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DETERMINATION OF OPTIMUM ROW SPACING FOR BETTER SEED YIELD AND YIELD CONTRIBUTING CHARACTERS OF ADVANCED MUSTARD (*Brassica napus* L.) MUTANTS IN BANGLADESH

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Abstract

A field experiment was conducted at BINA substations, Rangpur and Magura in 2018-19 to evaluate the different row spacing on the yield and yield contributing characteristics of advance mustard lines RM-03, RM-07, RM-10 along with one check variety BARI sarisha-15 during Rabi season. BARI sarisha-15 was irradiated with 700 Gy Cobalt 60 (^{60}Co) Gamma source and advanced mutant lines M_6 generation of mustard mutant (RM-03, RM-07, RM-10) were evaluated along with the check variety BARI sarisha-15 using four different row spacings viz. 20cm, 25cm, 30cm and 35cm. The experiment was laid out in split-split plot design with three replications. Among the advance lines, RM-03 produced the highest seed yield (1.60 t ha^{-1}) followed by RM-10 (1.50 t ha^{-1}). Among different line spacing, 20cm showed highest seed yield (1.66 t ha^{-1}). The interaction of mutant/variety and location revealed that the yield of RM-10 was the highest (1.54 t ha^{-1}) at Rangpur. The interaction effect of line spacing and location showed that 25cm line spacing produced the maximum seed yield (1.68 t ha^{-1}) in Magura followed by 20 cm (1.64 t ha^{-1}) in Rangpur. The interaction effect of mutant and line spacing showed that mutant line RM-03 at 20 cm produced maximum seed yield (1.68 t ha^{-1}) in Rangpur. The interaction effect of mutant/variety, line spacing and location showed that RM-10 produced the highest seed yield (1.73 t ha^{-1}) at 20cm line spacing in Rangpur followed by RM-07 (1.66 t ha^{-1}) at same spacing.

Key words: Mustard, Mutant/Variety, Line Spacing, Yield.

Introduction

Mustard stands as one of the most important oilseed crops throughout the world after soybean. Total mustard seed production reached 532,769 tones in 2021 in the World according to (FAO, 2021). It belongs to the genus Brassica under the family Cruciferae. There are three edible oil producing species, namely, Brassica napus, Brassica campestris and Brassica juncea. The mustard seeds contain 40-44% oil, 25% protein and 6.4% nitrogen (FAO, 2012). Mustard holds the first position in terms of area and production among the oilseed crops grown in Bangladesh. The total area and production of mustard 330.72 thousand hectare and 409.66 thousand MT in 2021-22 in Bangladesh whereas average yield is 1.23 t ha^{-1} (BBS, 2022). The present yield of mustard is very low compared to other oil seed producing countries. The main reasons of lower yield are lack of good quality varieties, seeds and inadequate adoption of improved technologies developed by different research institutes (Miah *et al.*, 2014). Bangladesh is rapidly becoming self-sufficient for different

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agricultural commodities, such as rice higher level of adoption of modern technologies generated by different research institutes. The country is producing about 0.4 million tons of edible oil per year as against the total requirement of 2.4 million tons (BBS, 2022). The government needs to import about 88% edible oil to meet the demand. Out of total cropped area of 13.53 million ha, oil crops occupy only 0.561 million ha which is about 4.2% of the total cropped area. Rapeseed/ mustard occupies 60% of the oil cropped area (Wahab *et al.*, 2002). Mustard oil has only 6 per cent saturated fat, which is lower than any other vegetable oil. It is also composed of 58 per cent monounsaturated fat, a desirable trait to consumers. Mustard meal is a safe protein source in animal feeds with 32-38 per cent protein (Myers *et al.*, 1995). The prospect of mustard in Bangladesh appears to be good. Mustard is a popular edible oil in rural area and is considered important for improving the taste of food items. It also serves as an important raw material for industrial use such as in soaps, paints, varnishes, lubricants, textile auxiliaries, pharmaceuticals etc. The gap between supply and demand of edible oils costs us a huge amount of foreign exchange every year. The highest seed yield (2.01 t ha^{-1}) was produced when the seeds of Sambal were sown at 30 cm row spacing and the same variety with 10cm row spacing produced the lowest seed yield (0.60 t ha^{-1}). The interaction of variety, seed rate and row spacing had no significant influence on yield and yield contributing characteristics of mustard (Fatema *et al.*, 2023). For this, due attention is required to enhance the production of mustard in Bangladesh. Mustard is a cold loving Rabi crop which grows during October-February usually under rainfed and low input condition in Bangladesh. The experiment was designed to investigate the optimum spacing to get full potential yield of mustard mutants.

Materials and methods

Experimental site and weather

The experiment was conducted at the field of BINA substations Rangpur (25.45 °N, 89.15 °E) and Magura (23.48 °N, 89.40 °E) during Rabi season in year 2018-19. The climatic parameters during the growing period of Rabi season in different time are presented in Fig. 1.

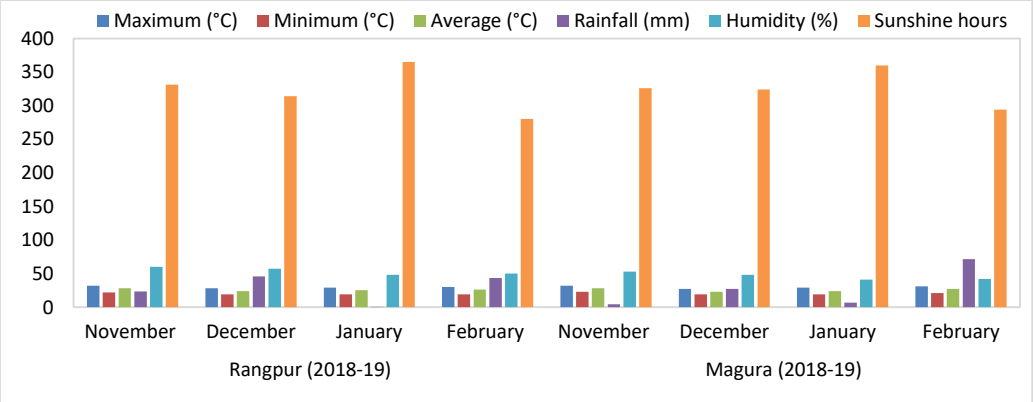

Fig. 1: The climatic parameters during the growing season of Rabi in 2018-19

Treatments and cultural practices

The experiment was carried out in two different location at Rangpur and Magura with three advance mustard lines/variety viz. RM-03, RM-07, RM-10 along with one check variety BARI sarisha-15. Major features of Bari sarisha-15 includes short duration variety, plant height 75-85 cm, leaf light green, smooth, siliqua plant^{-1} 80-102, two chambers are present in pod but as like as four chambers. Seed siliqua^{-1} 22-26, seed color pink, 1000 seed weight 3.5-3.8 g, crop duration 75-80 days. Because of its short duration, BARI sarisha-15 can easily be grown after harvest of aman rice and before transplanting of boro rice. Four different line spacings at 20 cm, 25 cm, 30 cm and 35 cm were used and seed rate of mustard mutant/variety was 7.5 kg ha^{-1}. The experiment was laid out in a split split plot design with three replications.

Land preparation

The land preparation was started two weeks prior to sowing. The land was sufficiently ploughed and cross ploughed with followed by laddering to have a good tilth. All kinds of stubble and residues of previous crop were removed from the field. After uniform leveling, the experimental plots were laid out according to design of the experiment.

Fertilization and manuring

The plots of mustard field were fertilized with N 92 kg ha^{-1}, P_20_5 75 kg ha^{-1}, K_2O 50 kg ha^{-1}, $CaSO_4$ $2H_2O$ 150 kg ha^{-1} and FYM 5 t ha^{-1}. The whole amount of di-ammonium phosphate, muriate of potash except zinc sulphate were applied to the soil at the time of final land preparation. Urea was applied in three equal splits. One split of urea was applied with other fertilizers as basal dose and the other two splits were applied 21 and 45 DAS.

Intercultural operation

Intercultural operations were done in order to ensure and to maintain the normal growth of the plant as and when needed. The experimental plots were infested with some common weeds which were removed twice by hand weeding. Observations were regularly made with frequent intervals.

Harvesting and data collection

The maturity of crops was determined when some 80% of the siliqua attained color. Plot-wise seed and stover yields were recorded after threshing, winnowing and drying in the sun properly including the seed and stover of the sample plants. The weight of seed was adjusted to 8% moisture content. Stover of mustard dried 72 hours at 80^0C. Seed and stover yields were then converted to t ha^{-1}. From the 10 randomly harvested plants of each plot, the data on yield contributing characters were recorded.

Data processing and analysis

Data recorded for different parameters were subjected to analysis of variance (ANOVA) Gomez and Gomez 1984) and the treatment means were compared using the least significant different test. The statistical analysis was done by using the software Statistix 10.

Results and discussion

Effect of location

Between two location Rangpur and Magura the seed yield of mustard mutants was statistically not significant.

Effect of advance lines

Among different advance lines/variety, RM-03 produced highest seed yield (1.60 t ha^{-1}) followed by RM-10 (1.50 t ha^{-1}).

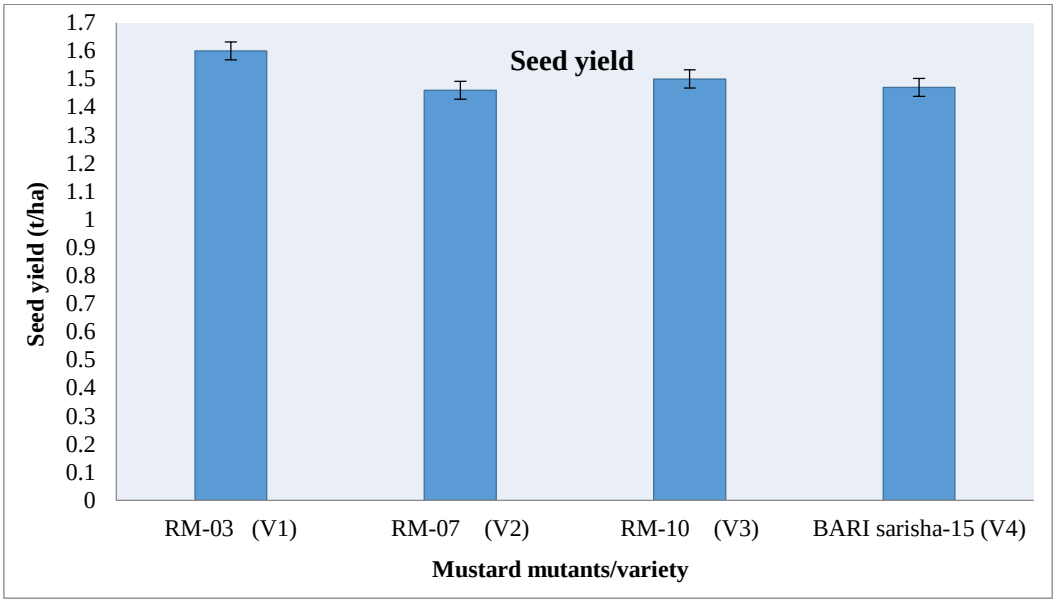

Fig. 2: Seed yield at different line mutant/variety

Effect of row spacing

Among different line spacing, 20 cm showed highest seed yield (1.66 t ha^{-1}) Row spacing had a significant effect on plant height, no. of branches $plant^{-1}$, no. of filled pods $plant^{-1}$, unfilled pods $plant^{-1}$, length of pod, no. of seeds pod^{-1}, 1000 seed weight, seed yield and stover yield (Table 1).

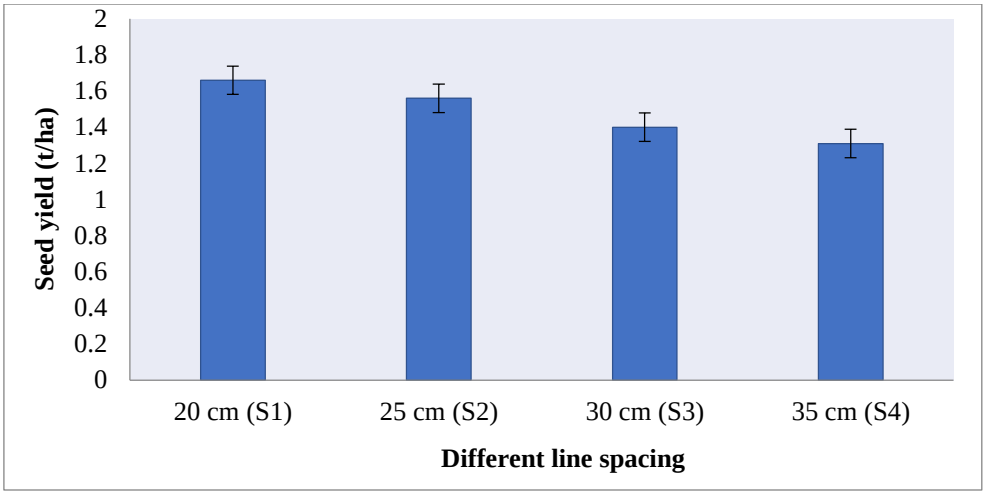

Fig. 3: Seed yield at different line spacing

Table 1. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety in BINA Sub-station Rangpur and Magura

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Siliqua length (cm)	Seeds siliqua (cm)	1000 seed wt. (g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Crop duration (days)
Location(s)										
Rangpur (L_1)	79.2	55.5	4.1	71.1	3.5	17.7	3.2	1.47	3.09	
Magura (L_2)	83.8	53.0	4.7	67.6	4.4	19.9	3.2	1.50	3.08	
T value	NS	NS	*	*	*	NS	NS	NS	NS	
Mutant/variety										
RM-03 (V_1)	77.4	53.6	4.6	68.0	4.1	20.4	3.5	1.60	3.00	86
RM-07 (V_2)	77.5	55.5	4.3	73.1	4.1	17.5	3.3	1.46	3.18	86
RM-10 (V_3)	73.4	54.7	4.7	70.1	3.9	18.9	3.3	1.50	3.15	86
BARI sarisha-15 (V_4)	97.7	53.1	4.0	66.2	3.7	18.2	2.7	1.47	3.00	88
$LSD_{0.05}$	4.3	NS	0.3	NS	0.2	1.0	0.1	NS	NS	
Line spacing										
20 cm (S_1)	79.3	63.0	4.3	66.3	4.1	18.9	3.2	1.66	3.32	
25 cm (S_2)	81.7	57.1	4.3	68.3	3.9	18.8	3.2	1.56	3.19	
30 cm (S_3)	81.9	52.4	4.3	68.8	3.9	19.0	3.2	1.40	2.88	
35 cm (S_4)	83.3	44.3	4.7	74.0	4.0	18.4	3.2	1.31	2.95	
$LSD_{0.05}$	2.2	1.7	NS	3.2	NS	1.0	0.1	0.03	0.15	
CV%	8.5	5.3	10.4	7.9	8.3	9.3	5.4	10.78	8.43	

Effect of interaction of advance lines and row spacing

The interaction of mutant/variety and location revealed that the yield of RM-10 was the highest (1.54 t ha^{-1}) at Rangpur.

Effect of interaction of advance lines and location

The effect of line spacing and location showed that 25 cm line spacing produced the maximum seed yield (1.68 t ha^{-1}) in Magura followed by 20 cm (1.64 t ha^{-1}) in Rangpur (Table 2). Shahidulla *et al.* (1997) conducted a field experiment during 1994-95 to observe the effect of row spacing and plant spacing on mustard (B. campestris). The treatments were three row spacing (20, 30 and 40 cm) and four plant spacing (10, 15, 20 and 30 cm). They reported that 30 cm row spacing gave the highest seed yield.

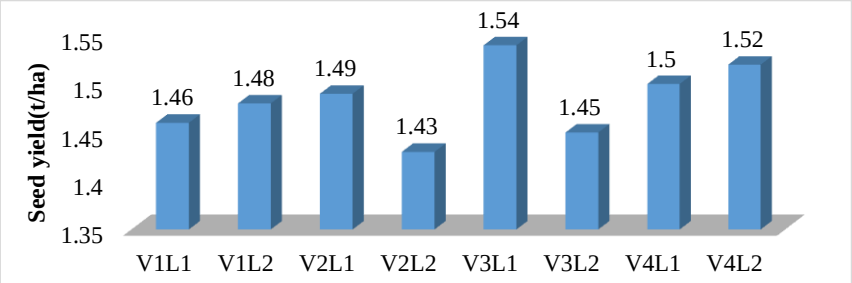

Fig. 4: Seed yield at different mutant/variety and location

Table 2. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety in BINA Sub-station Rangpur and Magura

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Siliqua length (cm)	Seeds siliqua (cm)	1000 seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Mutants/Variety × Location									
V_1L_1	74.0	54.2	5.0	72.6	3.7	20.7	3.5	1.46	3.03
V_1L_2	76.2	54.8	3.9	74.0	3.7	15.2	3.3	1.48	3.17
V_2L_1	71.8	58.8	4.5	74.2	3.4	18.7	3.3	1.49	3.17
V_2L_2	95.0	54.1	3.0	63.7	3.4	16.1	2.8	1.43	2.99
V_3L_1	80.9	53.0	4.1	63.4	4.6	20.1	3.4	1.54	2.98
V_3L_2	78.8	56.3	4.7	72.2	4.5	19.9	3.3	1.45	3.20
V_4L_1	75.1	50.7	4.9	66.1	4.5	19.1	3.3	1.50	3.12
V_4L_2	100.5	52.1	5.1	68.6	4.0	20.4	2.7	1.52	3.02
$LSD_{0.05}$	6.1	NS	0.4	NS	0.3	1.4	0.1	NS	NS
Line spacing × Location									
S_1L_1	77.4	64.2	4.0	68.6	3.8	17.8	3.3	1.64	3.26
S_1L_2	80.4	58.8	4.0	71.7	3.4	18.0	3.2	1.54	3.23
S_2L_1	78.4	54.0	3.9	69.8	3.4	17.9	3.2	1.68	2.84
S_2L_2	80.7	44.9	4.4	74.4	3.5	17.0	3.2	1.49	3.02
S_3L_1	81.2	61.9	4.6	64.1	4.3	20.0	3.1	1.39	3.37
S_3L_2	83.0	55.5	4.5	64.8	4.4	19.7	3.1	1.58	3.16
S_4L_1	85.3	50.8	4.7	67.8	4.4	20.0	3.2	1.42	2.92
S_4L_2	85.8	43.8	4.9	73.6	4.5	19.8	3.2	1.33	2.87
$LSD_{0.05}$	3.1	2.4	NS	4.5	0.3	1.4	0.1	0.05	0.21
CV%	8.5	5.3	10.4	7.9	8.3	9.3	5.4	10.78	8.43

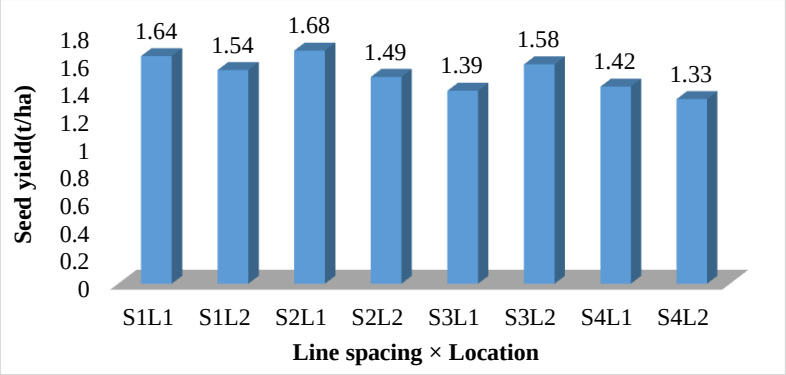

Fig. 5: Seed yield at different spacing and location in 2018-19

Effect of interaction of row spacing and location

The effect of mutant and line spacing showed that mutant line, RM-03 at 20 cm produced maximum seed yield (1.68 t ha^{-1}) line spacing in Rangpur (Table 3). The number of seeds pod^{-1} was significantly influenced by different row spacing (Table 4). Thirty cm row spacing produced the highest number of seeds pod^{-1} and 10 cm row spacing produced the lowest number of seeds pod^{-1}.

Table 3. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety in BINA Sub-station Rangpur and Magura

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Siliqua length (cm)	Seeds siliqua (cm)	1000 seed wt. (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Mutants/Variety × Line spacing									
V_1S_1	74.9	61.0	4.6	66.4	4.3	20.8	3.5	1.68	3.33
V_1S_2	79.8	56.7	4.2	63.5	3.9	20.7	3.5	1.51	3.07
V_1S_3	77.6	51.5	4.6	68.7	4.2	21.0	3.4	1.44	2.87
V_1S_4	77.5	45.2	4.8	73.4	4.2	19.2	3.5	1.37	2.74
V_2S_1	76.4	66.7	4.1	69.5	4.0	17.4	3.3	1.61	3.50
V_2S_2	76.9	57.8	4.1	72.8	4.0	18.1	3.2	1.61	3.38
V_2S_3	77.7	53.0	4.4	71.9	4.0	17.6	3.3	1.36	2.86
V_2S_4	78.9	44.7	4.5	78.2	4.3	17.0	3.3	1.26	2.99
V_3S_1	69.8	64.7	4.6	68.5	4.1	18.5	3.2	1.66	3.14
V_3S_2	71.0	57.0	4.8	71.5	3.9	19.0	3.3	1.59	3.29
V_3S_3	75.5	52.7	4.3	68.7	3.8	18.7	3.3	1.41	2.93
V_3S_4	77.5	44.5	5.0	71.8	4.0	19.4	3.3	1.33	3.22
V_4S_1	96.1	59.8	4.0	60.8	3.9	18.8	2.8	1.68	3.29
V_4S_2	99.0	57.0	3.9	65.3	3.8	17.5	2.7	1.54	3.04
V_4S_3	96.7	52.5	3.9	66.0	3.7	18.6	2.8	1.39	2.85
V_4S_4	99.2	43.0	4.3	72.5	3.5	18.0	2.8	1.29	2.83
$LSD_{0.05}$	4.3	3.3	0.8	6.3	0.4	2.0	0.1	0.07	0.30
CV%	8.5	5.3	10.4	7.9	8.3	9.3	5.4	10.78	8.43

Table 4. Effect of different levels of line spacing on the yield and yield contributing characters of mustard mutant/variety in BINA Sub-station Rangpur and Magura

Treatment	Plant height (cm)	Populations m^{-2} (no.)	Branches $plant^{-1}$ (no.)	Siliqua $plant^{-1}$ (no.)	Siliqua length (cm)	Seeds siliqua (cm)	1000 seed wt. (g.)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Location × Mutant/Variety × Line spacing									
$L_1V_1S_1$	72.9	62.0	5.2	73.2	4.1	20.5	3.5	1.62	3.29
$L_2V_1S_1$	75.1	56.7	4.4	68.2	3.3	21.7	3.6	1.48	3.15
$L_1V_1S_2$	75.1	52.7	4.9	75.3	3.6	21.9	3.5	1.40	2.91
$L_2V_1S_2$	72.8	45.3	5.5	73.6	3.5	18.8	3.6	1.33	2.76
$L_1V_1S_3$	74.3	67.0	3.5	68.9	3.8	15.0	3.4	1.63	3.52
$L_2V_1S_3$	75.5	57.3	3.9	77.8	3.4	15.5	3.3	1.62	3.41
$L_1V_1S_4$	75.3	51.3	4.0	71.7	3.4	15.0	3.3	1.39	2.71
$L_2V_1S_4$	79.5	43.7	4.1	77.5	4.1	15.2	3.2	1.27	3.04
$L_1V_2S_1$	67.1	68.7	4.3	74.7	3.5	17.7	3.3	1.66	3.08
$L_2V_2S_1$	72.8	62.3	4.9	77.7	3.4	19.1	3.3	1.58	3.32
$L_1V_2S_2$	70.8	57.7	3.9	68.4	3.3	18.5	3.3	1.41	2.96
$L_2V_2S_2$	76.5	46.3	5.0	75.8	3.3	19.6	3.3	1.32	3.31
$L_1V_2S_3$	95.4	59.0	2.9	57.4	3.7	17.9	2.8	1.63	3.16
$L_2V_2S_3$	98.1	58.7	2.8	62.9	3.5	15.6	2.7	1.49	3.04
$L_1V_2S_4$	92.3	54.3	2.9	63.7	3.3	16.3	2.8	1.34	2.79
$L_2V_2S_4$	94.1	44.3	3.2	70.6	3.1	14.5	2.8	1.25	2.96
$L_1V_3S_1$	76.9	60.0	4.0	59.7	4.4	21.1	3.4	1.74	3.38
$L_2V_3S_1$	84.5	56.7	4.0	58.7	4.5	19.7	3.4	1.55	3.00
$L_1V_3S_2$	80.0	50.3	4.4	62.0	4.8	20.1	3.4	1.48	2.82
$L_2V_3S_2$	82.3	45.0	4.1	73.3	4.8	19.7	3.5	1.41	2.72
$L_1V_3S_3$	78.5	66.3	4.6	70.1	4.2	19.9	3.3	1.60	3.48
$L_2V_3S_3$	78.4	58.3	4.3	67.7	4.5	20.7	3.2	1.60	3.35
$L_1V_3S_4$	80.1	54.7	4.8	72.1	4.6	20.1	3.3	1.34	3.01
$L_2V_3S_4$	78.2	45.7	4.9	78.9	4.5	18.8	3.3	1.25	2.95
$L_1V_4S_1$	72.5	60.7	4.8	62.3	4.6	19.4	3.2	1.62	3.21
$L_2V_4S_1$	69.2	51.7	4.7	65.3	4.4	18.9	3.3	1.60	3.25
$L_1V_4S_2$	80.1	47.7	4.8	68.9	4.3	18.9	3.3	1.41	2.91
$L_2V_4S_2$	78.5	42.7	5.1	67.9	4.6	19.2	3.3	1.34	3.13
$L_1V_4S_3$	96.8	60.7	5.1	64.3	4.1	19.7	2.7	1.63	3.43
$L_2V_4S_3$	99.8	55.3	5.1	67.6	4.1	19.3	2.7	1.58	3.03
$L_1V_4S_4$	101.1	50.7	4.9	68.3	4.1	21.0	2.7	1.43	2.92
$L_2V_4S_4$	104.3	41.7	5.3	74.4	4.0	21.5	2.7	1.33	2.70
$LSD_{0.05}$	6.1	4.7	1.1	9.0	0.5	2.9	0.2	0.09	0.43
CV%	8.5	5.3	10.4	7.9	8.3	9.3	5.4	10.78	8.43

Seed yield of mutant at different spacings

The result of the experiment showed that line spacings had a significant effect on plant height, no. of filled pods $plant^{-1}$, no. of seeds pod^{-1}, 1000-seed weight, seed yield and stover yield.

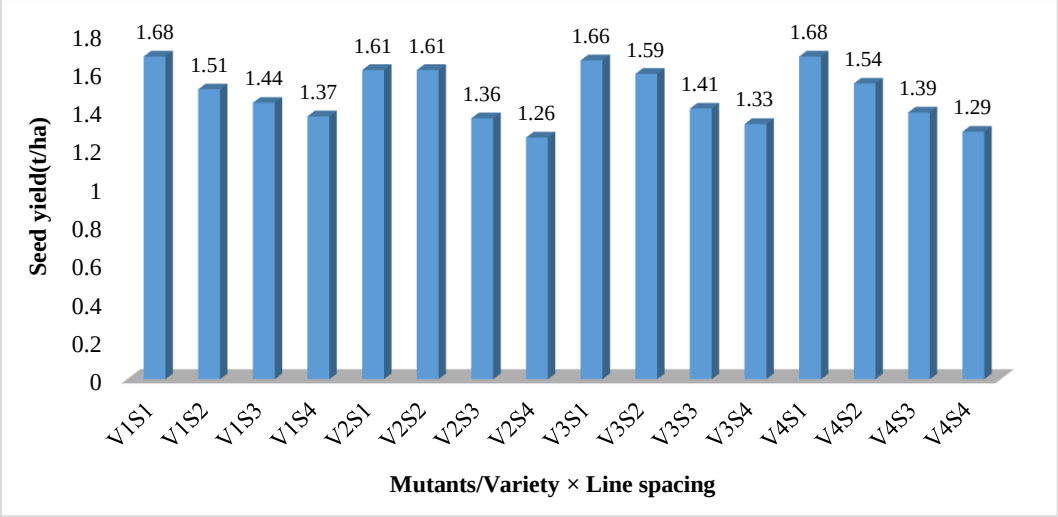

Fig. 6: Seed yield at different spacing

Effect of interaction of advance lines, row spacing and location

The effect of mutant/variety, line spacing and location showed that RM-10 produced highest seed yield (1.73 t ha^{-1}) at 20 cm line spacing in Rangpur followed by RM-07 produced highest seed yield (1.66 t ha^{-1}) at same spacing and same location. The data recorded on crop duration revealed that the advanced mutant line RM-03, RM-07, RM-10 required the least average 86 days and BARI sarisha-15 required maximum average 88 days.

Conclusions

The performance of mustard mutant/variety, line spacing and location showed that RM-10 produced highest seed yield at 20 cm line spacing followed by RM-07. The study suggests that mustard mutant line RM-10 at 20 cm line spacing produces highest seed yield. It could be concluded that higher seed yield of mustard could be obtained by using 20 cm row spacing under the agro-climatic conditions of Rangpur and Magura. After further study from multilocation trial of mutants in different AEZ to investigate the optimum spacing to get full potentialities all over Bangladesh.

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Competing interests

Authors have declared that no competing interest exist.

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