod length (cm)	Seeds pod^{-1} (no)	1000 seed weight (g)	Seed yield (t ha^{-1})
$L_2D_1V_1S_1$	38.0	31.0	0.9	8.5	5.9	9.7	40.0	826.7
$L_2D_1V_1S_2$	40.0	31.1	0.3	8.9	8.2	10.7	38.8	803.3
$L_2D_1V_1S_3$	31.0	33.5	0.3	9.1	8.8	8.7	44.3	823.3
$L_2D_1V_2S_1$	44.2	30.7	0.4	9.5	6.3	10.5	42.8	823.3
$L_2D_1V_2S_2$	38.0	32.1	0.7	9.1	8.7	10.8	37.3	773.3
$L_2D_1V_2S_3$	35.6	27.9	0.2	6.4	8.1	9.9	40.7	730.0
$L_2D_1V_3S_1$	45.0	30.9	0.3	9.3	8.3	10.4	36.3	760.0
$L_2D_1V_3S_2$	37.5	31.3	0.7	9.5	8.4	9.9	39.2	706.7
$L_2D_1V_3S_3$	37.5	34.1	0.7	14.4	7.4	8.8	39.2	660.0
$L_2D_1V_4S_1$	40.0	28.3	0.6	9.0	7.9	9.7	40.8	733.3
$L_2D_1V_4S_2$	37.5	30.3	0.6	8.4	8.6	11.3	39.7	686.7
$L_2D_1V_4S_3$	42.5	29.5	0.5	9.7	8.6	9.3	41.2	663.3
$L_2D_2V_1S_1$	45.0	45.0	0.2	11.3	11.9	10.4	38.5	829.7
$L_2D_2V_1S_2$	40.0	44.7	0.2	15.7	7.6	10.3	42.7	803.3
$L_2D_2V_1S_3$	38.5	43.6	0.5	12.3	8.1	11.0	36.7	823.3
$L_2D_2V_2S_1$	42.5	50.7	0.3	11.3	8.5	10.4	42.5	823.3
$L_2D_2V_2S_2$	45.0	47.0	0.3	12.4	7.9	10.0	42.1	773.3
$L_2D_2V_2S_3$	40.0	46.4	0.1	10.1	8.1	9.5	41.3	730.0
$L_2D_2V_3S_1$	42.5	48.9	0.3	8.9	8.5	10.3	42.3	760.0
$L_2D_2V_3S_2$	47.5	45.1	0.5	9.7	8.3	11.1	40.3	706.7
$L_2D_2V_3S_3$	47.5	44.5	0.5	13.7	7.8	10.3	43.6	660.0
$L_2D_2V_4S_1$	42.5	48.2	0.2	11.2	8.5	10.2	45.1	733.3
$L_2D_2V_4S_2$	42.5	50.3	0.5	15.4	8.3	9.9	43.3	686.7
$L_2D_2V_4S_3$	47.5	43.5	0.7	12.7	8.4	11.1	38.8	663.3
$L_2D_3V_1S_1$	45.0	57.1	1.2	7.7	6.3	10.4	37.8	826.7
$L_2D_3V_1S_2$	40.0	61.1	0.9	3.5	5.7	10.6	36.6	803.3
$L_2D_3V_1S_3$	40.8	45.5	1.3	6.6	6.6	10.6	38.6	823.3
$L_2D_3V_2S_1$	39.8	64.1	1.1	8.2	6.2	9.4	43.0	823.3
$L_2D_3V_2S_2$	40.0	69.4	1.8	6.3	5.7	9.5	45.6	773.3
$L_2D_3V_2S_3$	42.5	71.1	1.6	11.3	6.6	10.7	40.6	730.0
$L_2D_3V_3S_1$	47.5	60.1	1.7	7.6	6.0	8.5	44.6	760.0
$L_2D_3V_3S_2$	42.5	67.7	2.1	8.7	6.1	9.4	41.8	706.7
$L_2D_3V_3S_3$	42.5	62.6	1.3	5.3	5.9	8.7	38.3	660.0
$L_2D_3V_4S_1$	47.5	56.3	1.4	8.7	6.8	9.9	43.8	733.3
$L_2D_3V_4S_2$	42.5	64.5	0.9	6.7	6.1	9.3	39.6	686.7
$L_2D_3V_4S_3$	42.5	65.4	1.4	6.5	7.1	10.7	37.8	663.3
$L_2D_4V_1S_1$	47.5	66.8	1.5	13.1	6.7	11.4	36.7	776.7
$L_2D_4V_1S_2$	42.5	63.7	1.0	11.9	6.9	10.6	40.0	736.7
$L_2D_4V_1S_3$	40.0	69.8	0.5	12.6	7.3	11.1	41.4	690.0
$L_2D_4V_2S_1$	45.0	62.7	0.7	11.3	7.0	10.3	42.5	806.7
$L_2D_4V_2S_2$	42.5	67.9	0.6	13.3	7.0	10.8	39.5	773.3
$L_2D_4V_2S_3$	42.5	72.9	0.9	15.1	6.1	10.3	40.2	663.3
$L_2D_4V_3S_1$	47.5	68.9	0.6	11.8	6.9	10.7	44.2	700.0
$L_2D_4V_3S_2$	42.5	68.3	0.6	18.2	7.2	11.7	41.7	706.7
$L_2D_4V_3S_3$	40.0	61.9	0.7	15.3	6.6	10.5	39.8	626.7
$L_2D_4V_4S_1$	40.0	62.7	1.0	10.7	7.1	10.7	38.8	730.0
$L_2D_4V_4S_2$	45.0	65.2	0.9	12.2	6.9	10.7	39.3	686.7
$L_2D_4V_4S_3$	42.5	63.8	1.3	14.1	7.5	12.3	39.2	640.0
$LSD_{0.05}$	8.9	11.0	0.6	5.14	1.78	1.85	6.5	106.7
CV (%)	10.1	12.3	17.4	10.0	14.4	11.2	8.1	7.2

Conclusions

The total yield and yield attributing features of mungbean reveal that the advance mutant lines MBM-656-51-2 produced better yield during a two-year experiment in three agro-ecological zones. Overall results suggest that to ensure satisfactory yield of mungbean mutants sowing at Feb.15 to Feb. 28 sowing at 20 to 25 cm row spacing should be maintained at Barishal, Ishurdi and Magura regions.

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