GROWTH AND YIELD RESPONSES OF RAPESEED-MUSTARD VARIETIES GROWN WITH DIFFERENT SOWING TIMES

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CERTIFICATE

This is to certify that the thesis entitled " ***GROWTH AND YIELD RESPONSES OF RAPESEED-MUSTARD VARIETIES GROWN WITH DIFFERENT SOWING TIMES"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***JANNATUL FERDOUS*** *registration. no.* ***12-04990*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated: **June, 2018**

Dhaka, Bangladesh

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The Author

GROWTH AND YIELD RESPONSES OF RAPESEED- MUSTARD VARIETIES GROWN WITH DIFFERENT SOWING TIMES

ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka to investigate the growth and yield responses of rapeseed-mustard varieties grown with different sowing times during November, 2017 to April, 2018. The experiment consisted of two factors of which were Factor A: Two mustard variety *viz.*, V_1= BARI Sarisha-11 (mustard) and V_2= BARI Sarisha-17 (rapeseed) and Factor B: Five sowing time *viz.*, S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November and S_5= 30 November. The experiment was laid out in Randomize Block Design (RCBD) with three replications. Plant height (cm), dry matter weight plant^{-1} (g), branches plant^{-1} (no.) siliquae plant^{-1} (no.), seeds siliqua^{-1} (no.), length of siliqua (cm), 1000 grain weight (g), seed yield plant^{-1} (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) were compared for different treatments. Results indicated that, variety and sowing time had significant influence on most of the growth, yield and yield contributing characters of mustard. The maximum seed yield (1.31 t ha^{-1}) was obtained from mustard variety BARI Sarisha-11 and the minimum seed yield (0.90 t ha^{-1}) was obtained from BARI Sarisha-17 (rapeseed). The mustard variety BARI Sarisha-11 gave 45.56 % higher yield than BARI Sarisha-17. Under this investigation it was revealed that delaying of sowing time resulted with decreased seed yield of the crop. The highest grain yield (1.78 t ha^{-1}) was produced when the seed sown on 2nd day of November (S_1) which was 295.56 % higher than the seed sown on 30th November (S_5) (0.45 t ha^{-1}). The highest grain (2.22 t ha^{-1}) was produced by BARI Sarisha-11 which was sown on November, 2nd and the lowest one (0.33 t ha^{-1}) was produced by BARI Sarisha-17 which was sown on 30th November. BARI Sarisha-11 along with sowing date S_1 produced 572.73 % higher mustard grain than BARI Sarisha-17 along with sowing date 30 November. So it may be concluded that BARI Sarisha-11 along with sowing date November, 2nd could be the best production package for cultivation of mustard.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
µg	=	Micro gram
^{0}C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
g	=	Gram (g)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
Hr	=	Hour
kg	=	Kilogram
LSD	=	Least Significant Difference
mm	=	Millimeter
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non significant
ppm	=	Parts per million
q	=	Quintal
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

INTRODUCTION

Rapeseed and mustard belong to the family Brassicaceae (or Cruciferae) are important oil crops. Among the species, *Brassica napus* and *Brassica campestris* are regard as rapeseed while *Brassica juncea* is regard as mustard. Rapeseed and mustard are the second most important edible oil in the world. About 13.2% of the annual edible oil comes from these crop (FAO, 2005). *Brassica* oil crop is the most important group that supplies major edible oil in Bangladesh. Bangladesh is running a short of 60-75% of the demand of edible oil (Rahman, 2002). Rapeseed/Mustard oil of plant origin constitute important component of human diet, ranking third after cereals and animal products and are nutritionally superior to animal oil (Singh *et al.*, 2002). Rapeseed and mustard are rich source of oil and contains 44% to 46% good quality oil (Rashid, 2013). In 2012-2013, the edible oil production from major oilseed crops in the world is 497.0 M. tons where rapeseed contributes 64.3 M. tons. The annual oil seed production of 0.41 million tons of which the share of rapeseed was 0.21 million tons, which comes about 52 % of the total edible oil seed production (BBS, 2005). Bangladesh is running with acute shortage of about 70% edible oil. Annually producing about 0.16 million tons of edible oil as against the requirement of 0.5 million tons and to meet up the demand, the country has to import oil and oilseeds to the tune of about 160 million US $ every year (Wahhab *et al*. 2002). In Bangladesh these crops cover less than 3% of the total cultivated land.

It is a cool season crop. It is also a thermo sensitive as well as photosensitive crop (Ghosh and Chatterjee, 1988). The seed contains 40-45% oil and 20-25% protein. It also serves as an important raw material for industrial use such as in soap, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals, etc. It is widely used as a cooking ingredient, condiment and for its medicinal value. Moreover, mustard oil cake is utilized as cattle feed and small quantities are also used as manure. Last ten years have witnessed gradual decline in an area of 104 thousand hectare and production 68 thousand tons of mustard and rapeseed (Anonymous, 2006). Though the production of edible oil is being decreased, whereas, the demand is increasing day by day with the increasing population.

Total area and annual production of mustard and rapeseed crops are 2.42 lac hectare and 2.22 lac metric tons respectively (BBS, 2010). The average grain yield of mustard is only 0.92 t ha^{-1} (BBS, 2010), which is very low as compared to those of mustard growing countries in the world. The major reasons for such poor yield is mainly due to use of indigenous variety and poor management as practiced at farmer's field. Therefore, attempts must be made to increase the per unit production by using HYV and by adopting better management practices such as appropriate sowing time and other cultural operations.

An understanding of some morpho-physiological characters in mustard is necessary to make progress in genotypic improvement and for the management of the crop either to increase yield and quality or to reduce the cost of production (Mendham and Salisbury, 1995). High yield potential of a variety is the prerequisite for increasing the production of a crop. In the recent years, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) has developed a number of high yielding varieties of mustard with yield potential up to 2.5 t ha^{-1}. Genotypes play an important role in crop production and the potential yield of a genotype within the genetic limit is determined by its environment (Iraddi, 2008). The release of high yielding varieties has contributed a great deal towards the improvement of mustard yields. The yield potential of these high yielding varieties can be further exploited through better agronomic practices involving many physiological changes.

Time of sowing is very important for mustard production (Mondal and Islam, 1993 and Mondal *et al.*, 1999). Sowing either too early or too late has been reported to be unfavorable (Uzun *et al.* 2009). In late autumn sowing seed germination is very slow and this leads to limited seedling development (Christensen and Drabble, 1984). Late sowings not only reduce the seed yield, but also decrease oil level in winter rapeseed (Ozer 2003). Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield. Decreasing crop yield in delayed sowing date has been reported by many workers (McDonald *et al.*, 1983 and Degenhardt and Kondra, 1981). Hall (1992) reported that flowering was the most sensitive stage for temperature stress damage probably due to vulnerability during pollen development, anthesis and fertilization

leading to reduce crop yield. High temperature in *Brassica* enhanced plant development and caused flower abortion with appreciable loss in seed yield (Rao *et al.* (1992). Flowering duration had a strong influence on seed yield and a rise of 3°C in maximum daily temperature (21-24° C) during flowering caused a decline of 430 kg ha^{-1} in mustard seed yield (Nuttall *et al*., 1992). Hocking and Stapper (2001) reported that oil concentration reduced by 3% when mustard was planted delayed after 15th October. They concluded that reduction was due to increased temperature during the grain filling stage. Mustard sown on 14th and 21st October took significantly more days to 50% flowering (55 and 57) and maturity (154 and 156) compared to 7th October planting (Kumar *et al*., 2001). Date of sowing influence the incidence of insect-pest and disease also. Sowing on 21st October resulted in least *Sclerotina* incidence (Gupta *et al*., 2004). The late sowing of mustard decreased seed yield through synchronization of siliquae filling period with high temperatures, the decrease in assimilates production, drought stress occurrence, shortened siliquae filling period and acceleration of plant maturity (Mendham *et al.,* 1995). Different sowing dates expose the crop to different weather conditions affecting temperature and solar radiation captured by the crop canopy and crop growth. Consequently with delay in sowing crop is exposed to low temperature and lower amount of solar radiation during vegetative and high temperature during pod formation to physiological maturity which shortens the life cycle of rapeseed mustard (Pradhan *et al.,* 2014). The final grain yield of a crop is closely related to light in the form of photosynthetically active radiation (PAR) which is used directly food synthesis. The photosynthesis process is controlled by the temperature and amount of radiation interception. The light efficiency is further attributed to the leaf area of the crop which is more or less controlled by temperature and water. A suitable planting date is one of them which are very important for good agronomic performance of mustard. Therefore, the present study was undertaken with following objectives:

Objectives:

i. To find out the optimum planting date for mustard seed production.
ii. To find out the best combination between the varieties and sowing dates for boosting up of yield of the crop.

CHAPTER II

REVIEW OF LITERATURE

Mustard is an important oil seed crop in Bangladesh. The production is not as good as developed country due to its sub-optimal production strategies, climatic fluctuation and agronomic managements. Among these factors the sowing time is very crucial as it is a thermo sensitive crop. So, to prepare a well plan for the present piece of work the secondary sources of information regarding the growth and yield responses of rapeseed-mustard varieties grown with different sowing times different were reviewed in this chapter.

2.1 Plant height (cm)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha 15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the maximum plant height (104.87 cm) was obtained by BARI Sarisha 15 and the minimum plant height (84.78 cm) was obtained by BARI Sarisha 14. The maximum plant height (108.00 cm) was obtained by sowing date 30 November and the minimum plant height (81.57 cm) was obtained by sowing date 30 December.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum plant height (135.00 cm) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (93.00 cm) was recorded seeds were sown on D_4 (27Nov.).

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.,* D_1 (42^{nd} MW), D_2 (43^{rd} MW), D_3 (44^{th} MW), D_4 (45^{th} MW) and D_5 (46^{th} MW) and two sub-treatments of varieties *viz.,* V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest plant height (163.51 cm) was recorded from D_2 treatment and the lowest plant height (148.08 cm) was recorded from D_5treatment.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25^{th} September), D_2 (5^{th} October), D_3 (15^{th} October) and D_4 (25^{th} October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the tallest plant (139.50 cm) was recorded from V_3 (Coral-437) and the shortest one (118.75 cm) was from V_1 (Rohini). The tallest plant (146.34 cm) was recorded from sowing date D_4 (25 Oct.) and the shortest one (110.99 cm) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15^{th} and 25^{th}, Nov 5^{th} and 15^{th}) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum plant height (226.70 cm) was found when the seeds were sown on Oct. 15 and the minimum one (208.60 cm) was found when the seeds were sown on Nov.15.

The experiment was conducted by Akhter *et al*. (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated

field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the tallest plant (106.78 cm) was obtained from BINA Sarisha-6 and the shortest one (89.24 cm) was obtained from BARI Sarisha-14. The tallest plant (102.78 cm) was obtained from sowing date 18 October and the shortest one (91.37 cm) was obtained from sowing date 3 December.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sarisha-15 (V_1), BINA Sarisha-5 (V_2) and BARI Sarisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the tallest plant (112.60 cm) was found from BINA Sarisha-5 along with sowing date 15 November and the shortest one (93.78 cm) was found from BARI Sarisha-9 along with sowing date 15 January.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and Binasarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the variety BARI Sarisha-15 produced the tallest plant (122.0cm) and it was identical with BARI Sarisha-8 (117.5cm) and line BC-05118 Y (109.4cm) whereas, BARI Sarisa-14 produced the shortest plant (83.6cm).

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum plant height (82.00 cm) was achieved by T_2 (30 October) and the minimum plant height (66.13 cm) was achieved by T_5 (15 November).

A field experiment was conducted by Sattar *et al*. (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15^{th} October), late (30^{th} Oct) and very late (15^{th} November). The results of their showed that, the tallest plant (177.40 cm) was recorded from sowing date 15^{th} October and the shortest plant (161.80 cm) was recorded from sowing date 15^{th} November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the taller plant (96.72 cm) was scored by mustard variety BARI Sarisha-9 and the shorter one (84.86 cm) was scored by mustard variety BARI Sarisha-6. The tallest plant (99.38 cm) was scored by sowing date November 10 and the shortest one (79.96 cm) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They

revealed that, the tallest plant (115 cm) was scored by sowing date November 10 and the shortest plant (100 cm) was scored by sowing date November 30.

2.2 Dry matter weight plant^{-1} (g)

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.*, D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest dry matter accumulation plant^{-1} (33.48 g) was recorded from D_2 treatment and the lowest dry matter accumulation plant^{-1} (28.38 g) was recorded from D_5 treatment.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest dry matter accumulation plant^{-1} (128.47 g) was recorded from V_3 (Coral-437) and the lowest one (109.36 g) was from V_1 (Rohini). The highest dry matter accumulation plant^{-1} (134.77 g) was recorded from sowing date D_4 (25 Oct.) and the lowest one (102.21 g) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sarisha-15 (V_1), BINA Sarisha-5 (V_2) and BARI Sharisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the

maximum total dry matter plant^{-1} (21.63 g) was found from BARI Sarisha-9 along with sowing date 15 November and minimum the total dry matter plant^{-1} (13.00 g) was found from BARI Sarisha-9 along with sowing date 15 January.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, dry matter of BARI Sarisha-8 was the highest (309.21g plant^{-1}) and the lowest (163.93 g plant^{-1}) from variety BARI Sarisha-14.

2.3 Branches plant^{-1} (no.)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha 15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the maximum branches plant^{-1} (7.46) was obtained by BARI Sarisha 15 and the minimum branches plant^{-1} (6.03) was obtained by BARI Sarisha 14. The maximum branches plant^{-1} (7.84) was obtained by sowing date 10 December and the minimum branches plant^{-1} (5.80) was obtained by sowing date 30 November.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported

that, maximum branches plant^{-1} (5.10) was observed in sowing date 16 October and the minimum branches plant^{-1} (3.20) was observed in sowing date 21 November.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum branches plant^{-1} (3.95) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (3.25) was recorded seeds were sown on D_4 (27Nov.).

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.,* D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.,* V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest number of branches plant^{-1} (10.16) was recorded from D_2 treatment and the lowest number of branches plant^{-1} (9.00) was recorded from D_5 treatment.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest branches plant^{-1} (29.55) was recorded from V_3 (Coral-437) and the lowest one (25.15) was from V_1 (Rohini). The highest branches plant^{-1} (31.00) was recorded from sowing date D_4 (25 Oct.) and the lowest one (23.51) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15^{th}& 25^{th}, Nov 5^{th}& 15^{th}) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum branches $plant^{-1}$ (17.70) was found when the seeds were sown on Oct. 15 and the minimum one (12.35) was found when the seeds were sown on Nov.15.

The experiment was conducted by Akhter *et al*. (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the maximum branches $plant^{-1}$ (4.75) was obtained from BINA Sarisha-5 and the minimum one (3.17) was obtained from BINA Sarisha-6. The maximum branches $plant^{-1}$ (4.67) was obtained from sowing date 18 October and the minimum one (3.07) was obtained from sowing date 3 December.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the maximum branches $plant^{-1}$ (3.30) was scored by mustard variety BARI Sarisha-6 and the minimum branches $plant^{-1}$ (1.59) was scored by mustard variety BARI Sarisha-9. The maximum branches $plant^{-1}$ (2.94) was scored by sowing date November 10 and the minimum branches $plant^{-1}$ (1.89) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum branches plant^{-1} (6.85) was scored by sowing date October 20 and the minimum branches plant^{-1} (6.20) was scored by sowing date November 30.

2.4 Siliquae plant^{-1} (no.)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the maximum siliquae plant^{-1} (125.06) was obtained by BARI Sarisha 15 and the minimum siliquae plant^{-1} (90.85) was obtained by BARI Sarisha 14. The maximum siliquae plant^{-1} (129.50) was obtained by sowing date 10 November and the minimum siliquae plant^{-1} (70.63) was obtained by sowing date 30 November.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported that, the maximum siliquae plant^{-1} (697.30) was observed in sowing date 16 October and the minimum siliquae plant^{-1} (329.50) was observed in sowing date 21 November.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were

four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum siliquae plant^{-1} (137) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (78) was recorded seeds were sown on D_4 (27Nov.).

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.,* D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.,* V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest siliquae plant^{-1} (141.98) was recorded from D_2 treatment and the lowest siliquae plant^{-1} (109.56) was recorded from D_5 treatment.

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15th& 25th, Nov 5th& 15th) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum siliquae plant^{-1} (363.10) was found when the seeds were sown on Oct. 15 and the minimum one (278.80) was found when the seeds were sown on Nov.15.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest siliquae plant^{-1} (316.22) was recorded from sowing date D_4 (25 Oct.) and the lowest one (239.82) was from sowing date D_1 (25 Sep.).

The experiment was conducted by Akhter *et al.* (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of

rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the maximum siliquae plant^{-1} (64.06) was obtained from BINA Sarisha-5 and the minimum one (41.61) was obtained from BINA Sarisha-6. The maximum siliquae plant^{-1} (78.93) was obtained from sowing date 18 October and the minimum one (30.59) was obtained from sowing date 3 December.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sharisha-15 (V_1), BINA Sharisha-5 (V_2) and BARI Sharisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the maximum number of siliquae plant^{-1} (194.70) was found from the treatment combination of the variety BINA Sharisha-5 and early sowing of 30 November and the minimum was (117.0) in BARI Sharisha-9 with delay sowing at 15 January.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and Binasarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the

maximum number of siliquae plant^{-1} was produced by the variety Improved Tori (120.27) and it was statistically similar with BARI sarisha-8, BARI sarisha-9, BARI sarisha-14 and BARI sarisha-15.On the contrary, two advanced lines (BC-05115 Y and BC-05117 Y) produced similar and lowest no. of siliquae plant^{-1} (46-49).

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum siliquae plant^{-1} (85.00) was achieved by T_2 (30 October) and the minimum siliquae plant^{-1} (68.50) was achieved by T_5 (15 November).

A field experiment was conducted by Gawariya *et al.* (2015) during rabi 2011-2012 at Forage Management and Research Centre, National Dairy Research Institute, Karnal to study the effect of date of sowing and crop geometry on seed yield and quality of forage mustard (var. Chinese cabbage)". There were 24 treatment combinations consisting of four dates of sowing (1st October, 16th October, 31st October and 15th November) and six crop geometry (60×15, 45×15, 45×20, 45×25, 30×20 and 30×25 cm) and the experiment was laid out in split plot design with four replications. The results of the experiment revealed that, the highest siliquae plant^{-1} (139.15) was recorded from sowing date 1 October and the lowest siliquae plant^{-1} (65.68) was recorded from sowing date 15 November.

A field experiment was conducted by Sattar *et al*. (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15th October), late (30th Oct) and very late (15th November). The results of their showed that, the maximum siliquae plant^{-1} (388.95) was recorded from sowing date 15th October and the minimum siliquae plant^{-1} (343.01) was recorded from sowing date 15th November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the maximum number of siliquae $plant^{-1}$ (153.26) was scored by mustard variety BARI Sarisha-6 and the minimum number of siliquae $plant^{-1}$ (138.75) was scored by mustard variety BARI Sarisha-9. The maximum number of siliquae $plant^{-1}$ (161.17) was scored by sowing date November 10 and the minimum number of siliquae $plant^{-1}$ (128.89) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum siliquae $plant^{-1}$ (85.00) was scored by sowing date October 30 and the minimum siliquae $plant^{-1}$ (66.00) was scored by sowing date November 30.

2.5 Seeds $siliqua^{-1}$ (no.)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha 15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the maximum seeds $siliqua^{-1}$ (33.84) was obtained by BARI Sarisha 14 and the minimum seeds $siliqua^{-1}$ (25.73) was obtained by BARI Sarisha 15. The maximum seeds $siliqua^{-1}$(32.10) was obtained by sowing date 20 November and the minimum seeds $siliqua^{-1}$ (26.10) was obtained by sowing date 10 November.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum seeds siliqua^{-1} (13.80) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and D_2 (7 Nov.) and the minimum one (12.7) was recorded seeds were sown on D_4 (27Nov.).

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest seeds siliqua^{-1} (13.44) was recorded from sowing date D_4 (25 Oct.) and the lowest one (10.91) was from sowing date D_1 (25 Sep.).

The experiment was conducted by Akhter *et al*. (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the maximum seeds siliqua^{-1} (26.61) was obtained from BINA Sarisha-5 and the minimum one (18.39) was obtained from BINA Sarisha-6. The

maximum seeds siliqua^{-1} (22.56) was obtained from sowing date 18 October and the minimum one (20.48) was obtained from sowing date 3 December.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sarisha-15 (V_1), BINA Sarisha-5 (V_2) and BARI Sarisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the maximum no. of seeds siliqua^{-1} (22.00) was found from the variety BINA Sarisha-5 in 30 November sowing and the minimum no. of seeds siliqua^{-1} was (13.00) in delay sowing of BARI Sarisha-9.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the maximum number of seeds siliqua^{-1}(36.27) was produced by the line BC-05118 Y and it was statistically identical to the line BC-05117 Y (31.23), BARI Sarisha-14(34.30) and BARI Sarisha-8 (32.37). The minimum number of seeds/siliqua was produced by the variety BARI sarisha-12(16.77) and it was similar to the variety Improved tori (19.43), TS-72 (17.20) and BARI sarisha-9(18.20) statistically.

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum seeds

siliqua^{-1} (29.00) was achieved by T_2 (30 October) and the minimum seeds siliqua^{-1} (20.10) was achieved by T_5 (15 November).

A field experiment was conducted by Sattar *et al*. (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15th October), late (30th Oct) and very late (15th November). The results of their showed that, the maximum seeds siliqua^{-1} (25.98) was recorded from sowing date 15th October and the minimum seeds siliqua^{-1} (19.05) was recorded from sowing date 15th November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the maximum number of seeds siliqua^{-1} (20.63) was scored by mustard variety BARI Sarisha-9 and the minimum number of seeds siliqua^{-1} (13.48) was scored by mustard variety BARI Sarisha-6. The maximum number of seeds siliqua^{-1} (18.39) was scored by sowing date November 20 and the minimum number of seeds siliqua^{-1} (16.11) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum seeds siliqua^{-1} (24.00) was scored by sowing date October 30 and the minimum seeds siliqua^{-1} (18.75) was scored by sowing date November 30.

2.6 Length of siliqua (cm)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the longer siliqua (4.92 cm) was obtained by BARI Sarisha 15 and the shorter siliqua (4.64 cm) was obtained by BARI Sarisha 14. The longer siliqua (5.35) was obtained by sowing date 30 November and the shorter siliqua (4.06) was obtained by sowing date 30 December.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum length of siliqua (4.74 cm) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (4.16 cm) was recorded seeds were sown on D_3 (17 Nov.).

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the longest siliqua (7.49 cm) was recorded from sowing date D_4 (25 Oct.) and the shortest one (5.68 cm) was from sowing date D_1 (25 Sep.).

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components

of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the maximum siliqua length (5.84 cm) was scored by mustard variety BARI Sarisha-9 and the minimum siliqua length (4.70 cm) was scored by mustard variety BARI Sarisha-6. The maximum siliqua length (5.64 cm) was scored by sowing date November 10 and the minimum siliqua length (4.59 cm) was scored by sowing date November 30.

2.7 1000 seed weight (g)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the higher 1000 grain weight (2.55 g) was obtained by BARI Sarisha 14 and the lower 1000 grain weight (2.36 g) was obtained by BARI Sarisha 15. The higher 1000 grain weight (3.09 g) was obtained by sowing date 20 November and the lower 1000 grain weight (1.80 g) was obtained by sowing date 30 December.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported that, the maximum 1000 grain weight (4.77 g) was observed in sowing date 16 October and the minimum 1000 grain weight (4.18 g) was observed in sowing date 21 November.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were

four sowing dates 27th October, 7th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the maximum 1000 grain weight (5.12 g) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (3.53 g) was recorded seeds were sown on D_4 (27 Nov.).

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest 1000 seed weight (4.74 g) was recorded from sowing date D_4 (25 Oct.) and the lowest one (4.39 g) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15th and 25th, Nov 5th and 15th) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum 1000 grain weight (6.70 g) was found when the seeds were sown on Oct. 15 and the minimum one (5.50 g) was found when the seeds were sown on Nov. 15.

The experiment was conducted by Akhter *et al*. (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three

varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the maximum 1000 seed weight (3.04 g) was obtained from BINA Sarisha-5 and the minimum one (2.74 g) was obtained from BINA Sarisha-6. The maximum 100 seed weight (3.11) was obtained from sowing date 18 October and the minimum one (2.67) was obtained from sowing date 3 December.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sharisha-15 (V_1), BINA Sharisha-5 (V_2) and BARI Sharisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the highest weight of 1000 seeds (3.29 g) was recorded from the variety BINA Sharisha-5 in early sowing of 30 November which was significantly differed with other treatment combinations. In contrast, the lowest weight of 1000-seeds (1.99 g) was found from the variety BARI Sharisha-9 in delay sowing of 15 January which was statistically similar (2.093 g) with the same variety in 30 December sowing.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the highest 1000 seed weight (4.00g) was recorded in the variety BINA Sarisha-4 while moderate seed weight found in BARI Sarisha-14 (3.67g) and BARI Sarisha-15 (3.63g). The lowest 1000 seed weight (2.90g) was recorded from the variety Improved Tori which was similar to variety TS-72 (2.97g) and line BC-05115 Y (2.90g) and BC-05118Y (2.93g).

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum 1000 grain weight (4.00 g) was achieved by T_2 (30 October) and the minimum 1000 grain weight (3.10 g) was achieved by T_5 (15 November).

A field experiment was conducted by Sattar *et al*. (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15^{th} October), late (30^{th} Oct) and very late (15^{th} November). The results of their showed that, the maximum 1000 grain weight (3.61 g) was recorded from sowing date 15^{th} October and the minimum 1000 grain weight (3.26 g) was recorded from sowing date date 15^{th} November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the maximum 1000 grain weight (2.76 g) was scored by mustard variety BARI Sarisha-6 and the minimum 1000 grain weight (2.68 g) was scored by mustard variety BARI Sarisha-9. The maximum 1000 grain weight (3.11 g) was scored by sowing date November 20 and the minimum 1000 grain weight (2.89 g) was scored by sowing date November 30.

2.8 Seed yield $plant^{-1}$ (g)

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best

sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the higher seed yield plot^{-1} (0.74 Kg) was obtained by BARI Sarisha 15. and the lower seed yield plot^{-1} (0.64 Kg) was obtained by BARI Sarisha 14. The higher seed yield plot^{-1} (1.12 Kg) was obtained by sowing date 20 November and the lower seed yield plot^{-1} (0.15 Kg) was obtained by sowing date 30 December.

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.*, D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest seed yield plant^{-1} (7.27 g) was recorded from D_2 treatment and the lowest seed yield plant^{-1} (5.08 g) was recorded from D_5 treatment.

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum seed yield plot^{-1} (450.00 g) was achieved by T_2 (30 October) and the minimum seed yield plot^{-1} (300.00 g) was achieved by T_5 (15 November).

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum seed yield plant^{-1} (3.78 g) was scored by sowing date October 30 and the minimum seed yield plant^{-1} (3.41 g) was scored by sowing date November 30.

2.9 Seed yield (t ha^{-1})

The experiment was investigated by Azam *et al.* (2018) in RARS, BARI Hathazari during Robi season in 2014-2015 and 2015-2016 to find out the best variety and best sowing time of mustard under the agro ecological condition of Chittagong region. There were two varieties viz. V_1=BARI Sarisha 14 and V_2=BARI Sarisha15 and six sowing date viz. S_1=10 November, S_2=20 November, S_3= 30 November, S_4=10 December, S_5=20 December and S_6=30 December. The results of the investigation revealed that, the higher seed yield (1240.70 Kg ha^{-1}) was obtained by BARI Sarisha 15 and the lower seed yield (1071.20 Kg ha^{-1}) was obtained by BARI Sarisha 14. The higher seed yield (1875.00 Kg ha^{-1}) was obtained by sowing date 20 November and the lower seed yield (250.00 Kg ha^{-1}) was obtained by sowing date 30 December.

The investigation was carried out by Singh *et al*. (2018) at Research farm of Punjab Agricultural University, Ludhiana in split-split plot design with three replications during rabi, 2015-16. Three cultivars of rapeseed-mustard (PBR 357, PC6 and GSC 7) as subplots were grown at three sowing dates as main plots along with two row orientations (north-south) and (east-west) as sub-sub plot. The crop was sown on 7th October, 17th October and 27th October, 2015. They concluded that, the highest grain yield (20.10 q ha^{-1}) was attained when the seeds were sown on 7th October and the lowest grain yield (14.80 q ha^{-1}) was attained when the seeds were sown on 27th October. The highest grain yield (19.10 q ha^{-1}) was attained by mustard cultivar PBR 357 and the lowest grain yield (15.90 q ha^{-1}) was attained by mustard cultivar PC 6.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported that, the maximum seed yield (2009.24 kg ha^{-1}) was observed in sowing date 16 October and the minimum seed yield (929.16 kg ha^{-1}) was observed in sowing date 21 November.

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the highest seed yield (1091 kg ha^{-1}) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (684 kg ha^{-1}) was recorded seeds were sown on D_4 (27 Nov.).

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.*, D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest seed yield (820 kg ha^{-1}) was recorded from D_2 treatment and the lowest seed yield (579 kg ha^{-1}) was recorded from D_5 treatment.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest seed yield (18.49 q ha^{-1}) was recorded from sowing date D_4 (25 Oct.) and the lowest one (14.02 q ha^{-1}) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15th& 25th, Nov 5th& 15th) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum seed yield (2.64 t ha^{-1}) was found when the seeds were sown

on Oct. 15 and the minimum one (1.60 t ha^{-1}) was found when the seeds were sown on Nov.15.

The experiment was conducted by Akhter *et al*. (2016) to investigate the effects of sowing time and weeding on the seed yield and yield components of three varieties of rapeseed at the experimental field of Rajshahi University Campus during from October, 2006 to March, 2007 and October, 2008 to March, 2009 growing seasons. The experiment was laid out in a split-split plot design with three replications. Each replicated field was divided into four main plots for sowing treatments (S_1 = 18 October, S_2 = 2 November, S_3 = 17 November, S_4 = 3 December). Each main plot was divided into three sub-plots for weeding treatment (W_0 = no weeding, W_1 = one hand weeding, W_2 = two hand weeding). Each sub-plot was lastly divided into three sub-sub plots for three varieties of rapeseed (V_1- BARI Sarisha-14, V_2- BINA Sarisha-5 and V_3= BINA Sarisha-6). They found that, the highest seed yield (750 Kg ha^{-1}) was obtained from BINA Sarisha-5 and the lowest one (519 Kg ha^{-1}) was obtained from BINA Sarisha-6. The maximum seed yield (908.00 Kg ha^{-1}) was obtained from sowing date 18 October and the minimum one (294.00 Kg ha^{-1}) was obtained from sowing date 03 December.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sarisha-15 (V_1), BINA Sarisha-5 (V_2) and BARI Sarisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, the highest grain yield (1.94 t ha^{-1}) was recorded from the treatment combination of the variety BINA Sarisha-5 and 30 November sowing and the lowest (1.08 t ha^{-1}) in delay sowing at 15 January with BARI Sarisha-9.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi

season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the variety BARI Sarisha-8 produced the maximum seed yield (1.46 t ha^{-1}) and it was statistically similar with BARI Sarisha-15 (1.29 t ha^{-1}), BARI Sarisha-14 (1.20 t ha^{-1}) and BINA Sarisha-4 (1.19 t ha^{-1}).On the other hand, lowest seed yield (0.72 t ha^{-1}) was obtained from the line BC-05115 Y.

The experiment was conducted by Alam *et al.* (2015) at Shibganj upazila under Bogra district during October, 2014 to January, 2015 to observe the effect of planting dates on the yield of mustard seed. There were five planting dates *viz.* 25 October, 30 October, 05 November, 10 November and 15 November. They reported that, the maximum seed yield (1.50 t ha^{-1}) was achieved by T_2 (30 October) and the minimum seed yield (1.00 t ha^{-1}) was achieved by T_5 (15 November).

A field experiment was conducted by Gawariya *et al.* (2015) during rabi 2011-2012 at Forage Management and Research Centre, National Dairy Research Institute, Karnal to study the effect of date of sowing and crop geometry on seed yield and quality of forage mustard (var. Chinese cabbage)". There were 24 treatment combinations consisting of four dates of sowing (1st October, 16th October, 31st October and 15th November) and six crop geometry (60×15, 45×15, 45×20, 45×25, 30×20 and 30×25 cm) and the experiment was laid out in split plot design with four replications. The results of the experiment revealed that, the highest seed yield (2013.48 kg ha^{-1}) was recorded from sowing date 1 October and the lowest seed yield (1216.62 kg ha^{-1}) was recorded from sowing date 15 November.

A field experiment was conducted by Sattar *et al.* (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot

size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15th October), late (30th Oct) and very late (15th November). The results of their showed that, the highest seed yield (2174.30 Kg ha^{-1}) was recorded from sowing date 15th October and the lowest seed yield (1816.90 Kg ha^{-1}) was recorded from sowing date 15th November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the higher seed yield (1.54 t ha^{-1}) was scored by mustard variety BARI Sarisha-6 and the lower seed yield (1.41 t ha^{-1}) was scored by mustard variety BARI Sarisha-9. The highest seed yield (2.77 t ha^{-1}) was scored by sowing date November 10 and the lowest seed yield (2.69 t ha^{-1}) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum seed yield plant^{-1}(1.86 t ha^{-1}) was scored by sowing date October 30 and the minimum seed yield plant^{-1} (1.47 t ha^{-1}) was scored by sowing date November 30.

2.10 Stover yield (t ha^{-1})

The field experiment was conducted by Lakra *et al*. (2018) during the winter (rabi) seasons of 2015-16 at Birsa Agricultural University Farm under irrigated condition. The experiment was laid out in split plot design with 3 replications. On main plots there were four sowing dates 27th October, 07th November 17th November and 27th November and on sub plots there were 5 planting geometries *viz.*30X10cm, 30X20cm, 30X30cm, 45X15cm and 45X30cm was laid out. They revealed that, the highest stover yield (3105 kg ha^{-1}) was recorded when the seeds were sown on sowing date D_1 (28 Oct.) and the minimum one (2229 kg ha^{-1}) was recorded seeds were sown on D_4 (27 Nov.).

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.*, D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the highest stover yield (2126.60 kg ha^{-1}) was recorded from D_2 treatment and the lowest stover yield 1255.30 kg ha^{-1}) was recorded from D_5 treatment.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest stover yield (57.81 q ha^{-1}) was recorded from sowing date D_4 (25 Oct.) and the lowest one (43.84 q ha^{-1}) was from sowing date D_1 (25 Sep.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct 15th and 25th, Nov 5th and 15th) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}).

They reported that, the maximum stover yield (9.19 t ha^{-1}) was found when the seeds were sown on Oct. 15 and the minimum one (6.01 t ha^{-1}) was found when the seeds were sown on Nov.15.

A field experiment was conducted by Gawariya *et al.* (2015) during rabi 2011-2012 at Forage Management and Research Centre, National Dairy Research Institute, Karnal to study the effect of date of sowing and crop geometry on seed yield and quality of forage mustard (var. Chinese cabbage)". There were 24 treatment combinations consisting of four dates of sowing (1st October, 16th October, 31st October and 15th November) and six crop geometry (60×15, 45×15, 45×20, 45×25, 30×20 and 30×25 cm) and the experiment was laid out in split plot design with four replications. The results of the experiment revealed that, the highest stover yield (10147.57 kg ha^{-1}) was recorded from sowing date 16 October and the lowest stover yield (4774.30 kg ha^{-1}) was recorded from sowing date 15 November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March, 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the higher stover yield (3.37t ha^{-1}) was scored by mustard variety BARI Sarisha-6 and the lower stover yield (3.34 t ha^{-1}) was scored by mustard variety BARI Sarisha-9. The higher stover yield (1.53 t ha^{-1}) was scored by sowing date November 10 and the lower stover yield (1.41 t ha^{-1}) was scored by sowing date November 30.

An experiment was conducted by Bhuiyan *et al.* (2008) at the Agriculture Research Station, Bangladesh Agricultural Research Institute, Burirhat, Rangpur during rabi season of 2004-05 to find out optimum planting time for the newly selected genotype BCYS-03. There were five planting dates for the experiment as follows: D_1 = October 20, D_2 = October 30, D_3 = November 10, D_4 = November 20 and D_5 = November 30. They revealed that, the maximum stover yield $plant^{-1}$ (6.06 t ha^{-1}) was scored by sowing date

October 20 and the minimum stover yield plant^{-1} (4.80 t ha^{-1}) was scored by sowing date November 30.

2.11 Biological yield (t ha^{-1})

The investigation was carried out by Singh *et al*. (2018) at Research farm of Punjab Agricultural University, Ludhiana in split-split plot design with three replications during rabi, 2015-16. Three cultivars of rapeseed-mustard (PBR 357, PC6 and GSC 7) as subplots were grown at three sowing dates as main plots along with two row orientations (north-south) and (east-west) as sub-sub plot. The crop was sown on 7th October, 17th October and 27th October, 2015. They concluded that, rhe highest biological yield (90.00 q ha^{-1}) was attained when the seeds were sown on 7th October and the lowest biological yield (79.40 q ha^{-1}) was attained when the seeds were sown on 27th October. The highest biological yield (86.80 q ha^{-1}) was attained by mustard cultivar PBR 357 and the lowest biological yield (83.00 q ha^{-1}) was attained by mustard cultivar PC 6.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported that, the maximum biological yield (5243.76 kg ha^{-1}) was observed in sowing date 16 October and the minimum biological yield (27.65.18 kg ha^{-1}) was observed in sowing date 21 November.

An investigation was carried out by Jiotode *et al.* (2017) at Agronomy Farm, College of Agriculture, Nagpur during rabi season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.*, D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.*, V_1 (Pusa bold) and V_2 (ACN-9) replicated thrice. The results revealed that, the biological yield (2946.60 kg ha^{-1}) was recorded from D_2 treatment and the lowest biological yield 18.34.30 kg ha^{-1}) was recorded from D_5 treatment.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, the maximum biomass yield (5.91 t ha^{-1}) was obtained by the variety BARI Sarisha-8 which was statistically identical with BINA Sarisha-4, BARI Sarisha-15, Improved Tori and the minimum (3.18 t ha^{-1}) by the line BC-05115 Y followed by BC-05117 Y, TS-72 and BARI Sarisha-12.

A field experiment was conducted by Sattar *et al*. (2013)to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15^{th} October), late (30^{th} Oct) and very late (15^{th} November). The results of their showed that, the highest biological yield (19112 Kg ha^{-1}) was recorded from sowing date 15^{th} October and the lowest seed yield (16386 Kg ha^{-1}) was recorded from sowing date 15^{th} November.

2.12 Harvest index (%)

The investigation was carried out by Singh *et al*. (2018) at Research farm of Punjab Agricultural University, Ludhiana in split-split plot design with three replications during rabi, 2015-16. Three cultivars of rapeseed-mustard (PBR 357, PC6 and GSC 7) as subplots were grown at three sowing dates as main plots along with two row orientations (north-south) and (east-west) as sub-sub plot. The crop was sown on 7^{th} October, 17^{th} October and 27^{th} October, 2015. They concluded that, the highest harvest index (22.30 %) was attained when the seeds were sown on 7^{th} October and the lowest harvest index

(18.70 %) was attained when the seeds were sown on 27th October. The highest harvest index (21.80 %) was attained by mustard cultivar PBR 357 and the lowest highest harvest index (19.10 %) was attained by mustard cultivar PC 6.

The experiment was conducted by Kumar *et al.* (2018) with 6 genotypes of Indian mustard (Brassica juncea L.) *viz.* RH-0116, RH-725, RH-923, RH-1019, RH-1077, RH-1301 for three dates of sowing *i.e.* 23 September, 16 October and 21 November in the field in randomized block design during rabi season of 2015-16 at Oil Seed Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar to observe the effect of sowing dates on yield and yield attributes of Indian mustard genotypes. They reported that, the maximum harvest index (38.20 %) was observed in sowing date 16 October and the minimum harvest index (33.30%) was observed in sowing date 21 November.

A field experiment was carried out by Singh *et al.* (2017) at Agronomy Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad during the Rabi season of 2011-12 to access the effect of sowing dates and varieties for higher productivity of Indian mustard (*Brassica juncea* L.). Treatments consisted of four dates of sowing viz. D_1 (25th September), D_2 (5th October), D_3 (15th October) and D_4 (25th October) was kept as main plot and five varieties viz.V_1 (Rohini), V_2 (Maya), V_3 (Coral-437), V_4 (Kranti) and V_5 (PBR-357) was kept as sub plot replicated three under split plot design. Results revealed that, the highest harvest index (24.36 %) was recorded from sowing date D_1 (25 Sep.) and the lowest one (24.31 %) was from sowing date D_4 (25 Oct.).

A field experiment was conducted by Keerthi *et al.* (2017) during rabi seasons of 2013-15 at Hisar to find out the response of Indian mustard to four dates of sowing (Oct. 15th & 25th, Nov. 5th & 15th) and five nitrogen levels (0, 40, 60, 80 and 100 kg N ha^{-1}). They reported that, the maximum harvest index (21.90 %) was found when the seeds were sown on Oct. 15 and the minimum one (19.60 %) was found when the seeds were sown on Nov. 15.

A field experiment was conducted by Sharif *et al.* (2016) at the Field Laboratory of the Patuakhali Science and Technology University, Patuakhali, Bangladesh during the period

from November, 2011 to March 2012 under the tidal Floodplain region. The experiment was consisted with two factors where three mustard genotypes *viz*., BARI Sarisha-15 (V_1), BINA Sarisha-5 (V_2) and BARI Sarisha-9 (V_3) was used as a factor A and four sowing time *viz.* 30 November (T_1), 15 December (T_2), 30 December (T_3) and 15 January (T_4) were used as a factor B. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The results of the experiments revealed that, maximum harvest index (32.67%) was found in BINA sarisha-5 with 30 November combination and the minimum (29.63%) in BARI Sarisha-9 with 15 January seed sowing.

An experiment of rapeseed-mustard was conducted by Helal *et al*. (2016) at the Agronomy Research field of Sylhet Agricultural University, Sylhet, during the Rabi season to identify the suitable short durable variety for utilizing the fallow land of Sylhet region that remain fallow after harvest of T. Aman rice. Eight varieties (Improved Tori, TS-72, BARI Sarisha-8, BARI Sarisha-9, BARI Sarisha-12, BARI Sarisha-14, BARI Sarisha-15, and BINA Sarisha-4) and four promising lines (BC-05115 Y, BC-05117 Y, BC-05118 Y and Nap-205) of rapeseed-mustard were evaluated. Results indicated that, maximum (27.73%) harvest index found in the variety BARI sarisha-14 and similar with BARI sarisha-15 (27.47%) and the minimum (23.57%) in the line BC-05118 Y.

A field experiment was conducted by Sattar *et al*. (2013) to investigate the response of phenology, yield and oil contents of canola cultivars to different sowing time which was carried out at Agronomic Research Area, University of Agriculture Faisalabad-Pakistan. The experiment was laid out in split plot design having three replications using net plot size of 5.0 m x 1.8 m. Treatments were comprised of three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates, early (15^{th} October), late (30^{th} Oct) and very late (15^{th} November). The results of their showed that, the highest harvest index (11.42 %) was recorded from sowing date 15^{th} October and the lowest seed yield (11.10 %) was recorded from sowing date 15^{th} November.

Study conducted by Afroz *et al.* (2011) at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November, 2007 to March,

2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The treatments included two varieties *viz.* BARI Sarisha-9 and BARI Sarisha-6; three sowing date *viz.* 10, 20 and 30 November, and three seed rates *viz*. 8, 10 and 12 kg seeds ha^{-1}. They reported that, the higher harvest index (31.33 %) was scored by mustard variety BARI Sarisha-6 and the lower harvest index (29.69 %) was scored by mustard variety BARI Sarisha-9. The higher harvest index (31.36 %) was scored by sowing date November 10 and the lower harvest index (29.75 %) was scored by sowing date November 30.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to study the growth and yield responses of rapeseed-mustard varieties grown with different sowing times. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-Ecological Zone - Modhupur Tract (AEZ -28). The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix- II.

3.1.2 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The prevailing weather conditions during the study period have been presented in Appendix-III.

3.2 Plant materials

BARI Sarisha-11 (mustard) and BARI Sarisha-17 (rapeseed) were used as planting material. BARI Sarisha-11 was released and developed by BARI in 2001. Plant height of the cultivar ranges from 120 to 130 cm. It produces 3-5 primary branches. Leaf with petiole and rough surface and green color. It produces 75-150 siliquae plant^{-1} with two chambers. Each siliqua contains 12-15 seeds. 1000 grain weight is 3.50-4.00 g. It produces 20-25% more grain than ‘Doulat’.

BARI Sarisha-17 developed through crossing between BARI Sarisha-15 and 'Sonali'. After field trial in regional research centre it has been released as a variety in 2013. It is a short duration crop. Total life span is 82-86 days. Average height is 95-97 cm. It produces 60-65 siliquae plant^{-1} and 28-30 seeds siliqua^{-1}. Seed with yellow color produces 3-4% more oil than brown color seed. 1000 grain weight is 3.00-3.40 g. Average yield is 1.70-1.80 t ha^{-1}. It produces 5-10 more grain than BARI Sarisha-14. Due to short duration it is well fitted to T. Aman-Mustard-Boro cropping pattern.

3.3 Treatments under investigation

There were two factors in the experiment namely variety and sowing time as mentioned below:

A. Factor-1: Variety (2):

a) V_1= BARI Sarisha-11 (Mustard)
b) V_2= BARI Sarisha-17 (Rapeseed)

B. Factor-2: Sowing time (5):

a) S_1= 2 November
b) S_2 = 9 November
c) S_3 = 16 November
d) S_4 = 23 November
e) S_5 = 30 November

3.4 Experimental design and layout

The experiment was laid out in Randomized Completely Block Design (RCBD) design having 3 replications. There were 10 treatment combinations and 30 unit plots. The unit plot size was 5 m^2 (2.5 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively.

3.5 Land preparation

The experimental land was opened with a power tiller on 22nd October, 2017. Ploughing and cross ploughing were done with this tiller followed by laddering. Land preparation was completed on 1st November, 2017 and was made ready for sowing seeds as of treatments designed.

3.6 Fertilizer application

The Urea, TSP, MoP, Gypsum, $ZnSO_4$ and Boric acid were applied @ 250 kg ha^{-1}, 170 kg ha^{-1}, 85 kg ha^{-1}, 150 kg ha^{-1}, 5 kg ha^{-1} and 5 kg ha^{-1}, respectively. All the fertilizers were applied during final land preparation except urea. A half portion of urea was applied during final land preparation and the rest half was applied at 20 DAS in all plots. All fertilizers were applied by broadcasting and covered with soil by laddering.

3.7 Sowing of seeds

Seeds were sown at the rate of 12 kg ha^{-1} in the furrow as of treatment and the furrows were covered with the soils soon after seeding. The rows were made in 30 cm apart and the seeds were sown continuously in row by hand. The seed to seed distance (10 cm) were tried to maintain while thinning of the crop.

3.8 Intercultural operations

3.8.1 Weed control

The crop was infested with some weeds during the early stage of crop establishment. Two hand weddings were done; first weeding was done at 10 days after sowing followed by second weeding at 15 days after first weeding.

3.8.2 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre sowing and second was done at 20 DAS and the third one was done at 50 DAS.

3.8.3 Plant protection measures

The crop was infested by common cutworm. Siphanon 57 E.C. (containing active ingredient malathion) was applied two times at an interval of 1 week to control insect, 1st one was at 20 DAS. There was no disease infestation during the experimentation period, so no fungicide was applied.

3.9 Harvesting and sampling

The crop was harvested plot wise when about 80% of the pods became yellowish in color. Samples were collected from different places of each plot leaving undisturbed very small in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor.

3.10 Threshing

Seeds were separated from the plants by beating the bundles with bamboo sticks. The seeds were separated, cleaned and dried in the sun for 3 to 5 days for achieving safe moisture of seed.

3.11 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.12 Recording of data

The data were recorded on the following parameters

i. Plant height (cm)
ii. Dry matter weight plant^{-1} (g)
iii. Branches plant^{-1} (no.)
iv. Siliquae plant^{-1} (no.)
v. Seeds siliqua^{-1} (no.)

vi. Length of siliqua (cm)
vii. 1000 seed weight (g)
viii. Seed yield (t ha^{-1})
ix. Stover yield (t ha^{-1})
x. Biological yield (t ha^{-1})
xi. Harvest index (%)

3.13 Procedure of recording data

i. Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant at 30, 45, 60 DAS and harvest.

ii. Dry matter content $plant^{-1}$(g)

Ten plants were collected randomly from each plot at 30, 45, 60 DAS and harvest. The sample plants were oven dried for 72 hours at 70°C and then dry matter content $plant^{-1}$ was determined.

iii. Branches $plant^{-1}$ (no.)

The branches $plant^{-1}$ was counted from five randomly sampled plants at harvest. It was done by counting total number of branches of all sampled plants then the average data were recorded.

iv. Siliquae $plant^{-1}$ (no.)

Siliquae $plant^{-1}$ was counted from the 10 selected plant sample and then the average siliqua number was calculated.

v. Length of siliqua (cm)

Length of siliqua was measured by meter scale from 10 siliquae of plants and then the average length was calculated.

vi. Seeds siliqua^{-1} (no.)

Seeds siliqua^{-1} was counted from 20 selected siliquae of plants and then the average seed number was calculated.

vii. Weight of 1000 seeds (g)

1000 seeds were counted, which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were recorded.

viii. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} and was calculated in t ha^{-1}.

ix. Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell harvested area was sun dried and the weight was recorded and then converted into t ha^{-1}.

x. Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield was the biological yield. Biological yield (t ha^{-1}) =Grain yield (t ha^{-1}) + Stover yield (t ha^{-1}).

xi. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

Harvest index (HI %) = $\frac{Seed yield}{Biological yield} \times 100$

Here, Biological yield = Grain yield + stover yield

3.14 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

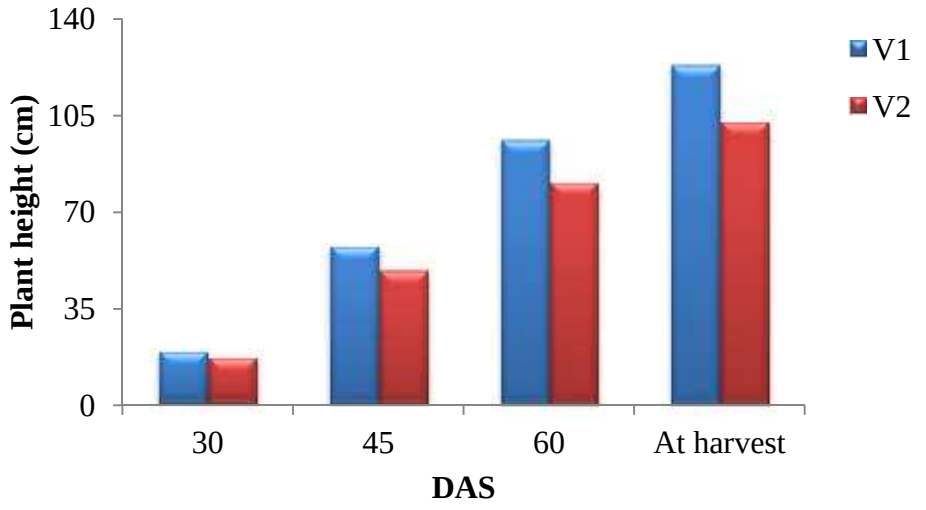
RESULTS AND DISCUSSION

Results obtained from the present study regarding the growth and yield responses of rapeseed-mustard varieties grown with different sowing times have been presented, discussed and compared in this chapter. The analytical results have been presented in tables (1 to 4) and figures (1 to 24).

4.1 Plant height (cm)

4.1.1 Effect of variety

Plant height of mustard was significantly influenced by different mustard varieties at all the growth period except 60 days after sowing (DAS) shown in the figure 1. The obtaining results of our investigation revealed that, the tallest plant (19.04 cm, 56.97 cm and 122.77 cm) were recorded from BARI Sarisha-11 (V_1) at 30, 45 DAS and harvest, respectively and the shortest plant (16.76 cm, 48.25 cm and 102.30 cm) were recorded from BARI Sarisha-17 (V_2) at 30, 45 DAS and harvest, respectively. These results were in the agreement with the result of Azam *et al.* (2018), Jiotode *et al.* (2017), Alam *et al.* (2015), Alam (2014) Awasthi *et. al.*, (2007), Rahman *et al.* (2007), Sharma (2006), Sana *et al*. (2003) and Ali *et al.*,(1996) who stated that plant height differed significantly among the mustard varieties. Akhter *et al.* (2016) reported that BINA Sarisha-6 possessed the maximum plant height while BARI Sarisha-14 had the minimum plant height. Helal *et al.* (2016) reported that the variety BARI Sarisha-15 produced the tallest plant (122.0cm) and it was identical with BARI Sarisha-8 (117.5cm) and line BC-05118 Y (109.4cm).



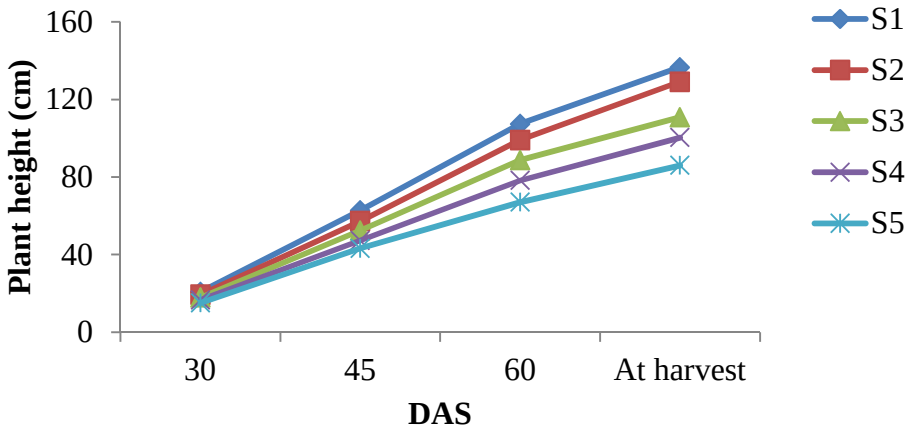
V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 1. Effect of variety on the plant height of mustard at different days after sowing (LSD $_{0.05}$ = 1.36, 3.69, 7.06 and 8.87 at 30, 45, 60 DAS and harvest, respectively)

4.1.2 Effect of sowing time

Plant height of mustard was significantly influenced by different sowing times at all the growth periods; shown in the figure 2. The obtaining results of our investigation revealed that, the tallest plant (20.72 cm, 62.80 cm, 107.30 cm and 136.50 cm) were recorded when the mustard sown on 2 November (S_1) at 30, 45, 60 DAS and harvest, respectively which were statistically similar with when the mustard sown on 9 November (S_2) at 30, 45, 60 DAS and harvest and the shortest plant (15.05 cm, 43.19 cm, 67.02 cm and 85.96 cm) were recorded when the mustard sown on 30 November (S_5) at 30, 45, 60 DAS and at harvest, respectively which were statistically similar with when the mustard sown on 23 November (S_4) at 30 and 40 DAS. Thermo and photosensitivity of oil seed crop limits the sowing period. Delayed sowing causes the mortality of tender seedling due to chilling temperature which retarded the cell division and enlargement and also degenerated cell due to chilling temperature. Lakra *et al.* (2018) reported that crop sown on 27th October and 07th November produced taller plants. Plant height decreased with progressive delay in sowing from 27th October to 27th November. Our results were compatible with the studies carried out by Azam *et al.* (2018), Jiotode *et al.* (2017), Singh *et al.* (2017),Akhter

et al. (2016), Alam *et al.* (2015), Sattar *et al.* (2013), Fashami *et al.* (2012), Turhan *et al.* (2011), Uzun *et al*. (2009), Bhuiyan *et al.* (2008), Razzaque *et al.* (2007), Ghanbahadur and Lanjewar (2004), Robertson *et al*. (2004), Kumar and Kumar (2002), and Oz (2002) who reported that plant height decreased with too early and delayed sowing.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 2. Effect of sowing time on the plant height of mustard at different days after sowing (LSD $_{0.05}$ = 2.15, 5.84, 11.16 and 14.02 at 30, 45, 60 DAS and harvest)

4.1.3 Interaction effect of variety and sowing date

Plant height of mustard was significantly influenced by the interaction effect of different mustard varieties and sowing times at all the growth periods; shown in the table 1. The obtaining results of our investigation revealed that, the tallest plant (21.84 cm, 66.98 cm, 116.20 cm and 145.80 cm) were recorded when the mustard variety BARI Sarisha-11(V_1) sown on 2 November (S_1) at 30, 45, 60 DAS and harvest, respectively which were statistically similar with V_1S_2, V_1S_3 and V_2S_1 at 30 DAS; with V_1S_2 at 45, 60 and harvest. On the other hand, the shortest plant (14.13 cm, 38.62 cm, 60.08 cm and 77.18 cm) were recorded when the mustard variety BARI Sarisha-17 (V_2) sown on 30 November (S_5) which were statistically similar with the treatment combinations V_2S_4 and V_2S_3 at 30 DAS; with V_2S_4 at 45, 60 DAS and harvest. Plant height is one of the most important growth contributing characters for any corps which would be related on several factors like genetic makeup, nutrient availability, environmental or climatic condition, soil

characteristics, regional adaptability etc. These results were in the agreement with the result of Azam *et al.* (2018), Sharif *et al.* (2016), Umeh *et al*. (2011), Mahmud Abadi *et al*. (2008) and Rahman *et al.* (2007) who stated that plant height differed significantly among the interaction of mustard varieties and sowing times.

Table 1. Interaction effect of variety and sowing times on the plant height of mustard at different days after sowing (DAS)

Treatment combinations	Plant height at DAS			
	30	45	60	At Harvest
V_1S_1	21.84 a	66.98 a	116.2 a	145.8 a
V_1S_2	20.80 ab	62.03 ab	107.4 ab	138.9 ab
V_1S_3	19.03 a-c	56.74 bc	96.19 b-d	123.5 bc
V_1S_4	17.56 cd	51.31 c-e	84.84 c-e	110.9 cd
V_1S_5	15.97 de	47.76 de	73.96 ef	94.73 d-f
V_2S_1	19.60 a-c	58.62 bc	98.36 bc	127.3 a-c
V_2S_2	17.86 b-d	52.51 cd	90.85 cd	119.3 bc
V_2S_3	16.63 c-e	48.15 de	81.25 de	98.15 de
V_2S_4	15.60 de	43.34 ef	71.56 ef	89.59 ef
V_2S_5	14.13 e	38.62 f	60.08 f	77.18 f
LSD $_{(0.05)}$	**3.03**	**8.26**	**15.78**	**19.83**
CV (%)	**9.88**	**9.16**	**10.44**	**10.27**

Values with common letter(s) within a column do not differ significantly at 5% level of probability

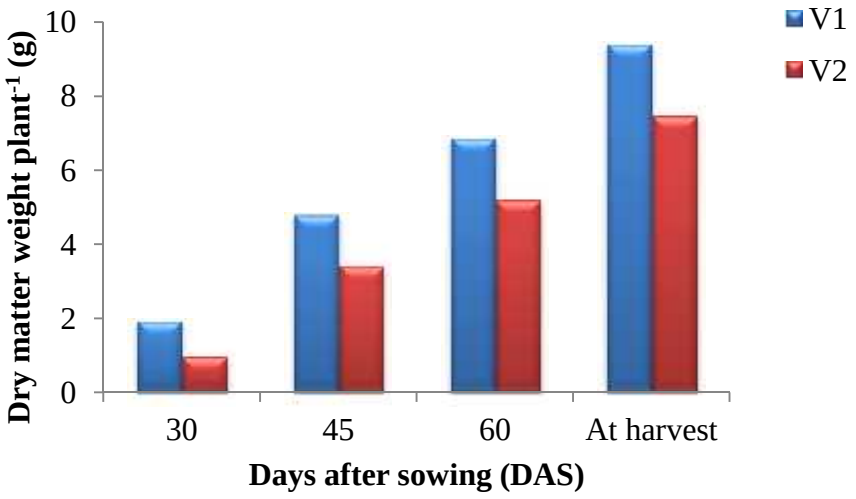
V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17; S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

4.2 Dry matter weight plant^{-1} (g)

4.2.1 Effect of variety

Dry matter weight pant^{-1} of mustard was significantly affected by varietal variation at all the growth durations (Figure 3). The obtaining results of our study revealed that, the maximum dry matter weight plant^{-1} (1.89 g, 4.76 g, 6.84 g and 9.37 g) were obtained from BARI Sarisha-11 (V_1) at 30, 45, 60 DAS and harvest, respectively and minimum dry matter weight plant^{-1} (0.94 g, 3.39 g, 5.18 g and 7.43 g) were obtained from BARI

Sarisha-17 (V_2) at 30, 45, 60 DAS and harvest, respectively. Dry matter production pattern at different days after sowing showed that different varieties varied their dry matter production pattern. The probable reason of varying dry matter production may be attributed to genetic characters of tested mustard varieties which have higher capacity to utilize the photosynthates more efficiently through maximum leaf area index, number of branches plant^{-1} and ultimately the dry matter production. Helal *et al.* (2016) reported that dry matter of BARI Sarisha-8 was the highest (309.21 g plant^{-1}) and the lowest (163.93g plant^{-1}) from variety BARI Sarisha-14. The similar findings have also been reported by Jiotode *et al.* (2017), Singh *et al.* (2017), Chaplot *et al.,* 2012, Shukla *et al.,* (2001) and Kumar *et al.,* (2000) who reported that the dry matter production of mustard varied due to varietal difference.



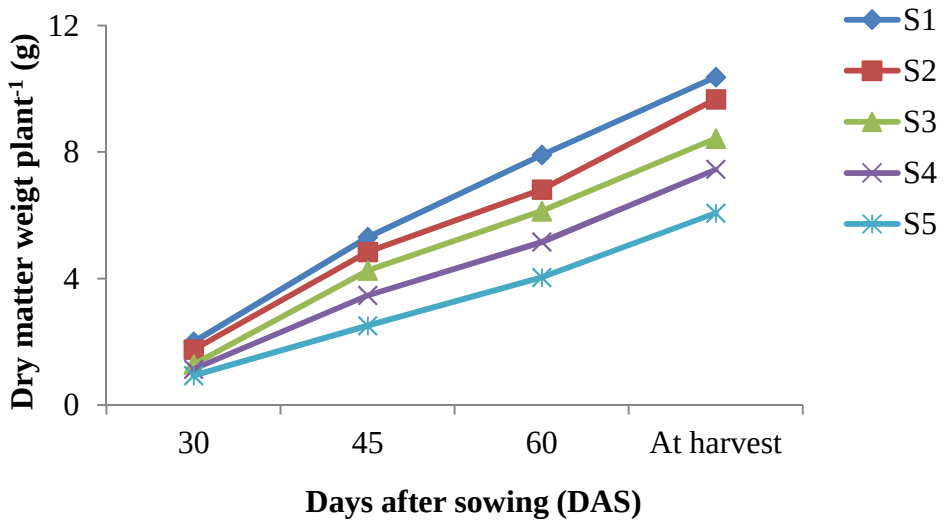
V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 3. Effect of variety on the dry matter weight plant^{-1} of mustard at different days after sowing (LSD $_{0.05}$ =0.14, 0.28, 0.46 and 0.60 at 30, 45, 60 DAS and harvest)

4.2.2 Effect of sowing time

Dry matter weight plant^{-1} of mustard was significantly varied by different sowing times at all the growth periods (Figure 4). The obtaining results of our study revealed that, the maximum dry matter weight plant^{-1} (2.00 g, 5.31 g, 7.91 g and 10.37 g) were obtained from sowing time S_1 at 30, 45, 60 DAS and harvest, respectively which were statistically

at par with S_2 only at harvest and the minimum dry matter weight plant^{-1} (0.93 g, 2.51 g, 4.04 g and 6.07 g) were obtained from sowing time S_5 at 30, 45, 60 DAS and harvest, respectively which were statistically at par with S_4 only at 30 DAS. Jiotode *et al.* (2017) reported that accumulation dry matter plant^{-1} (g) is considered as the best index of crop growth put forth by crop. Optimum sowing period facilitates luxurious crop growth resulting in maximum dry matter accumulation. Accumulation of dry matter in the plant is directly related to their vigorous plant height, leaf area index and number of branches plant^{-1} which were appreciably depressed as sowing were delayed. Singh *et al.* (2017) reported that crop sown on 25th October accumulated significantly higher dry mater plant^{-1} which did not differed significantly than those sown on 15th October. However, crop sown on 5th October and 25th September accumulated lower dry matter than 25th October sowing. These results were conformation with the findings reported by Sharma (2006), Khushu and Singh (2005), Ghanbahadur and Lanjewar (2004), Panda *et al*. (2004) and Kumar (2002) who concluded that there were drastic decrease in dry matter accumulation of mustard was also observed due to too early and late sowing of mustard.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 4. Effect of sowing time on the dry matter weight plant^{-1} of mustard at different days after sowing (LSD $_{0.05}$ = 0.22, 0.44, 0.73 and 0.95 at 30, 45, 60 DAS and harvest)

4.2.3 Interaction effect of variety and sowing time

Dry matter weight plant^{-1} of mustard was significantly varied by the interaction effect of different mustard varieties and sowing times (Table 2). The obtaining results of our study revealed that, the maximum dry matter weight plant^{-1} (2.76 g, 6.04 g, 8.79 g and 11.20 g) were obtained from treatment combination V_1S_1 at 30, 45, 60 DAS and harvest, respectively which were statistically at par with V_1S_2 at 45 DAS and harvest and the minimum dry matter weight plant^{-1} (0.70 g, 1.97 g, 3.05 g and 4.80 g) were obtained from treatment combination V_2S_5 at 30, 45, 60 DAS and harvest, respectively which were statistically at par with V_2S_4 and V_2S_3 at 30 DAS; with V_2S_4 at 60 DAS. Similar findings were also reported by Sharif *et al.* (2016) and Hokmalipour *et al*. (2011) who reported that maximum dry matter accumulation was (21.63 g plant^{-1}) found in BARI Sarisha-9 plants planted with 10 November.

Table 2. Interaction effect of variety and sowing times on the dry matter weight plant^{-1} of mustard at different days after sowing (DAS)

Treatment combinations	Dry matter weight plant^{-1} (g) at different days after sowing			
	30	45	60	At Harvest
V_1S_1	2.76 a	6.04 a	8.79 a	11.20 a
V_1S_2	2.45 b	5.44 ab	7.26 b	10.62 ab
V_1S_3	1.64 c	5.10 bc	6.86 b	9.24 c
V_1S_4	1.45 cd	4.15 d	6.24 bc	8.43 c-e
V_1S_5	1.16 d-f	3.05 ef	5.02 de	7.33 ef
V_2S_1	1.23 de	4.57 cd	7.02 b	9.53 bc
V_2S_2	1.05 e-g	4.23 d	6.37 bc	8.73 cd
V_2S_3	0.92 f-h	3.41 e	5.39 cd	7.61 d-f
V_2S_4	0.82 gh	2.78 f	4.06 ef	6.47 f
V_2S_5	0.70 h	1.97 g	3.05 f	4.80 g
LSD $_{(0.05)}$	**0.31**	**0.62**	**1.03**	**1.35**
CV (%)	**12.84**	**8.84**	**10.03**	**9.37**

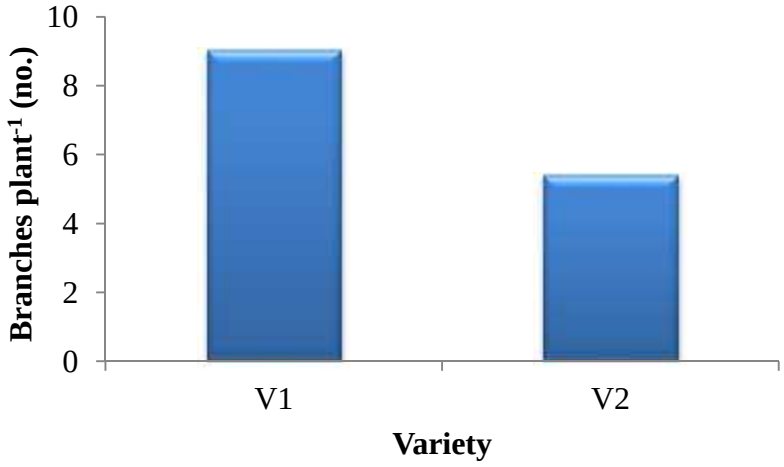
Values with common letter(s) within a column do not differ significantly at 5% level of probability

V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17; S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

4.3 Branches plant^{-1} (no.)

4.3.1 Effect of variety

Branches plant^{-1} was significantly influenced by varietal variation (Figure 5). Results showed that, the V_1 produced maximum branches plant^{-1} (9.00) where as the minimum branches plant^{-1} was obtained from V_2 (5.36). These results showed that the difference among branches plant^{-1} might be due to the genetic variation in varietals character. Akhter *et al.* (2016) revealed that BINA Sarisha-5 produced highest branches plant^{-1} followed by BARI Sarisha-14 and BINA Sarisha-6. Mamun *et al.* (2014) also revealed that BARI Sarisha-15 produced 7.45 branches plant^{-1} whereas, minimum branches plant^{-1} produced by the mustard line BC-05117Y. The finding of our investigation were agreement with those of Jiotode *et al.* (2017), Singh *et al.* (2017), Helal *et al.* (2016), Sattar *et al.* (2013), Chaplot *et al.*, (2012), Cheema *et al.* (2012), Ghanbahadur and Lanjewar (2004), Sana *et al*. (2003), Shukla *et al.*, (2001) and Kumar *et al.* (2000) who also reported significant differences in branches plant^{-1} among different varieties of mustard.

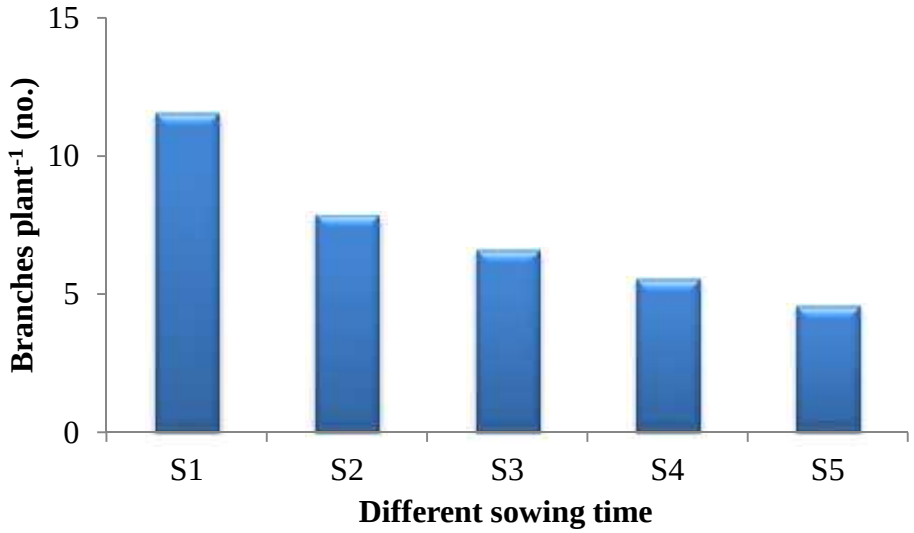


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 5. Effect of variety on the branches plant^{-1} of mustard (LSD $_{0.05}$=0.67)

4.3.2 Effect of sowing time

Different sowing time significantly influenced the branches plant^{-1} of mustard (Figure 6). The highest branches plant^{-1} (11.50) was obtained from the S_1. On the other hand the lowest branches plant^{-1} (4.50) was obtained from S_5 which was statistically similar with S_4. This could be ascribed due to prolonged vegetative growth period because of congenial environmental conditions, especially atmospheric temperature which formed a basis for rapid cell division in the meristematic tissues of the experimental crop which led to better growth attributes under normal sowing (11th October). These results are in conformity with the findings of Kumar *et al.* (2018), Jiotode *et al.* (2017), Singh *et al.* (2017), Akhter *et al.* (2016), Gawariya *et al.*(2015),Solanki and Mundra (2015), Singh *et al.* (2014), Dotaniya and Meena (2013), Fashami *et al.* (2012), Bhuiyan *et al.* (2008), Ghanbahadur and Lanjewar (2004), Panda *et al.* (2004), Kumar *et al*. (2004), Angrej *et al.* (2002), Sharif and Keshta (2002), Singh and Singh (2002), Kumar *et al.* (2002), Kurmi (2002) and Belgammwar (1998) who reported that delayed sowing drastically reduced the branches plant^{-1} in mustard crop.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 6. Effect of sowing time on the branches plant^{-1} of mustard (LSD $_{0.05}$=1.05)

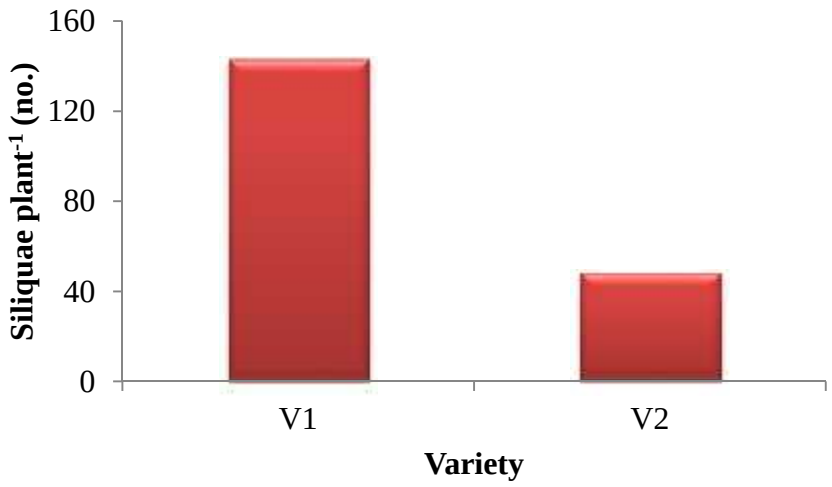
4.3.3 Interaction effect of variety and sowing time

Interaction effect of different varieties and sowing times significantly influenced the branches plant^{-1} of mustard (Table 3). The maximum branches plant^{-1} (16.00) was obtained from the treatment combination V_1S_1 and the minimum one (3.67) was obtained from treatment combinations V_2S_5 which was statistically similar with V_2S_4 and V_2S_3. These findings were close accordance with Azam *et al.* (2018) and Rahman *et al.* (2007) who stated that branches plant^{-1} differed significantly among the interaction of mustard varieties and sowing dates.

4.4 Siliquae plant^{-1} (no.)

4.4.1 Effect of variety

Siliquae plant^{-1} was significantly differed by varietal variation (Figure 7). Results revealed that, the V_1 scored maximum siliquae plant^{-1} (142.28) where as the minimum siliquae plant^{-1} (47.73) was scored by V_2. It was attributed due to genetic characters which truly indicated of total photosynthates production of mustard variety. Jiotode *et al.* (2017) found that among the two varieties (Pusa bold) found to be significantly superior over (ACN-9). Akhter *et al.* (2016) also found that BINA Sarisha-5 had the highest number of siliquae plant^{-1} followed by BARI Sarisha-14 and BINA Sarisha-6. The finding of our study experiment was agreement with those of Kumar *et al.* (2018), Singh *et al.* (2017), Helal *et al.* (2016), Sattar *et al.* (2013), Chaplot *et al.*, (2012), Cheema *et al.* (2012), Shukla *et al.* (2001) and Kumar *et al.* (2000) who also reported significant differences in siliquae plant^{-1} among different varieties of mustard.

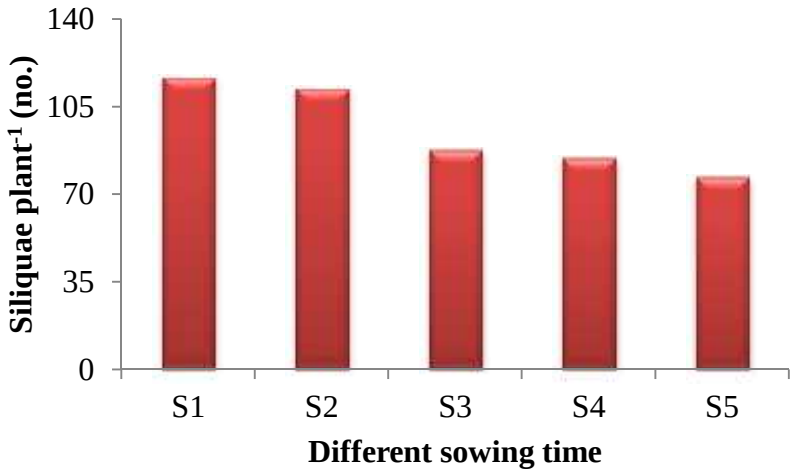


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 7. Effect of variety on the siliquae plant^{-1} of mustard ($LSD_{0.05}$= 7.31)

4.4.2 Effect of sowing time

Different sowing time was significantly differed the siliquae plant^{-1}of mustard (Figure 8). The maximum siliquae plant^{-1} (116.30) was scored by S_1 which was statistically similar with S_2 where as the minimum siliquae plant^{-1} (76.33) was scored by S_5 which was statistically similar with S_3 and S_4. This might be due to the fact that high temperature during the flowering burn pollen grain that facilitated lower rate of pollination and flower abortion, shedding in delayed sown mustard crop. On the other hand in optimum planting date the plant produced higher number of quality flower and the flowers got favorable condition for producing pollen grain and better pollination were occurred which ultimately increased the siliqua number. Jiotode *et al.* (2017) reported that siliquae initiation was progressively delayed due to late sowing as the crop took more days to flower initiation in late or advanced sowing after branching. Akhter *et al.* (2016) and Rahman *et al.* (1993) reported that the number of siliquae plant^{-1} greatly reduced for each week delay after 2 November sowing. These findings were close accordance with the Azam *et al.* (2018), Kumar *et al.* (2018), Singh *et al.* (2017), Alam *et al.* (2015), Panda *et al*. (2004),Singh and Singh (2002), Singh *et al*., (2001), Mondal *et al*. (1999), Balgamwar (1998), Thakur and Singh (1998) and Shashtry and kumar (1981).



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 8. Effect of sowing time on the siliquae plant^{-1} of mustard (LSD $_{0.05}$= 11.55)

4.4.3 Interaction effect of variety and sowing time

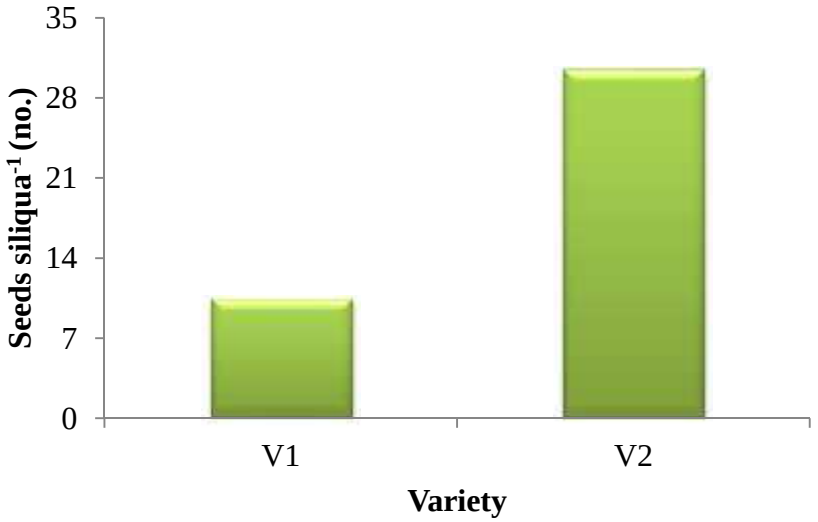
Interaction effect of different varieties and sowing times significantly influenced the siliquae plant^{-1}of mustard (Table 3). The maximum siliquae plant^{-1}(170.70) was scored by the treatment combination V_1S_1 which was statistically similar with V_1S_2 and the minimum one (35.00) was scored by treatment combinations V_2S_5 which was statistically similar with V_2S_4 and V_2S_3. Similar findings were also observed by Sharif *et al.* (2016), Aziz *et al*. (2011) and Umeh *et al*. (2011) who concluded that the maximum number of siliqua plant^{-1} (194.70) was found from the treatment combination of the variety BINA Sarisha-5 and early sowing of 30 November and the minimum was 117.0 in BARI Sarisha-9 with delay sowing at 15 January.

4.5 Seeds siliqua^{-1} (no.)

4.5.1 Effect of variety

Length of siliqua was significantly differed by varietal variation (Figure 9). Results exposed that, the V_2 scored maximum seeds siliqua^{-1} (30.40) where as the minimum Length of siliqua (10.33) was scored by V_1. These results showed that the difference among seeds siliqua^{-1} might be due to the genetic variation in varietals character. Helal *et al.* (2016) reported that the maximum number of seeds siliqua^{-1} (36.27) was produced by

the line BC-05118 Y and it was statistically identical to BARI Sarisha-14 (34.30) and BARI Sarisha-8 (32.37). The minimum number of seeds siliqua^{-1} was produced by the variety BARI Sharisha-12 (16.77). The finding of our study was agreement with those of Akhter *et al.* (2016), Sattar *et al.* (2013), Cheema *et al.* (2012) and Jahan *et al.* (1997) who also reported significant seeds siliqua^{-1} among different varieties of mustard.

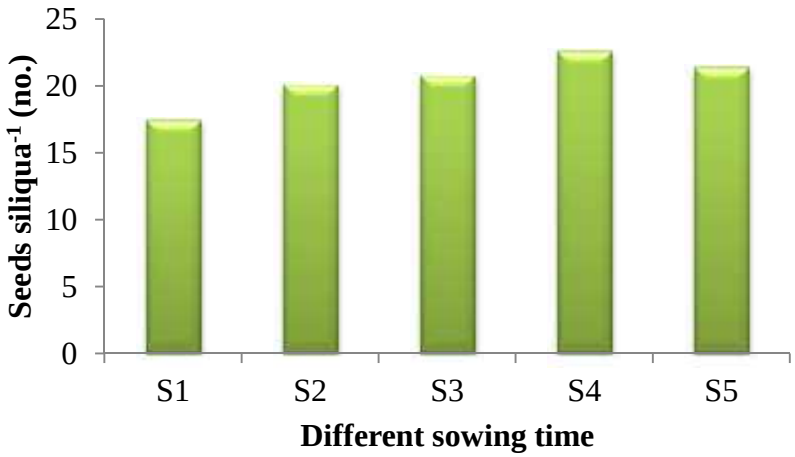


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 9. Effect of variety on the seeds siliqua^{-1} of mustard ($LSD_{0.05}$= 1.51)

4.5.2 Effect of sowing time

Different sowing times significantly influenced the seeds siliqua^{-1} of mustard (Figure 10). Result exposed that the maximum seeds siliqua^{-1} (22.50) was scored by S_4 which was statistically similar with S_1 and S_3 where as the minimum seeds siliqua^{-1} (17.33) was scored by S_1. The results of the present investigation with respect of seeds siliqua^{-1} fairly agreed with the findings of Azam *et al.* (2018), Akhter *et al.* (2016), Fashami *et al.* (2012), Bhuiyan *et al.* (2008), Razzaque *et al.* (2007), Nag *et al.* (2000), Mondal *et al.*, (1999), Bukhtiar *et al.* (1992) and Kalra *et al.* (1985).



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 10. Effect of sowing time on the seeds siliqua^{-1} of mustard (LSD $_{0.05}$= 2.39)

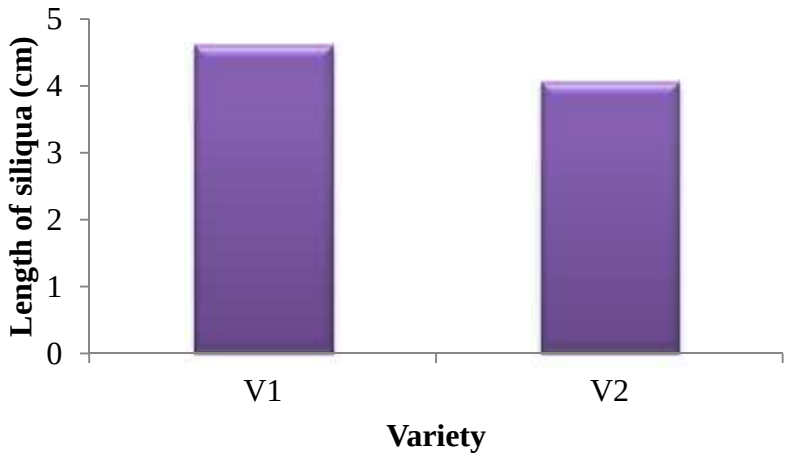
4.5.3 Interaction effect of variety and sowing time

Interaction effect of different varieties and sowing times significantly influenced the Length of siliqua of mustard (Table 3). The maximum seeds siliqua^{-1} (33.33) was scored by both the treatment combinations V_2S_5 and V_2S_4 which were statistically similar with V_2S_3 and the minimum one (9.33) was scored by treatment combinations V_1S_5 which was statistically similar with V_1S_1, V_1S_3, V_1S_2 and V_1S_4. Similar result also reported by Sharif *et al.* (2016), Aziz *et al*. (2011) and Umeh *et al*. (2011) who reported that seeds siliqua^{-1} varied due to interaction of mustard variety and sowing time.

4.6 Length of siliqua (cm)

4.6.1 Effect of variety

Significant variation was found for length of siliqua due to varietal difference (Figure11). Results proposed that, the V_1 produced longer siliqua (4.59 cm) where as the shorter one (4.04 cm) was produced by V_2.

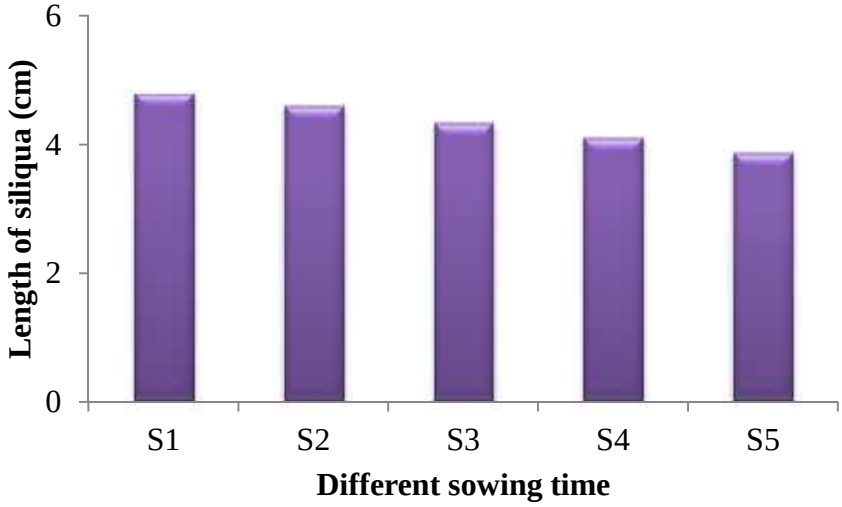


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 11. Effect of variety on the length of siliqua of mustard ($LSD_{0.05}$= 0.25)

4.6.2 Effect of sowing time

Significant variation was found for length of siliqua due to different sowing time (Figure12). Result exposed that the longest siliqua (4.77 cm) was produced by S_1 which was statistically similar with S_2 where as the shortest one (3.85 cm) was scored by S_5 which was statistically similar with S_4.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 12. Effect of sowing time on the length of siliqua of mustard ($LSD_{0.05}$= 0.39)

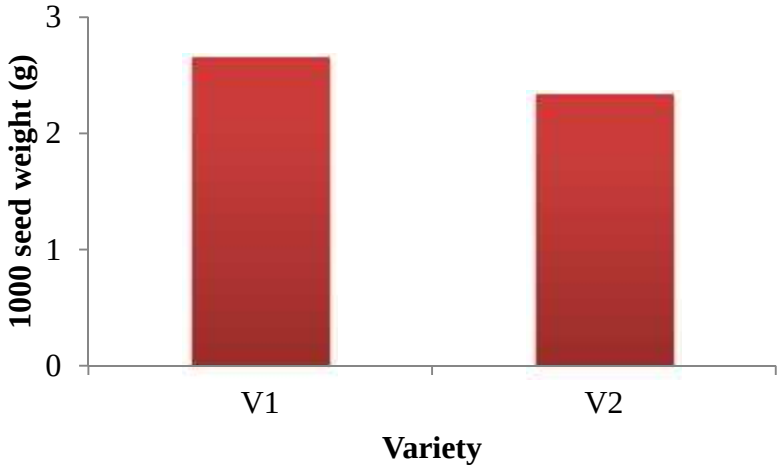
4.6.3 Interaction effect of variety and sowing time

Significant variation was found for length of siliqua due to interaction of different variety and sowing time (Table 3). Result proposed that, the longest siliqua (4.93 cm) was produced by the treatment combination V_1S_1 which were statistically similar with V_1S_2, V_1S_3 and V_2S_1 and the shortest one (3.47) was scored by treatment combinations V_2S_5 which was statistically similar with V_2S_3 and V_2S_4.

4.7 1000 seed weight (g)

4.7.1 Effect of variety

The 1000 seed weight was significantly influenced by the variety (Figure 13). The higher 1000 seed weight (2.65 g) was obtained from V_1 and the lower 1000 seed weight (2.33 g) was obtained from V_2. The variation of 1000-seeds weight between two varieties might be due to genetic constituents of the crops. The result of the present investigation was similar with the studies conducted by Akhter *et al.* (2016) Mamun *et al*., (2014) and Mondal *et al*. (2001) who reported that 1000 seed weight differed with varietal differences. Helal *et al.* (2016) reported that the highest 1000 seed weight (4.00g) was recorded in the variety BINA Sarisha-4 while lowest one found in BARI Sarisha-15 (3.63g).

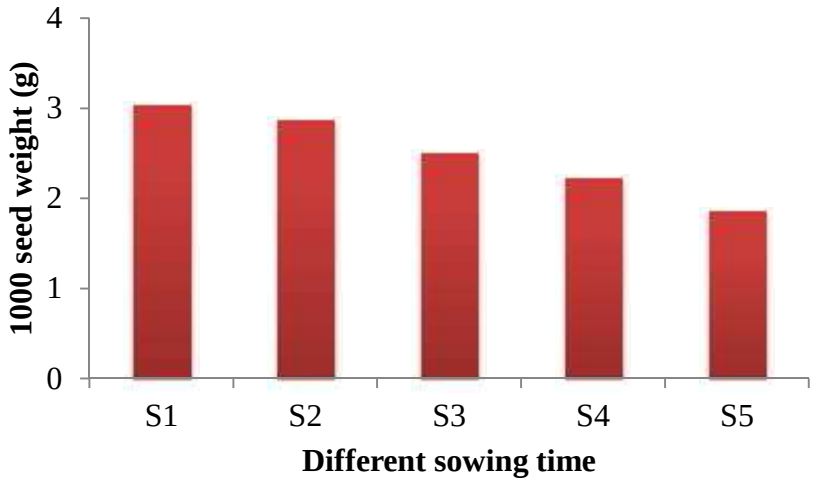


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 13. Effect of variety on the 1000 grain weight of mustard ($LSD_{0.05}$= 0.21)

4.7.2 Effect of sowing time

There was significant variation observed among the sowing time in respect of 1000 seed weight (Figure 14). The highest 1000 seed weight (3.03 g) was obtained from the S_1 which was statistically at par with S_2 and the lowest 1000 seed weight (1.85 g) was obtained from the S_5. This may be due to variation in prevailing weather condition. Earlier sown crop (11th October) faced favorable soil moisture condition and relatively warmer temperature during vegetative growth and conducive temperature during flowering and pod formation stages which boosting the siliqua formation and seed development inside the siliqua ultimately produced seed of good sized while later sown crop (10th November) faced low temperature at the time of emergence as well as flowering stage resulting the small seed sized and decreased the 1000 seed weight. Lakra *et al.* (2018) reported that crop sown on 27th October produced highest 1000 seed weight (5.12 gm) but further delay in sowing adversely affects the 1000 seed weight. These results had agreements with the findings of Azam *et al.* (2018), Akhter *et al.* (2016), Sharif *et al.* (2016), Fashami *et al.* (2012), Aziz *et al*. (2011), Bhuiyan *et al.* (2008), Razzaque *et al.* (2007) and Islam *et al.* (2000) who reported that 1000 seed weight showed gradual reduction with the delayed planting time.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 14. Effect of sowing time on the 1000 grain weight of mustard (LSD $_{0.05}$= 0.33)

4.7.3 Interaction effect of variety and sowing time

Interaction effect between variety and sowing time was found significant in respect of 1000 seed weight (Table 3). The highest 1000 seed weight (3.17 g) was obtained from treatment combination V_1S_1 which was similar with the interactionofV_1S_2, V_2S_1 and V_2S_2. The lowest 1000 seed weight (1.50 g) was obtained from V_2S_5. These results were in the agreement with the result of Azam *et al.* (2018) and Rahman *et al.* (2007) who stated that 1000 seed weight differed significantly due to interaction of mustard variety and sowing time.

Table 3. Interaction effect of variety and sowing times on the branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1}, length of siliqua and 1000 seed weight of mustard

Treatment combinations	Branches plant^{-1}	Siliquae plant^{-1}	Seeds siliqua^{-1}	Length of siliqua (cm)	1000 seed weight (g)
V_1S_1	16.00 a	170.70 a	9.67 d	4.93 a	3.17 a
V_1S_2	9.00 b	163.40 a	11.00 d	4.83 ab	2.93 ab
V_1S_3	8.00 bc	132.70 b	10.00 d	4.62 a-c	2.57 b-e
V_1S_4	6.67 cd	126.90 b	11.67 d	4.33 b-d	2.40 d-f
V_1S_5	5.33 de	117.70 b	9.333 d	4.23 cd	2.20 ef
V_2S_1	7.00 c	62.00 c	25.00 c	4.60 a-c	2.90 a-c
V_2S_2	6.67 cd	60.00 c	29.00 b	4.32 b-d	2.80 a-d
V_2S_3	5.11 ef	41.00 d	31.33 ab	4.00 de	2.43 c-f
V_2S_4	4.33 ef	40.67 d	33.33 a	3.83 de	2.03 f
V_2S_5	3.67 f	35.00 d	33.33 a	3.47 e	1.50 g
LSD $_{(0.05)}$	**1.49**	**16.34**	3.38	**0.55**	**0.47**
CV (%)	**12.10**	**10.03**	9.66	**7.48**	**11.03**

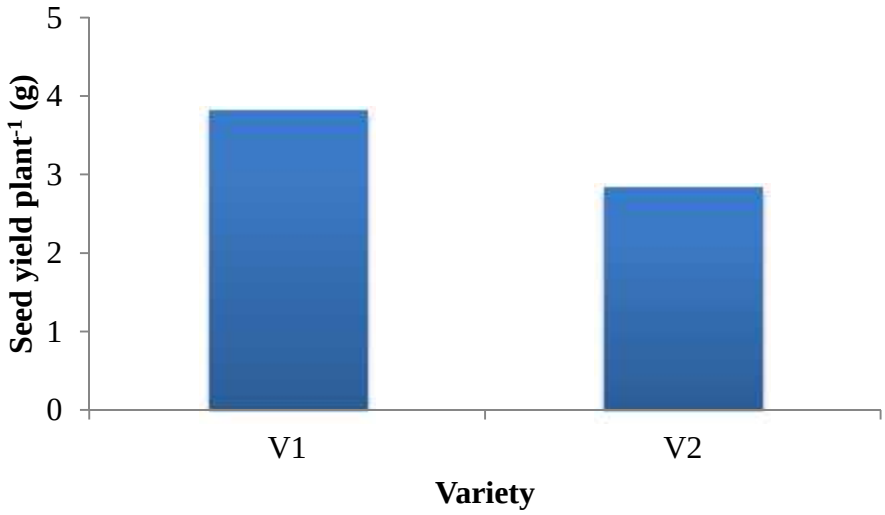
Values with common letter(s) within a column do not differ significantly at 5% level of probability

V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17; S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

4.8 Seed yield plant^{-1}(g)

4.8.1 Effect of variety

Seed yield plant^{-1} was significantly influenced by the variety (Figure 15). The higher seed yield plant^{-1} (3.81 g) was recorded from the mustard variety V_1 compared to the yield (2.83 g) of V_2. This result was due to the variety to variety variation between their potential to produce seed yield plant^{-1}. Akhter *et al.* (2016) concluded that among the varieties BINA Sarisha-5 gave highest seed yield and BINA Sarisha-6 produced lowest yield. Jiotode *et al.* (2017) also reported that the variety 'Pusa bold' recorded higher seed yield plant^{-1} (6.69 g) than ACN-9. The results of our study were in conformation with the findings reported by Mamun *et al*. (2014) and Bhalerao (1997).



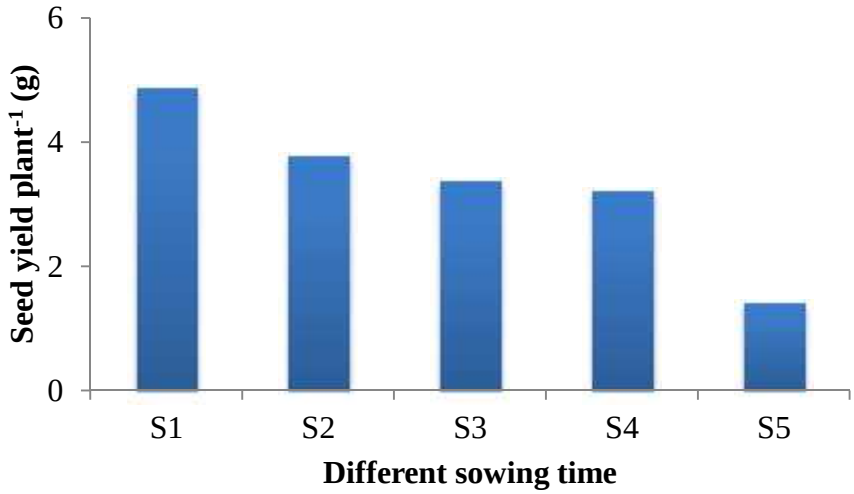
V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 15. Effect of variety on the seed yield plant^{-1} of mustard ($LSD_{0.05}$= 0.28)

4.8.2 Effect of sowing time

Sowing time had significant effect on seed yield plant^{-1} of mustard (Figure 16). The S_1 produced significantly the highest seed yield plant^{-1} (4.87 g). The lowest seed yield plant^{-1} (1.40 g) was produced by S_5 and the rest of the sowing times produced intermediate seed yield plant^{-1}. The results are in close accordance with the findings of Jiotode *et al.*

(2017) and Ghanbahadur and Lanjewar (2004) who revealed that delay in sowing might be reducing the seed yield plant^{-1} (g) due to environmental conditions.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 16. Effect of sowing time on the seed yield plant^{-1} of mustard (LSD $_{0.05}$= 0.44)

4.8.3 Interaction effect of variety and sowing time

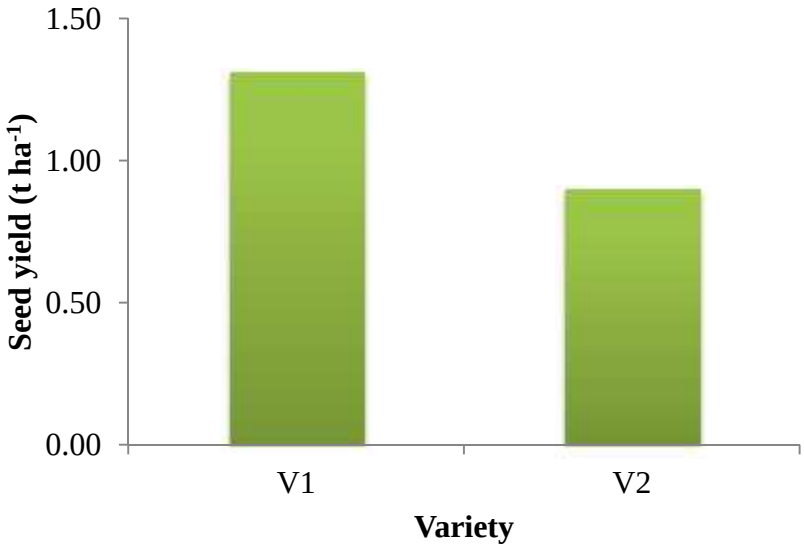
Interaction effect between variety and sowing time was found significant in respect of seed yield plant^{-1} (Table 4). The highest seed yield plant^{-1} (5.60 g) was produced by treatment combination V_1S_1. The lowest seed yield plant^{-1} (1.07 g) was produced by treatment combination V_2S_5.

4.9 Seed yield (t ha^{-1})

4.9.1 Effect of variety

Seed yield was significantly affected by the variety (Figure 17). The higher seed yield (1.31 t ha^{-1}) was produced by the mustard variety V_1 compared to the yield (0.90 t ha^{-1}) of V_2. V_1 produced 45.56% more seed compared to that of V_2. Helal *et al.* (2016) concluded that the variety BARI Sharisha-8 produced the maximum seed yield (1.46 t ha) and lowest one was produced by BINA Sarisha-4 (1.19 t ha^{-1}). These findings were closed accordance with Kumar *et al.* (2018), Jiotode *et al.* (2017), Singh *et al.* (2017), Solanki and Mundra (2015), Gawariya *et al*. (2015), Sudhir *et al.* (2013), Ram*et al*. (2012),Gupta

and Saini (2004), Bharadwaj (1991), Shukla *et al.* (2001) and Kumar *et al.* (2000) who reported that the yield difference might be due to the variation in different genotypes in their genetic makeup.



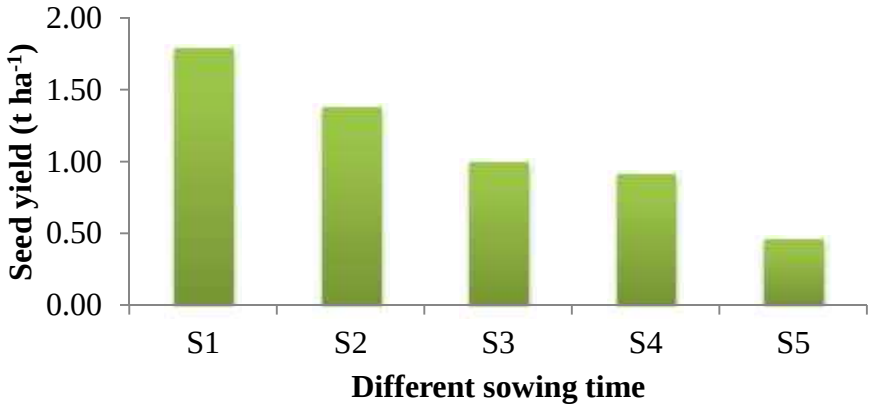
V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 17. Effect of variety on the seed yield of mustard ($LSD_{0.05}$= 0.08)

4.9.2 Effect of sowing time

Sowing time had significant influenced on seed yield of mustard (Figure 18). The S_1 produced significantly the highest seed yield (1.78 t ha^{-1}) where as the lowest one (0.45 t ha^{-1}) was produced by S_5 and the rest of the sowing times produced intermediate seed yield. Mustard seed sown on 2 November (S_1) produced 295.56% more seed than the seed sown on 30 November. Sattar *et al.* (2013) reported that the highest yield may be attributed due to better source sink relationship. Delaying sowing time resulted in significant reductions in seed yield which might be due to variation in temperatures in late sown mustard. Turhan *et al.* (2011) reported that sowing time significantly affected growth and yield in mustard and, furthermore, days to flowering and flowering duration, while seed yield reduced with delayed sowing time. The same trend was also determined by other researchers (Moore and Guy, 1997, Hocking and Stapper, 2001 and Uzun *et al.* 2009) who noted that late sowing caused delayed flowering time and reduced seed yield.

The increase in seed yield as a result of early planting date may be attributed to more light, water and mineral absorption by plant canopies thus, increasing photosynthetic capacity. On the other hand, late planting date not only decreases crop growing season but also causes weak pollination and seed filling at the end of season due to hot and dried days. Singh *et al.* (2017) reported that the lower yield of mustard might be due to poor growth and better translocation of photosynthates from source to sink. All the growth and yield attributes which determined the seed yield of mustard crop, were adversely influenced when the sowing were done on delayed date. Sharif *et al.* (2016) and Wang *et al*. (2012) revealed that mustard yield declined linearly with late sowing time, mainly due to shortened vegetative growth stages and varied significantly due to inter–annual climate variability. Akhter *et al.* (2016) reported that delayed sowing decreased seed yield by 15.72, 50.00 and 65.21% in the first year and 10.28, 49.93 and 67.62% in the second year, respectively 2 November, 17 November and 3 December sowing compared to 18 October sowing. These findings agreed with Azam *et al.* (2018), Kumar *et al.* (2018), Jiotode *et al.* (2017), Akhter *et al.* (2016), Gawariya *et al.* (2015), Khayat *et al.*(2015), Ram *et al.* (2015), Solanki and Mundra (2015) Ram *et al.* (2014), Alam *et al.* (2014), Amrawat *et al.* (2013), Azharudheen *et al.* (2013), Sudhir *et al*. (2013), Sattar*et al.*(2013), Fashami *et al.* (2012), Ram *et al.* (2012), Sharma and Sardana (2012),Aziz *et al*. (2011), Turhan *et al.* (2011), Kaur *et al.*(2011), Uzun *et al*. (2009), Bhuiyan *et al*. (2008), Razzaque *et al.* (2007), Khushu and Singh (2005), Ghanbahadur and Lanjewar (2004), Panda *et al.*, (2004), Sihag *et al*. (2003), Angrej*et al*. (2002), Hocking and Stapper (2001), Singh *et al.* (2001), Nag *et al.* (2000), Panwar *etal.* (2000), Khichar *et al.*, (2000), Islam *et al.* (2000), Singh *et al.* (1998), Moore and Guy (1997), Tyagi *et.al.* (1996) and Shashtry and Kumar (1981) who stated that late sowing caused delayed flowering time, decreased flowering duration and reduced seed yield. Therefore, to harvest a good crop, sowing at appropriate time which provides congenial environment is utmost important.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 18. Effect of sowing time on the seed yield of mustard (LSD $_{0.05}$= 0.12)

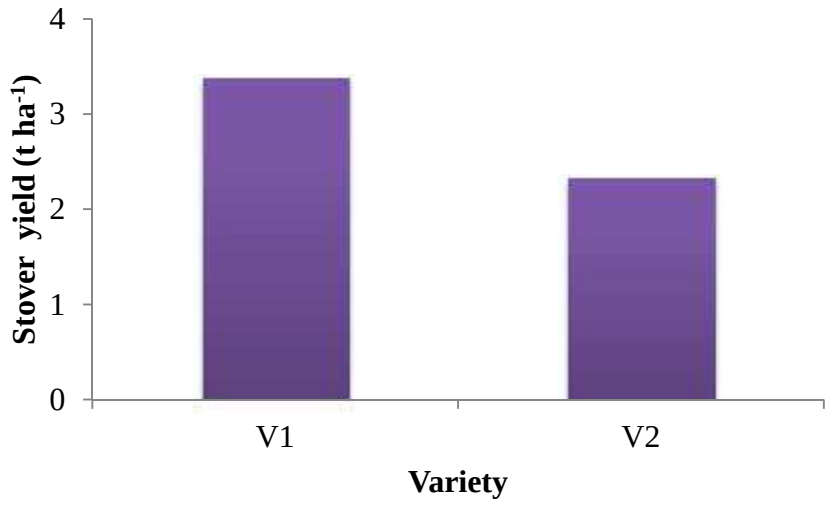
4.9.3 Interaction effect of variety and sowing time

Interaction effect between variety and sowing time was found significant in respect of seed yield (Table 4). The highest seed yield (2.22 t ha^{-1}) was produced by treatment combination V_1S_1. The lowest seed yield (0.33 t ha^{-1}) was produced by treatment combination V_2S_5. Treatment combination V_1S_1 produced 572.72% more seed than treatment combination V_2S_5. These results are in the agreement with the result of Azam *et al.* (2018) and Rahman *et al.* (2007) who stated that seed yield significantly varied among the mustard variety and date of sowing.

4.10 Stover yield (t ha^{-1})

4.10.1 Effect of variety

Stover yield was significantly influenced by the variety (Figure 19). The maximum stover yield (3.37 t ha^{-1}) was obtained from the V_1 compared to the stover yield (2.32 t ha^{-1}) of V_2. The V_1 gave 45.26 % higher stover yield than the V_2. Similar findings also reported by Jiotode *et al.* (2017) who stated that Pusa bold) mustard variety found to be significantly superior over ACN-9, with straw yield 1827.6 kg ha^{-1}.

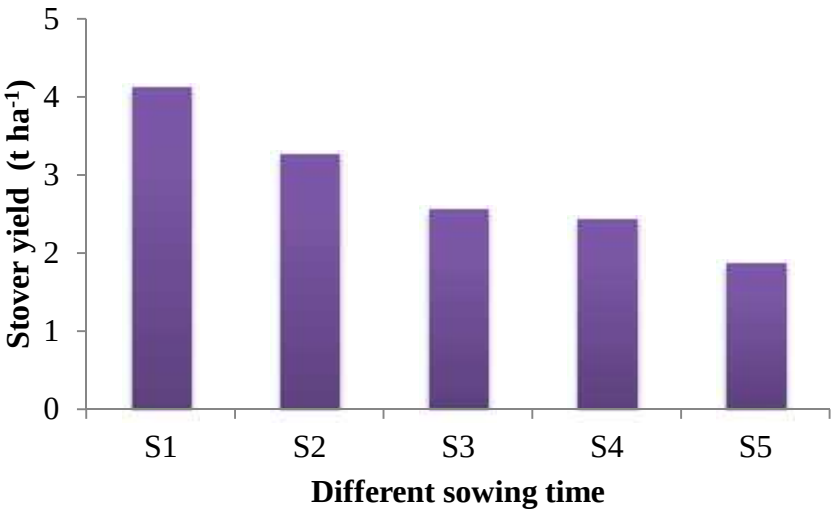


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 19. Effect of variety on the stover yield of mustard ($LSD_{0.05}$= 0.22)

4.10.2 Effect of sowing time

Sowing time had significant effect on stover yield (Figure 20). The S_1 produced significantly the highest stover yield (4.12 t ha^{-1}). The lowest stover yield (1.86 t ha^{-1}) was obtained from S_5.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 20. Effect of sowing time on the stover yield of mustard (LSD $_{0.05}$= 0.34)

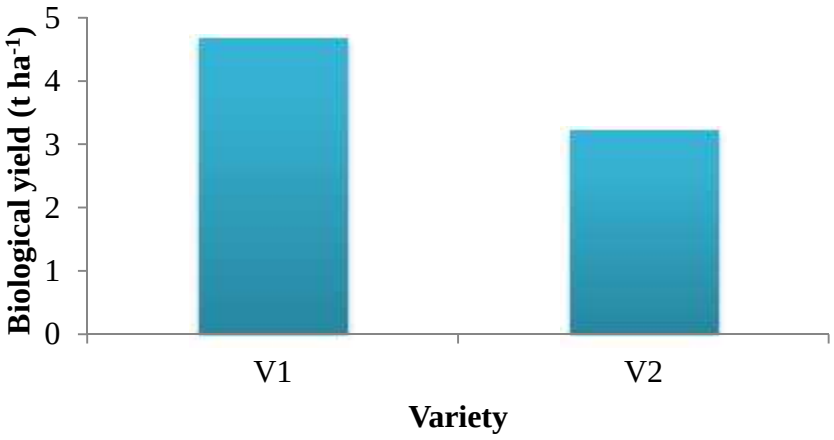
4.10.3 Interaction effect of variety and sowing time

Interaction effect between variety and sowing time was found significant in respect of stover yield (Table 4). The highest stover yield (4.50 t ha^{-1}) was obtained from V_1S_1. The lowest stover yield (1.38 t ha^{-1}) was obtained from V_1S_5 which was similar to the interaction of V_2S_3 and V_2S_4. It might be due to the maximum number of leaves $plant^{-1}$, taller plants, higher no. of branches $plant^{-1}$ and number of pods $plant^{-1}$ that contributed to the highest stover yield.

4.11 Biological yield (t ha^{-1})

4.11.1 Effect of variety

Biological yield was significantly differed by the varietal variation (Figure 21). The highest biological yield (4.68 t ha^{-1}) was obtained from the V_1 compared to the yield (3.22 t ha^{-1}) of V_2. The V_1 gave 45.34 % higher biological yield than the V_2. The higher biological yield might be attributed for their tall plants and more branching habits. Helal *et al.* (2016) reported that the maximum biomass yield (5.91t ha) was obtained by the variety BARI Sarisha-8 which was statistically identical with BINA Sarisha-4, BARI Sarisha-15, Improved Tori and the minimum (3.18 t ha^{-1}) by the line BC-05115 Y followed by BC- 05117 Y, TS-72 and BARI Sarisha-12. The results of our investigation were in conformity with the findings of Jiotode *et al.* (2017) and Mamun *et al*. (2014).

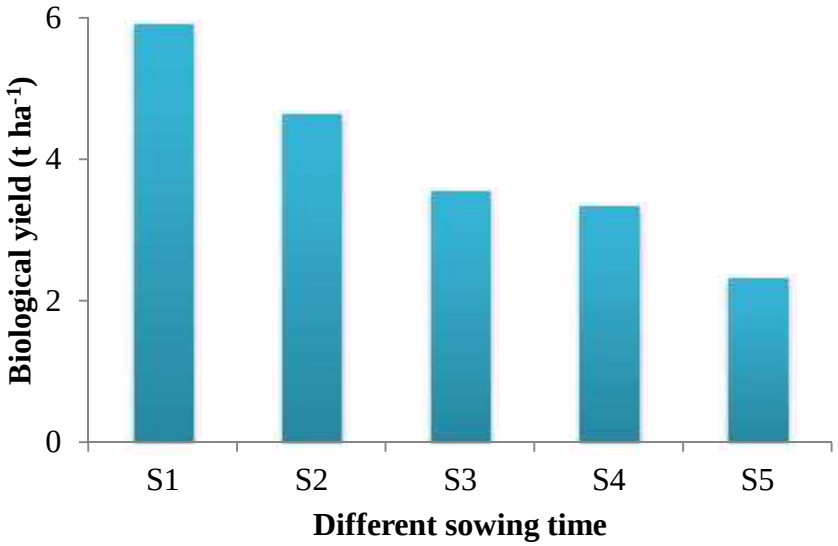


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 21. Effect of variety on the biological yield of mustard ($LSD_{0.05}$ = 0.22)

4.11.2 Effect of sowing time

Sowing time had significant effect on biological yield of mustard (Figure 22). The S_1 produced significantly the highest biological yield (5.91 t ha^{-1}) and the lowest one (2.32 t ha^{-1}) was produced by S_5.



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 22. Effect of sowing time on the biological yield of mustard (LSD $_{0.05}$= 0.34)

4.11.3 Interaction effect of variety and sowing time

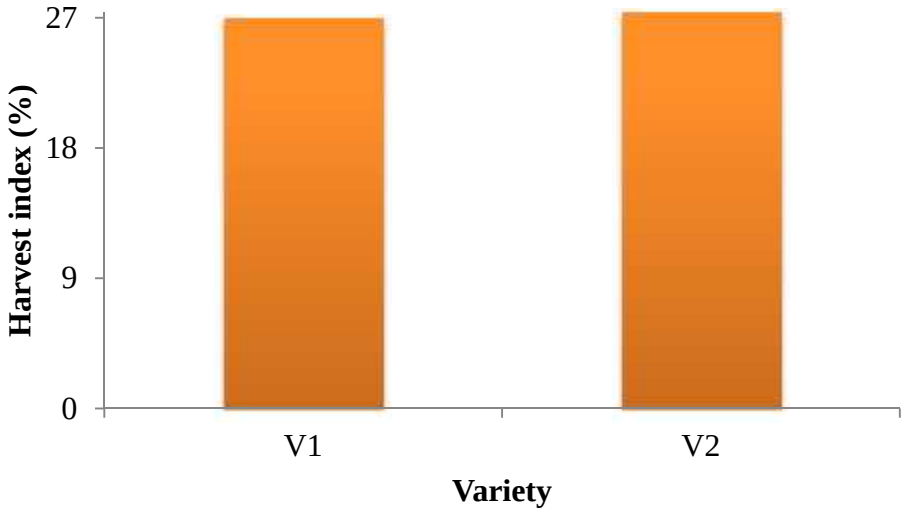
Interaction effect between variety and sowing time was found significant in respect of biological yield (Table 4). The highest biological yield (6.72 t ha^{-1}) was obtained from V_1S_1. The lowest biological yield (1.70 t ha^{-1}) was obtained from V_2S_5.

4.12 Harvest index (%)

4.12.1 Effect of variety

Harvest index was not significantly influenced by the varietal variation (Figure 23). Numerically the higher harvest index (27.33%) was found from the V_2 and the lower harvest index (26.93%) was found from the V_1. Similar findings were also reported by Helal *et al.* (2016) who revealed that the maximum (27.73%) harvest index found in the

variety BARI Sarisha-14 and similar with BARI Sarisha-15 (27.47%) and the minimum (23.57%) in the line BC-05118 Y.

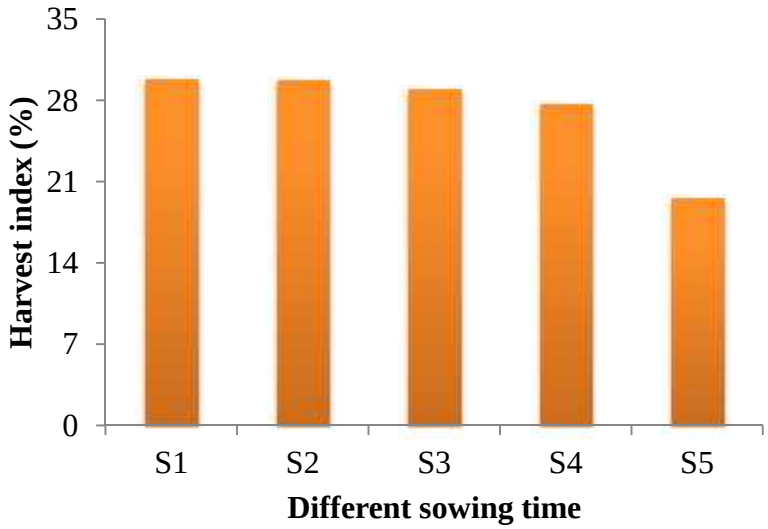


V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17

Figure 23. Effect of variety on the harvest index of mustard ($LSD_{0.05}$= NS)

4.12.2 Effect of sowing time

Sowing time had significant effect on harvest index (Figure 24). Mustard seed sown on 2 November (S_1) produced significantly the highest harvest index (29.81%) which was similar to S_2, S_3 and S_4 and the lowest one (19.56 %) was obtained from S_5 treatment. These results were in conformity with the findings of Singh *et al.* (2018) and Jha *et al.* (2015).



S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

Figure 24. Effect of sowing time on the harvest index of mustard (LSD $_{0.05}$= 3.20)

4.12.3 Interaction effect of variety and sowing time

Interaction effect between variety and sowing time was found significant in respect of harvest index (Table 4). The highest harvest index (33.02%) was obtained from V_1S_1 which was similar to the interaction of V_2S_3, V_1S_2, V_2S_2 and V_2S_4. The lowest harvest index (19.22%) was obtained from the V_2 with the interaction of S_5, which was similar to the interaction of V_1S_5. These results were in conformity with the findings of Sharif *et al.* (2016) who reported that maximum harvest index was found in BINA Sarisha-5 with 30 November combination and the minimum in BARI Sarisha-9 with 15 January seed sowing.

Table 4. Interaction effect of variety and sowing times on the seed yield plant^{-1} seed yield, stover yield, biological yield and harvest index of mustard

Treatment combinations	Seed yield plant^{-1} (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	5.60 a	2.22 a	4.50 a	6.72 a	33.02 a
V_1S_2	4.20 b	1.52 b	3.60 b	5.12 b	29.72 ab
V_1S_3	3.87 bc	1.13 d	3.28 bc	4.41 c	25.72 b
V_1S_4	3.67 bc	1.11 d	3.11 c	4.21 c	26.31 b
V_1S_5	1.73 e	0.58 f	2.35 d	2.93 d	19.89 c
V_2S_1	4.13 b	1.35 bc	3.74 b	5.09 b	26.59 b
V_2S_2	3.33 cd	1.23 cd	2.92 c	4.15 c	29.72 ab
V_2S_3	2.87 d	0.86 e	1.83 e	2.69 d	32.13 a
V_2S_4	2.73 d	0.71 ef	1.74 e	2.45 d	29.00 ab
V_2S_5	1.07 f	0.33 g	1.38 e	1.70 e	19.22 c
LSD $_{(0.05)}$	**0.62**	**0.17**	**0.49**	**0.49**	**4.52**
CV (%)	**10.92**	**9.02**	**9.92**	**7.29**	**9.71**

Values with common letter(s) within a column do not differ significantly at 5% level of probability

V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17; S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November, S_5= 30 November

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November, 2017 to April, 2018 to study the growth and yield responses of rapeseed-mustard varieties grown with different sowing times. The experimental field belongs to the Agro-Ecological Zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors. Factor A: Two mustard variety *viz.*, V_1= BARI Sarisha-11 and V_2= BARI Sarisha-17 and Factor B: Five sowing time *viz.*, S_1= 2 November, S_2= 9 November, S_3= 16 November, S_4= 23 November and S_5= 30 November. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was 5 m^2 (2.5 m × 2 m).Urea, TSP, MoP, Gypsum, $ZnSO_4$ and Boric acid were applied @ 250 kg ha^{-1}, 170 kg ha^{-1}, 85 kg ha^{-1}, 150 kg ha^{-1}, 5 kg ha^{-1} and 5 kg ha^{-1}, respectively were applied following BARI recommendation. Data on different yield contributing characters and yield were recorded to find out the best mustard variety and optimum sowing time for the potential yield of mustard.

Different growth and yield parameters were significantly influenced by different mustard variety. The taller plant (19.04, 56.97 and 122.77 cm at 30, 45 DAS and harvest, respectively) was obtained from BARI Sarisha-11 (V_1), while the shorter plant (16.76, 48.25 and 102.30 cm at 30, 45 DAS and harvest, respectively) was obtained from V_2 (BARI Sarisha-17). The maximum dry matter weight $plant^{-1}$ (1.89 g, 4.76 g, 6.84 g and 9.37 g) were obtained from BARI Sarisha-11 (V_1) at 30, 45, 60 DAS and harvest, respectively and minimum dry matter weight $plant^{-1}$ (0.94 g, 3.39 g, 5.18 g and 7.43 g) were obtained from BARI Sarisha-17 (V_2) at 30, 45, 60 DAS and harvest, respectively. The higher number of branches $plant^{-1}$ (9.00), siliquae $plant^{-1}$ (142.28), length of siliqua (4.59 cm), 1000 seed weight (2.65 g), seed yield $plant^{-1}$ (3.81 g), seed yield (1.31 t ha^{-1}), stover yield (3.37 t ha^{-1}), biological yield (4.68 t ha^{-1}) was recorded BARI Sarisha-11 (V_1) and the lower number of branches $plant^{-1}$ (5.36), siliquae $plant^{-1}$ (47.73), length of

siliqua (4.04 cm), 1000 seed weight (2.33 g), seed yield plant^{-1} (2.83 g), seed yield (0.90 t ha^{-1}), stover yield (2.32 t ha^{-1}), biological yield (3.22 t ha^{-1}) was recorded BARI Sarisha-17 (V_2). Again the higher seeds siliqua (30.40) was obtained from BARI Sarisha-17 (V_2) and the lower seeds siliqua (10.33) was obtained from BARI Sarisha-11 (V_1).

Different growth and yield parameters were significantly influenced by different sowing time. The tallest plant (20.72 cm, 62.80 cm, 107.30 cm and 136.50 cm) were recorded when the mustard sown on 2 November (S_1) at 30, 45, 60 DAS and harvest, respectively and the shortest plant (15.05 cm, 43.19 cm, 67.02 cm and 85.96 cm) were recorded when the mustard sown on 30 November (S_5) at 30, 45, 60 DAS and at harvest, respectively. The maximum dry matter weight plant^{-1} (2.00 g, 5.31 g, 7.91 g and 10.37 g) were obtained from sowing time S_1 at 30, 45, 60 DAS and harvest, respectively and the minimum dry matter weight plant^{-1} (0.93 g, 2.51 g, 4.04 g and 6.07 g) were obtained from sowing time S_5 at 30, 45, 60 DAS and harvest. The highest branches plant^{-1} (11.50), siliquae plant^{-1} (116.30), length of siliqua (4.77 cm), 1000 seed weight (3.03 g), seed yield plant^{-1} (4.87 g), seed yield (1.78 t ha^{-1}), stover yield (4.12 t ha^{-1}), biological yield (5.91 t ha^{-1}) and harvest index (29.81 %) were obtained from the S_1 and the lowest branches plant^{-1} (4.50), siliquae plant^{-1} (76.33), length of siliqua (3.85 cm), 1000 seed weight (1.85 g), seed yield plant^{-1} (1.40 g), seed yield (0.45 t ha^{-1}), stover yield (1.86 t ha^{-1}), biological yield (2.32 t ha^{-1}) and harvest index (19.56 %) were obtained from the S_5 treatment. Again the highest seeds siliqua^{-1} (22.50) was obtained from S_4 and the lower seeds siliqua^{-1} (17.33) was obtained from S_1.

The growth, yield and yield contributing characters of mustard were significantly influenced by the interaction effect of different mustard varieties and sowing times. The tallest plant (21.84 cm, 66.98 cm, 116.20 cm and 145.80 cm) were recorded when the mustard variety BARI Sarisha-11(V_1) sown on 2 November (S_1) at 30, 45, 60 DAS and harvest, respectively on the other hand, the shortest plant (14.13 cm, 38.62 cm, 60.08 cm and 77.18 cm) were recorded when the mustard variety BARI Sarisha-17 (V_2) sown on 30 November (S_5) at 30, 45, 60 DAS and harvest, respectively. The maximum dry matter weight plant^{-1} (2.76 g, 6.04 g, 8.79 g and 11.20 g) were obtained from treatment combination V_1S_1 at 30, 45, 60 DAS and harvest, respectively and the minimum dry

matter weight plant^{-1} (0.70 g, 1.97 g, 3.05 g and 4.80 g) were obtained from treatment combination V_2S_5 at 30, 45, 60 DAS and harvest, respectively. The highest branches plant^{-1} (16.00), siliquae plant^{-1} (170.70), length of siliqua (4.93 cm), 1000 seed weight (3.17 g), seed yield plant^{-1} (5.60 g), seed yield (2.22 t ha^{-1}), stover yield (4.50 t ha^{-1}), biological yield (6.72 t ha^{-1}) and harvest index (33.02 %) were obtained from the treatment combination V_1S_1 and the lowest branches plant^{-1} (3.67), siliquae plant^{-1} (35.00), length of siliqua (3.47 cm), 1000 seed weight (1.50 g), seed yield plant^{-1} (1.07 g), seed yield (0.33 t ha^{-1}), stover yield (1.38 t ha^{-1}), biological yield (1.70 t ha^{-1}) and harvest index (19.22 %) were obtained from the treatment combination V_2S_5 treatment. Again the highest seeds siliqua^{-1} (33.33) was obtained from treatment combinations V_2S_4 and V_2S_5 and the lower seeds siliqua^{-1} (9.67) was obtained from treatment combination V_1S_1.

The results in this study indicated that the plants performed better in respect of seed yield in V_1S_1 (2.22 t ha^{-1}) treatment than the combination V_2S_5 (0.33 t ha^{-1}) which showed the least performance. It can be therefore, concluded from the above study that the treatment combination V_1S_1 (mustard variety BARI Sarisha-11 sown on 2 November) was found to the most suitable combination for the potential yield of mustard in Bangladesh.

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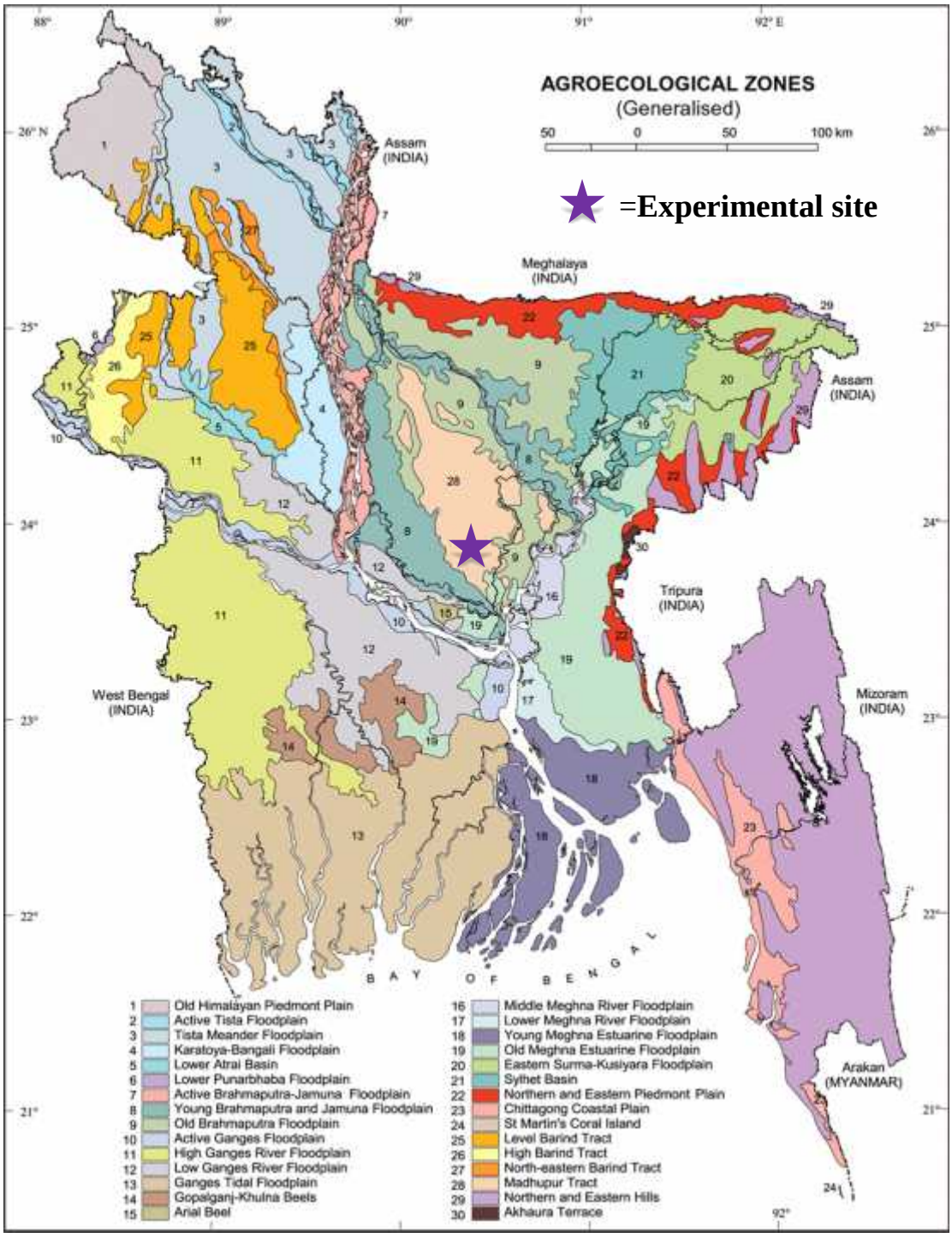
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix III. Monthly meteorological information during the period from November, 2017 to April, 2018

Year	Month	*Air temperature (^{0}C)		*Relative humidity (%)	*Rainfall (mm)
		Maximum	Minimum		
2017	November	28.8	18.6	69.5	35
	December	25.1	16.2	70.6	15
2018	January	24.2	12.1	68.5	7
	February	28.5	16.4	61.0	25
	March	32.6	20.5	72.7	65
	April	34.9	24.4	76.8	155

*Monthly average

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka

Appendix IV. Analysis of variance of the data on plant height of mustard as influenced by combined effect of different varieties and sowing time

Source of variation	df	Mean square of plant height at different days after sowing			
		30	45	60	At harvest
Replication	2	1.06	54.41	147.16	16.73
Variety (A)	1	38.87*	569.85*	1753.99*	3143.89*
Sowing time (B)	4	29.79*	363.54*	1547.58*	2564.31*
Variety (A) X Sowing time (B)	4	0.28*	0.57*	5.31*	14.07*
Error	18	3.13	23.20	84.58	133.57

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on dry matter plant^{-1} of mustard as influenced by combined effect of different varieties and sowing time

Source of variation	df	Mean square of dry matter weight plant^{-1} at different days after sowing			
		30	45	60	At harvest
Replication	2	0.03	0.08	0.11	0.64
Variety (A)	1	6.73*	13.93*	20.58*	28.13*
Sowing time (B)	4	1.18*	7.44*	13.33*	17.76*
Variety (A) X Sowing time (B)	4	0.35*	0.08*	0.38*	0.20*
Error	18	0.03	0.13	0.363	0.62

*Significant at 5% level of significance

^{NS} Non significant

Appendix VI. Analysis of variance of the data on yield contributing characters of mustard as influenced by combined effect of different varieties and sowing time

Source of variation	df	Mean square of				
		Branches plant^{-1}	Siliquae plant^{-1}	Seeds siliqua^{-1}	Length of siliqua	1000 grain weight
Replication	2	0.99	106.86	5.91	0.28	0.06
Variety (A)	1	99.66*	67035.48*	3020.03*	2.24*	0.77*
Sowing time (B)	4	44.23*	1912.87*	22.37*	0.81*	1.38*
Variety (A) X Sowing time (B)	4	13.72*	186.17*	17.37*	0.04*	0.08*
Error	18	0.76	90.71	3.87	0.104	0.08

*Significant at 5% level of significance

^{NS} Non significant

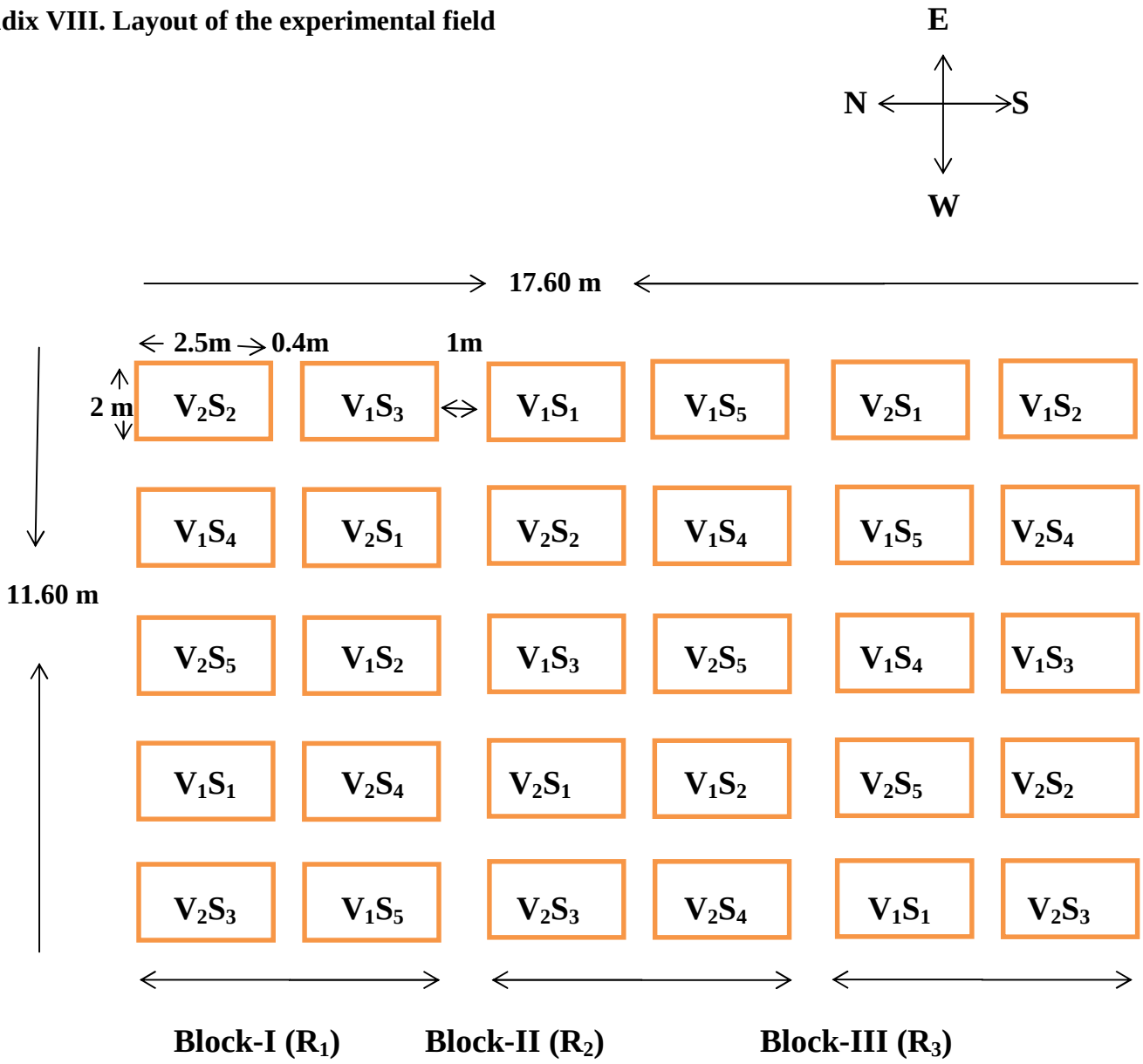
Appendix VII. Analysis of variance of the data on yield contributing characters of mustard as influenced by combined effect of different varieties and sowing time

Source of variation	df	Mean square of				
		Seed yield plant^{-1}	Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.07	0.03	0.06	0.03	13.39
Variety (A)	1	7.30*	1.29*	8.19*	15.99*	1.21^{NS}
Sowing time (B)	4	9.44*	1.51*	4.55*	11.26*	112.15*
Variety (A) X Sowing time (B)	4	0.13*	0.10*	0.18*	0.18*	33.51*
Error	18	0.13	0.01	0.08	0.08	6.94

*Significant at 5% level of significance

^{NS} Non significant

Appendix VIII. Layout of the experimental field



Legend:

Treatments	
Factor-1: Variety: V_1= BARI Sarisha-11 (Mustard) V_2= BARI Sarisha-17 (Rapeseed)	Factor-2: Sowing time: S1= 2 November S2 = 9 November S3 = 16 November S4 = 23 November S5 = 30 Novembe

Plate 1. General view of an experimental plot at seedling stage of BARI Sarisha-11

Plate 2. General view of an experimental plot at seedling stage of BARI Sarisha-17

Plate 3. General view of experimental plotsshowing plant height difference at different sowing dates

Plate 4. General view of the experimental plots at physiologically matured stage

Plate 5.The experimental plot (V_1S_1) resulting the highest seed yield of BARI Sarisha-11 Sown at 2 November, 2017