EFFECT OF DIFFERENT SOWING METHODS AND VARIETIES ON THE YIELD OF MUSTARD (*Brassica campestris* L.)

A THESIS

BY

AZIZUR RAHMAN

DEPARTMENT OF AGRICULTURAL BOTANY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

December, 2017

EFFECT OF DIFFERENT SOWING METHODS AND VARIETIES ON THE YIELD OF MUSTARD (*Brassica campestris* L.)

BY

AZIZUR RAHMAN

Registration No. : 16-07528

A Thesis

Submitted to the Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka, in partial
fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE
IN
AGRICULTURAL BOTANY

SEMESTER: JULY-DECEMBER/2017

Approved by:

Prof. Dr. Kamal Uddin Ahamed	**Prof. Dr. Md. Moinul Hoque**
Supervisor	**Co-Supervisor**

Prof. Dr. Nasima Akhter
Chairman
Examination Committee

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

PABX: +88029144270-9
Fax: +88029112649
Web site: www.sau.edu.bd

Ref: *Date: ……...*

CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF DIFFERENT SOWING METHODS AND VARIETIES ON THE YIELD OF MUSTARD (Brassica campestris L.)"*** *submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN AGRICULTURAL BOTANY,*** *embodies the results of a piece of bonafide research work carried out by* ***AZIZUR RAHMAN*** *Registration No.* ***16-07528*** *under my supervision and my guidance. No part of the 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 : December, 2017

Place: Dhaka, Bangladesh

Prof. Dr. Kamal Uddin Ahamed
Dept. of Agricultural Botany
SAU, Dhaka
Supervisor

DEDICATED TO
MY
BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah, the Supreme Ruler of the universe who enabled the Author to complete the present piece of work.

I would like to express my heartiest respect, my deep sense of gratitude and sincere, profound appreciation to my supervisor, ***Prof. Dr. Kamal Uddin Ahamed****, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

I would like to express my heartiest respect and profound appreciation to my Co-supervisor, ***Prof. Dr. Md. Moinul Hoque****, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

I express my sincere respect to the Chairman, ***Prof. Dr. Nasima Akhter,*** *and all the teachers of Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.*

I would like to thank my friends especially Nurul Islam and Arif to help me in my research works.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my father, mother, brothers, sisters, son, daughters, wife and friends for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate me to this level.

December, 2017 ***The Author***

SAU, Dhaka

EFFECT OF DIFFERENT SOWING METHODS AND VARIETIES ON THE YIELD OF MUSTARD (*Brassica campestris* L.)

BY

AZIZUR RAHMAN

ABSTRACT

The experiment was carried out at *Sher-e-Bangla* Agricultural University Farm, Dhaka-1207, Bangladesh during Rabi season, November 2017 to February 2018 to find out the effect of different sowing methods and varieties on the yield of (*Brassica campestris*). The experiment comprised of two factors - the treatment consisted of four sowing methods viz. S_0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm and S_3= Line to line space 30 cm and three different varieties viz. V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15 and V_3 = BARI Sarisha 17. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The collected data were statistically analyzed and a significant variation among the treatments was found in respect of majority of the observed parameters. The highest plant population was recorded from Broadcast method of sowing. The tallest plant was recorded from the plot of broadcast method. The maximum branches plant^{-1}, dry matter weight plant^{-1}, siliqua plant^{-1}and seed silliqua^{-1} were recorded from the treatment line to line space 30 cm. The maximum thousand seed weight (2.97 g) was recorded from the broadcast method. The maximum yield of seed ha^{-1} (1.11 t) was obtained from broadcast method. The highest plant population (77.25) was observed in case of BARI Sarisha 14. The tallest plant of mustard was found in case of with BARI Sarisha 15. The maximum branches plant^{-1}, dry matter weight plant^{-1}, siliqua plant^{-1}, seed silliqua^{-1}, and length of silliqua were obtained from BARI Sarisha 15. The highest yield of seed (0.95 t/ha) was obtained from BARI Sarisha 15. The combinations of different sowing methods and different varieties had significant effect on almost all the parameters. The highest biological yield per hectare (5.08 tones) was obtained from broadcast method with BARI Sarisha 15 treatment combination.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hactre
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
Wt.	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

CHAPTER I

INTRODUCTION

Mustard belongs to the family Cruciferae or Brassicaceae, is one of the most important oil crops of the world after soybean and groundnut (FAO, 2012). *Brassica napus*, *B. campestris* L. and *B. juncea* L. *are* the three species of mustard those produce edible oil. It is one of the most important and widely grown oilseed crops in Bangladesh which occupying 0.483 million hectare of land and the total production was 0.525 million metric ton (AIS, 2013). Vegetable oils and fats (lipids) constitute an important component of human diet and oils of plant origin are nutritionally superior to that of animal origin (Singh, 2000). It is not only a high energy food but also a carrier of fat soluble vitamins including vitamin A, D, E and K in the body. In Bangladesh it is an important source of cooking oil that meet the one third of edible oil requirement of the country (Ahmed, 2008). Cumilla, Tangail, Jeshore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur and Dhaka are the major mustard growing districts of Bangladesh (BBS, 2011). Bangladesh has been facing acute shortage of edible oil for the last several decades. For that it needs to import oil and oilseeds to meet up the deficit of edible oil. Our internal production can meet only about 21% of our consumption which can meet only a fraction of the cooking oil, requirement of the country and the rest 79% is needed to import (Begum *et al*., 2012). Due to insufficient oil production, a huge amount of foreign exchange involving over 160 million US$ is being spent every year for

importing edible oils in Bangladesh (Rahman, 2002). Mustard seed contains about 40-45% oil and by increasing production of mustard we can meet up the shortage of edible oil. The average yield of mustard (1,087 kg ha^{-1}) in our country is alarmingly very poor compared to the advanced countries like Germany, France, UK and Canada. At present the world average yield of mustard is 1,575 kg ha^{-1} (FAO, 2012).

Generally two main methods of sowing are followed in Bangladesh for mustard cultivation. They are broadcasting and line sowing. In broadcasting, seeds are sown scattered. In line sowing, seeds are sown in separate line by maintaining plant to plant distance. A suitable technique of sowing of mustard is to be found out for higher yield.

Production of any crops is influenced by several factors, of which sowing method is very important. Deep tillage improves the physical, chemical and biological properties of soil. Khan *et al*. (2000) carried out an experiment on mustard in saline field at Agricultural Research Institute (ARI) Tamab during 1997-98. Canola (*Brassica napus*) was sown using four different sowing techniques included drill, broadcast, furrow and ridge. Highest plant height found in ridge planting method. Abdel (1973) reported that planting radish in ridge method resulted in greater weight of individual root as well as total yield compared to that of flat method.

Brassica (genus of mustard) has three species that produce edible oil, they are *B. napus*, *B. campestris* and *B. juncea*. Of these, *B. napus* and *B. campestris* are of the greatest importance in the world's oil seed trade. In this subcontinent, *B. juncea* is also an important oil seed crop. Until recently, mustard varieties such as Tori-7, Sampad (*Brassica campestris*) and Doulat (*Brassica juncea*) were mainly grown in this country. Recently several varieties of high yielding potential characteristics have been developed by BARI.

Seed yield and other yield contributing characters significantly varied among the varieties of rapeseed and mustard (BARI, 2001). Uddin *et al.* (1987) reported that there was a significant yield difference among the varieties of rapes and mustard with the same species. Singh *et al.* (1999) found oil content variation due to different variety and different method. There are some HYVs of mustard, which have been released by the Sher-e-Bangla Agricultural University (SAU), Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). Yield contributing characters and yield of different variety varied significantly (Mamun *et al*., 2014, BARI, 2001). The yield of mustard in Bangladesh has been increased obviously with the introduction of high yielding varieties and improvement of management practices.

There are great scopes of increasing of mustard production by increasing cultivated area with choosing proper variety and sowing technique. The

productivity and quality of mustard and rapeseeds can be improved by proper adjustment of variety and sowing technique. In spite of all favourable condition and better scope of mustard production, Bangladesh is running with acute shortage of edible oil since long time. As a result, a huge amount of foreign exchange is being spent every year for importing edible oil.

The above discussion suggests that in order to improve productivity of mustard, high yielding variety with appropriate sowing technique is needed to be identified.

Therefore, keeping the above points in view, the present work was undertaken:

I. to identify the best effect of sowing methods of mustard,

II. to know the suitable variety of mustard which will give the profitable yield of mustard.

CHAPTER II

REVIEW OF LITERATURE

Mustard and rapeseed is important oil crop of Bangladesh which contributes to a large extent in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. Its growth and yield are determined by various factors of which sowing method is one of the most important. A very limited works have been done involving the sowing method with the mustard (rape seed) varieties. Some of the work applicable to the present study has been reviewed below:

2.1 Effect of sowing methods on different crop characters

2.1.1 Plant height

Plant height is a varietal character of rapeseed but environmental conditions and cultural operations may affect it. Planting technique has direct effect on plant height.

Khan *et al*. (2000) carried out an experiment on mustard in saline field at Agricultural Research Institute (ARI) Tamab during 1997-98. Canola (*Brassica napus*) was sown using four different sowing techniques included drill, broadcast, furrow and ridge. Highest plant height found in ridge planting method.

Sarkees (2013) conducted an experiment at Karda-Rasha/College of AgricultureErbil to evaluate the effect of different seeding rates using drill-row and broadcasting sowing methods on growth, seed and oil yields of rapeseed (*Brassica napus* L.) cv. Pactol. The tallest plants were produced in the drill-row sown plots. While the shortest plants were produced with broadcasting sowing, this result is in agreement with Khan *et al*. (2000) that the plants of broadcasting sowing are shorter than plants of drill sowing method.

Hossain *et al*. (2013) carried out an experiment at Agronomy Field laboratory, Department of Agronomy and Agricultural Extension, university of Rajshahi, to study the effect of irrigation and sowing method on yield and yield attributes of mustard. Sowing method had significant effect on plant height. Line sowing produced the tallest plant and the shortest one was found at broadcast method.

2.1.2 Number of primary branches plant^{-1}

Hossain *et al*. (2013) reported that sowing method had significant effect on the production of total branches plant^{-1}. Line sowing method produced the highest number of branches plant^{-1}. The lowest number of total branches plant^{-1}was observed in the broadcast method.

Sarkees (2013) conducted an experiment at Karda-Rasha /College of AgricultureErbil to evaluate the effect of different seeding rates using drill-row and broadcasting sowing methods. Growth, seed and oil yields of rapeseed (*Brassica napus* L.) cv. Pactol in Erbil/Kurdistan Region. Here he found no significant differences in case of no. of primary branches of plant due to different sowing methods.

According to Aiken *et al*. (2015), Seeding with a hoe drill (HD) resulted in the best emergence and stand ratings, and earlier flowering. Emergence and stand ratings for seeding with a no-till drill (NT) were better than ratings for broadcast seeding (BC). Canola (*Brassica napus* L.) had better stand rating and earlier flowering than Indian mustard (*Brassica juncea* (L.) Czernj & Cosson) and Camelina (*Camelina sativa* (L.) Crantz), which were similar.

2.1.3 Siliquae plant^{-1}

The number of siliquae plant^{-1}is an important yield contributing character of oil seed rape. Several studies suggest that a higher number of siliquae plant^{-1}has the greatest effect on seed yield on rape and mustard (Thurling, 1974 and Rahman *et al*., 1988).

Hossain *et al*. (2013) studied that in the closer plant population at broadcasting method, there were competitions for light, space, nutrients and environments and therefore, lowest number of branches plant-1, siliquae plant^{-1}, seeds siliqua^{-1}and 1000-seed weight were produced, ultimately seed yield plant^{-1}was decreased .

Khan *et al*. (2000) studied number of siliqua plant-1play a major role in yield which was significantly affected by sowing methods. Maximum siliqua plant^{-1} were produced by ridge sown plants. The results for the rest three methods (broadcast, furrow and drill) were statistically non-significant.

Sarkees (2013) reported that individual plants of drill-row sowing produced a higher number of siliques than those of broadcasting sowing.

2.1.4 Length of siliqua

Hossain *et al*. (2013) observed that siliqua length was not significantly influenced by sowing method. Numerically, the longest siliqua was found at line sowing method and the shortest one was obtained from broadcasting method.

2.1.5 Thousand seed weight

Sarkees (2013) reported that crop grown with drill-row sowing method showed significantly highest seed weight as compared to broadcasting which produced lowest seed weight.

According to Khan *et al*. (2000) two economically most important yield parameters of the crop, the 1000 grain weight and grain yield as affected by sowing method. Crop grown with ridge sowing method showed significantly highest 1000 grain weight as compared to drill sowing and furrow sowing, while broadcast sown crop produced lowest 1000 grain weight.

According to Hossain *et al*. (2013) the weight of 1000-seed was not influenced by sowing method. The maximum weight of 1000-seed was obtained from line

sowing method and the minimum weight of 1000-seed was found in broadcasting method.

2.1.6 Seed yield

Khan *et al*. (2000) found that the maximum grain yield of 1.12 t $ha^{-1}$was obtained when crop was grown on ridges which was significantly higher than rest of sowing methods. There were no significant differences between furrow and drill sowing methods. The lowest yield was obtained when the seed was broad casted.

Sarkees (2013) reported that maximum total yield of 1.09 t ha^{-1} was obtained when crop was grown by drill-row sowing, which was significantly higher than broadcasting of 140.9%.

According to Hossain *et al*. (2013) sowing method had significant influence on seed yield. The highest seed yield was found from line sowing. Whereas, the lowest seed yield was exhibited from the broadcasting method. At Shillongani, broadcast method was found to be more successful. Significantly

higher seed yield of toria (*Brassica rapa* var. toria) was harvested in broadcast sowing of toria over other practices. Toria broadcast at dough stage along with 80 kg N ha^{-1}gave the highest yield (AICRP-RM, 2006).

2.1.7 Stover yield

Hossain et al. (2013) was found significant influence on stover yield due to sowing method. The line sowing method produced the highest stover yield. The lowest stover yield was found in broadcasting method.

2.1.8 Biological yield

Khan *et al*. (2000) studied the result of biological yield as affected by different sowing methods. Maximum biological yield was observed in ridge sowing method which was at par to drill sowing method. The lowest biological yield was found in furrow and broadcast method.

2.2 Effect of variety on different crop characters

2.2.1 Plant height

Varietal performance of a crop depends on its genetic makeup. Ali *et al*. (1998) observed significant variation on plant height of different varieties of rape and mustard.

Ahmed *et al*. (1999) stated that the tallest plant (102.56 cm) was recorded on the variety Daulat. No significant difference was observed on plant height between Dhali and Nap-8509.

Zakaria and Jahan (1997) observed that Dhali gave the tallest plant height (142.5 cm) which was similar with Sonali (139.5 cm) and Japrai (138.6 cm). The shortest plant height was observed in Tori-7 (90.97 cm) which was significantly shorter than other varieties.

An experiment was conducted at the Regional Agricultural Research Station (RARS), Jeshore (AEZ11, High Ganges River Floodplain) during 2003-2006 to evaluate the response of different varieties of mustard to boron application. Boron application was made at 0 and 1 kg ha^{-1}.The varieties chosen from B. campestris were BARI Sarisha 6, BARI Sarisha 9 and BARI Sarisha 12. The B. napus varieties were BARI Sarisha 7, BARI Sarisha 8 and BARI Sarisha 13. Varieties BARI Sarisha 10 and BARI Sarisha 11 were from the *B. juncea* group. The seed yield was positively and significantly correlated with the yield contributing characters viz. Pods $plant^{-1}$, seeds pod^{-1}, and 1000-seed weight, but not with plant height and pod length (Hossain *et al*., 2012).

Hossain *et al*. (1996) observed that the highest plant was in Narenda (175 cm), which was identical with AGA-95-21 (166cm). The shortest variety was Tori-7.

Mondal *et al.* (1992) reported that variety had significant effect on plant height. They found the highest plant height (134.4 cm) in the variety J-5004, which was identical with SS-75 and was significantly taller than JS-72 and Tori-7.

Yadav *et al*. (1994) suggested that the plant height was greater in cv.Vaibhav (167 cm) as compared to cv. Varuna (158 cm). Reddy and Kumar (1997) observed that cv. GM-2 recorded significantly higher plant height (145 cm) overcv. TM-21 (125 cm). In Jodhpur, Singh *et al*. (2001) observed that the local cultivar was taller as compared to cultivar T- 59 (158 cm). Rana and Pachuari (2001) quoted that plant height was recorded significantly higher in cv. TERI (OE)M 21 (177 cm) as compared to cv. TERI (OE) R15 (129 cm).

Shah and Rahman (2009) observed that significantly higher plant height inrapeseed genotype RM-159-2 (180.8 cm) as compared to genotype RM-152-2(180.7 cm), Pak-Cheen (177.1 cm) and RM-182 (176.0 cm). Lallu *et al*. (2010) atKanpur (U.P) observed that among different mustard genotypes, plant height ofgenotype RGN-152 was significantly higher (184.7 cm) as compared to othergenotypes in normal sowing and in late sown condition cv. RGN- 145 exhibitedsignificantly higher (118.5 cm) plant height.

Rashid *et al*. (2010) in a field experiment observed that the variety BARIsharisa-15 was of the tall plant type and that others were of intermediate and short stature in plant height. Afroz *et al*. (2011) observed that cv. BARI Sarisha-6 exhibited significantly higher plant height (96.7 cm) as compared to cv. BARISarisha-9 (84.9 cm). Kumari *et al*. (2012) observed that hybrid DMH-1 recorded significantly higher plant height (212 cm) over cv. Kranti (203 cm) and hybrid NRCHB-506 (196 cm).

2.2.2 Branches plant^{-1}

The yield contributing characters such as number of primary, secondary and tertiary branches are important determinant of the seed yield of rapeseed and mustard. Varieties among Brassica species showed a marked variation in the arrangement of the branches and their number per plant.

Ali and Rahman (1986) found significant variation in plant height of different varieties of rapes and mustard.

BARI (2000) found that the number of primary branches/plant was higher (4.02) in the variety SS-75 and lower (2.1) in the variety BARI Sharisa-5 under poor management under medium management, the higher number of primary branches plant-1was found in BARI Sharisha-6 (5.5) and lower in BARI Sharisa-8 under higher management. The highest number of primary branches plant-1was with BARI Sharisha-6 (5.9) and lower (3.0) with Nap-248.

Hossain *et al*. (1996) stated that the varieties were statistically different with respect to number of primary branches. The maximum number of primary branches was recorded in the Hyola-401(5.0) and the minimum number was recorded in Semu-249/84.

Zakaria and Jahan (1997) found that the local varieties Tori-7 and Sampad produced the highest number of primary branches plant^{-1}(4.07) which was at par with BLN-900. The minimum number of primary branches plant^{-1}(2.90) was found in Jatarai which was identical to those found in Hhole-401 and BARI sarisha-8 varieties.

Mamun *et al*. (2014) conducted a field experiment to evaluate the effect of variety and different plant densities on growth and yield of rapeseed mustard during Rabi 2011-12 under rainfed conditions at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Four varieties (BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU Sarisha-3) and four plant densities. BARI Sarisha-13 produced the highest number of branches plant-1(6.14) which was 33.77% higher (4.59) than BARI Sarisha-15.

Sultana *et al*. (2009) carried out an experiment to evaluate the effect of irrigation and variety on yield and yield attributes of rapeseed. SAU Sarisha^{-1} produced the highest number of branches per plant (5.43) which was significantly higher than kollania (4.80) and Improved Tori-7 (4.40).

Mondal and Islam (1993) reported that variety had significant effect on plant height. They found the highest plant height (134.4 cm) on the variety J-5004,

which was identical with SS-75 and was significantly taller than JS-72 and Tori-7.

Yadav *et al*. (1994a) reported that the number of primary and secondarybranches (plant^{-1}) was recorded higher in cv. Vaibhav (5.9 and 13.7) as comparedto cv. Varuna (5.3 and 13.0). In Jagtial (Andhra Pradesh), Reddy and Kumar (1997) revealed that cv. Divya exhibited significantly higher number of primary branches (4.7 plant^{-1}) over cv. Kunthi (4.0 plant^{-1}). Singh *et al*. (2001) observedthat the number of primary branches (plant^{-1}) were recorded higher in cv. Pusa Bold (5.63) compared to local cultivar (4.67). Rana and Pachauri (2001) quoted that cv. TERI (OE) M 21 recorded higher number of primary branches (6.8 plant-1)as compared to cv. Bio-902 (6.2 plant^{-1}).

Singh *et al.* (2002) emphasized that the number of primary branches was observed significantly higher in cv. Varuna (7 plant^{-1}) over cv. BJH-1 (5 plant^{-1}).

Kumar *et al*. (2008) reported that the number of branches in Brassica spp. Wassignificantly greater in *B. juncea* cv. Kranti (14.8 plant^{-1}) as compared to *B. junceacv*. Urvarshi (14.6 plant^{-1}), *B. napus* cv. GSL-1(11.9 plant^{-1}), *B. napus* cv. Hyola-401 (8.5 plant^{-1}), B. carinata cv. Kiran (5.42 plant^{-1}) and B. ampestris cv. NDYS-2(5.2 plant^{-1}).

Afroz *et al*. (2011) observed that cv. BARI Sarisha-9 exhibited significantly higher number of branches (3.30 plant^{-1}) as compared to cv. BARI Sarisha-6 (1.59 plant^{-1}). Kumari *et al*. (2012) observed that hybrid DMH-1 recorded significantlyhigher primary and secondary branches (7.6, 18.5 plant^{-1}) over hybrid NRCHB-506 (7.2, 17 plant^{-1}) and cv. Kranti (6.5, 15.7 plant^{-1}).

2.2.3 Number of siliquae plant-1

Sultana *et al*. (2009) showed that Kollania produced the highest number of siliquae plant^{-1} (94.96) which was significantly higher than SAU Sarisha-1 and Improved Tori -7 (89.97 and 78.28, respectively.)

Mamun *et al*. (2014) conducted an experiment and found that maximum siliqua plant-1(126.90) was obtained in BARI Sarisha-13 which was more than three times higher than the minimum number of siliqua plant-*1*(50.10) produced by SAU Sarisha-3.

Hossain et al. (2012) found that BARI Sarisha 11 produced the highest number of pods plant-1followed by BARI Sarisha 10. BARI Sarisha 7, BARI Sarisha 8, and BARI Sarisha 13 produced statistically similar number of pods plant-1in the control plots.

Jahan and Zakaria (1997) reported that in case of number of siliquae plant^{-1}, the highest number was recorded in BLN-900 (130-9) which was identical with that observed in Dhali (126.3). Tori-7 had the lowest (46.3) number of siliquae plant^{-1}.

Mondal *et al*. (1992) stated that maximum number of siliquae plant-1was in the variety J-5004 which was identical with the variety Tori-7. The lowest number of siliquae plant^{-1} (45.9) was found in the variety SS-75.

Sharma (1992) at Gwalior (M.P.) observed significantly higher number ofsiliquae in cv. Kranti (281.9 plant^{-1}) as compared to cv. Varuna (226.7 plant^{-1}). Similarly, Yadav *et al*. (1994) also quoted that number of siliquae (plant-1) washigher in cv. Vaibhav (363) as compared to cv. Varuna (257). Reddy and Kumar (1997) reported that mustard cv. Divya recorded significantly higher number ofsiliquae (132 plant^{-1}) over cv. GM-2 (97 plant^{-1}). Sharma *et al*. (1997) emphasizedthat mustard cv. RH-819 exhibited significantly higher number of siliquae (421.3 plant^{-1}) over RH 30 (348.9 plant^{-1}).

Laxminarayana and Poornachand (2001) observed that cv. Kranti recordedsignificantly higher number of siliquae (260 plant^{-1}) over cv. Divya (208 plant^{-1}). Singh *et al*. (2001) observed that number of siliquae (plant^{-1}) was significantlyhigher in cv. Pusa Bold (257) as compared to cv. TS 9 (198). Rana and Pachauri(2001) quoted that number of siliquae (plant^{-1}) were recorded

significantly higherin cv. TERI (OE) R 15 (285) as compared to cv. Bio 902 (238).

Kumar *et al*. (2008) suggested that the number of siliquae (plant^{-1}) in *Brassica spp.* were significantly higher in *B. carinata* cv. Kiran (277) as compared to *B. napus* cv. GSL-1(219), *B.juncea* cv. Kranti (215), *B. juncea* cv. Urvarshi (206), *B. napus* cv. Hyola-401 (131), and *B. campestris* cv. NDYS-2 (66). InMymensingh (Bangladesh), Afroz *et al*. (2011) observed significantly higher number of siliquae (plant-1) in cv. BARI Sarisha-9 (153.3) as compared to cv. BARISarisha-6 (138.8). Kumari *et al*. (2012) observed that hybrid DMH-1 recorded significantly higher number of siliquae (342 plant^{-1}) over hybrid NRCHB-506 (286plant^{-1}) and cv. Kranti (235 plant^{-1}).

2.2.4 Siliqua length

The shortest pod length (4.62 cm) was found in the hybrid Semu-249/84 which was identical to those of Semu-DNK_89/218, AGH-7 and Tori-7. The longest pod (8.07 cm) was found in BLN-900and Hyola-401 (Jahan and Zakaria, 1997).

Masood *et al*. (1999) found significant genetic variation in pod length among seven genotypes of *B. campestris* and a cultivar of *B. napus*. Similar result for pod length was observed by Lebowitz (1989) and Olsson (1990).

Akhter (2005) reported that the variety BARI sarisha-8 showed longest siliqua length (7.30 cm) with harvesting at 100 days which was similar with the same variety harvested at 90 days (7.13 cm).

Hossain *et al*. (1996) stated that the varieties of rapeseed differed significantly in respect of siliqua length. The longer siliqua was found in hybrid BGN-900 (7.75 cm) that was similar to Hyole-101, Sampad, Dhali and Hyola-51.

2.2.5 Number of seeds siliqua^{-1}

Akhter (2005) reported that variations in number of seeds siliqua-1among the varieties were found statistically significant. The highest number of seeds siliqua-1 (23.80) was found from BARI sarisha-8 and the lowest was recorded as 10.78 from BARI sarisha-11 .The variety BARI sarisha-10 and BARI sarisha-7 showed the number of seeds siliqua-1 as 12.64 and 22.03 respectively.

Mamun *et al*. (2014) found that the number of seeds siliqua-1contributes considerably towards the final seed yield. The number of seeds siliqua-1differed significantly among varieties but not for plant densities, while the interaction effect of variety × plant density was significant. Highest number of seeds siliqua-1 (25.36) was obtained from BARI Sarisha-13 and BARI Sarisha-16 obtained the lowest (14.95).

Hossain *et al*. (2012) found that the number of seeds pod^{-1}also varied significantly among the varieties due to B application. The average number of seeds pod^{-1} ranged from 12.00 to 20.67 and 13.22 to 27.44 in the B untreated and treated plots, respectively. The maximum average number of seeds pod^{-1}(27.44) was recorded in B treated BARI Sarisha- 8.

Sharma (1992) observed that number of seeds (siliqua^{-1}) recordedsignificantly higher in cv. Kranti (15.0) over cv. Krishna (11. 8). Tyagi et al. (1995) reported that cv. Laxmi produced significantly higher number of seeds (12 siliqua^{-1}) followed by cvs. RH-30 and Varuna. Yadav *et al*. (1994b) revealed that numberof seeds (siliqua-1) recorded significantly higher in cv. Rohini (14.6) compared to cv. Vardan (13.5). Sharma *et al.* (1997) observed that number of seeds (siliqua-1) recorded significantly higher in cv. RH 819 (12.5) over RH 30 (11.3). Singh *et al*. (2001) reported that among the cultivars tested, cv. Pusa Bold recorded higher number of seeds (14.0 siliqua^{-1}) as compared to Local cultivar (11.2 siliqua^{-1}).

Rena and Pachauri (2001) quoted that the cv. TERI (OE) R 15 exhibited significantly higher number of seeds (18.0 siliqua^{-1}) as compared to cv. Bio

902(13.7 siliqua-1). Singh *et al.* (2002b) reported that cv. Laxmi recorded significantly higher number of seeds (13 siliqua^{-1}) over cv. BSH 1 (11 siliqua-1).

Kumar *et al.* (2008) reported that the number of seeds (siliqua^{-1}) inBrassica spp. were found significantly greater in *B. campestris* cv. NDYS-2 (24) ascompared to *B. napus* cv. Hyola-401(21), *B. napus* cv. GSL-1 (14), B. carinatacv. Kiran (12) and *B. juncea* cv. Kranti (11), *B. juncea* cv. Urvarshi (11). Afroz *et al*. (2011) conducted a field experiment and observed that significantly higher Number of effective seeds (siliqua-1) were found in cv. BARI Sarisha-6 (20.6) ascompared to cv. BARI Sarisha-9 (13.5). Kumari et al. (2012) observed that hybridDMH-1 recorded significantly higher number of seeds (13.8 siliqua^{-1}) over hybridNRCHB-506 (13.6 siliqua^{-1}) and cv. Kranti (11.7 siliqua^{-1}).

2.2.6 1000-seed weight

Mondal and Wahab (2001) found that weight of 1000 seeds of rapeseed and mustard varied from variety to variety and species to species. They found thousand seed weight 2.50-2.65 g in case of improved Tori-7 (*B. campestris*) and 1.50-1.80 g in case of Rai 5 (*B. napus*).

Yeasmin (2013) studied that the significantly highest yield was showed by BARI Sarisha-9 (1448.20 kg ha^{-1}). The significantly lowest yield was with BARI Sharisa– 15 (1270.10 kg ha^{-1})

Karim *et al*. (2000) reported that the varieties showed significant difference in weight of thousand seeds. They found higher weight of 1000 seed in J-4008 (3.50 g), J-3023 (3.43 g), J. - 3018 (3.42g).

Akhter (2005) reported that the highest weight of 1000 seeds (3.8 g) was recorded from BARI sarisha-7 with harvesting the crop at 90 days. The lowest 1000 seed weight (2.63 g) was recorded from BARI sarisha-10 with harvesting at 100 days, which was similar with the same variety harvesting at 90 and 110 days.

Sharma (1992) observed that 1000-seeds weight was significantly higherin cv. Pusa Bold (6.31 g) over cv. Varuna (5.26 g). Yadav *et al*. (1994b) quoted that 1000-seed weight recorded higher in cv. Rohini (4.9 g) compared to cv.Vaibhav (4.6 g). Tyagi *et al*. (1995) revealed that cv. RH-30 exhibited significantlyhigher 1000-seeds weight (6.5 g) followed by cvs. Varuna (5.6 g) and Laxmi (5.3g). Sharma *et al.* (1997) concluded that 1000-seeds weight recorded significantlyhigher in cv. RH 30 (6.66 g) over cv. RH-819 (4.70 g). Rana and Pachauri (2001) suggested that cv. Bio 902 recorded higher 1000-seeds weight (3.16 g) comparedto cv. TERI (OE) R 15 (2.18 g). Singh et al. (2001) observed that the cv. PusaBold recorded higher 1000-seeds weight (4.48 g) as compared to local cultivar (3.55 g). Similarly, Singh *et al*. (2002b) recorded significantly higher 1000-seedsweight in cv. RH 30 (6.2 g) over cv. Varuna (5.6 g).

Kumar *et al.* (2008) reported that 1000-seeds weight in Brassica spp.were found significantly greater in *B. juncea* cv. Urvarshi (4.57 g) as compared to *B. carinata* cv. Karan (4.43 g), *B. juncea* cv. Kranti (3.88 g), *B. campestris* cv.NDYS-2 (3.78 g). *B. napus* cv. Hyola- 401 (3.36 g) and *B. napus* cv. GSL-1 (2.91g). Afroz et al. (2011) observed significantly higher 1000-seeds weight in cv. BARI Sarisha-9 (2.76 g) as compared to cv. BARI Sarisha-6 (2.68 g). Kumari *et al*. (2012) revealed that hybrid DMH-1 recorded significantly higher 1000-seedsweight (4.11 g) over hybrid NRCHB-506 (3.82 g) and cv. Kranti (3.52 g)

2.2.7 Grain yield

Yadav *et al*. (2018) conducted during rabi season of 2014 on the topic entitled "Effect of planting geometry on growth and yield of mustard [*Brassica juncea* (L.)] Varieties" in sandy loam soil of N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The experimental comprised of three planting geometry viz., 40×15cm, 40×20cm, 40×25cm and three varieties viz., Varuna, Vardan and NDR-8501. Results revealed that planting geometry of 40×15cm produced significantly higher growth yield.

Akhter (2005) conducted an experiment at the Agronomy Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka, from November 2004 to February 2005 to observe the effect of harvesting time on shattering, yield and oil content of rapeseed and mustard. The highest grain yield (1.78 t ha^{-1}) was recorded from BARI sarisha-7 with 100 days of harvesting that was similar (1.57 t ha^{-1}) with BARI sarisha-11 harvested on 110 days. The lowest yield (1.04 t ha^{-1}) was shown by BARI sarisha-8 that harvested earlier.

Rahman (2002) stated that yield variation existed among the varieties whereas the highest yield was observed in BARI Sarisha-7, BARI Sarisha-8 and BARI Sarisha-11 (2.00-2.50 t ha^{-1}) and the lowest yield in variety Tori-7 (0.95-1.10 t ha^{-1}).

Islam and Mahfuza (2012) conducted an experiment at the research field of Agronomy Division, BARI, Joydebpur, Gazipur during rabi season of 2010-2011. BARI Sarisha-11 produced the highest seed yield (1472 kg ha^{-1}) while BARI Sarisha-14 the lowest (1252 kg ha^{-1}). The highest mean seed yield was recorded at maturity stage (1480 kg ha^{-1}) and decreased towards green silique stage.

Mamun *et al*. (2014) conducted an experiment and they indicated the result that variety, plant density and their interaction had significant effect on seed yield. Means comparison showed that the most (1.35 t ha^{-1}) and the least seed yield (0.92 t ha^{-1}) were belonged to the plots having BARI Sarisha-13 and BARI Sarisha-15, respectively.

Mondal *et al*. (1995) reported that after continuous efforts of plant breeders of Oilseed Research Centre, BARI had developed several short duration genotypes of B. napus with high yield potential. The genotype, Nap-3 was one of these genotypes (Biswas and Zaman, 1990).

Mendham *et al.* (1990) showed that seed yield was variable due to varietal difference in species of *B. napus*. Similar findings were noticed by Chay and Thurling (1989), and Sharaan and Gowad (1986).

Afroz *et al*. (2011) conducted an experiment 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 highest seed yield (1.53 t ha^{-1}) was recorded in 10 November sowing and the lowest one was achieved in 30 November sowing. Seed rate had also significant effect on plant height, branches $plant^{-1}$, pods $plant^{-1}$, effective pods $plant^{-1}$, pod length, no. of seeds pod^{-1} and seed yield.

2.1.8 Stover yield

Hossain *et al*. (2012) reported that BARI Sarisha 8 *(Brassica napus*) had the maximum response to B application. On the other hand, BARI Sarisha 11 (Brassica juncea) showed the minimum response. The mean yields of B. campestris varieties were 2224-2702 kg ha^{-1}, *B. napus* varieties were 2850-3199 kg ha^{-1}, and yields of B. Juncea varieties were 3080-3528 kg $ha^{-1}$for the B control plots.

Sultana *et al*. (2009) studied that stover yield for different varieties of rapeseed under study differed significantly. Kollania produced higher stover yield (2159.0 kg ha^{-1}) which was statistically at par with SAU Sarisha-1 (2156.0 kg ha^{-1}) and higher than Improved Tori -7 (1681.0 kg ha^{-1}).

Akhter (2005) observed that the highest straw yield (3.68 t ha^{-1}) was found from BARI sarisha-7 that was similar (3.42 t ha^{-1}) with the variety BARI sarisha-11. The lowest straw yield (3.08 t ha^{-1}) was recorded from BARI sarisha-10 that was similar to the variety BARI sarisha-8 (3.09 t ha^{-1}).

Yadav *et al*. (1994a) reported that seed yield was recorded higher in cv.Vaibhav (1330 kg ha^{-1}) compared to cvs. Varuna and Rohini (980 and 1020 kg ha^{-1}), respectively. Tyagi *et al*. (1995) at Hisar (Haryana) quoted that seed yield (q ha^{-1}) did not differ among three cultivars viz., RH-30, Varuna and Laxmi.

Sharma *et al*. (1997) recorded significantly higher seed yield in cv. RH-30 (1835kg ha^{-1}) over cv. RH 819 (1699 kg ha^{-1}). Reddy and Kumar (1997) quoted thatmustard cv. TM-9 recorded significantly higher seed yield (619 kg ha^{-1}) over cv. Kranthi (567 kg ha^{-1}).

Laxminarayana and Poornachand (2000) observed that cv. GM-1 recorded significantly higher seed yield (2009 kg ha^{-1}) over cv. Vardhan (1515 kg ha^{-1}).

Singh *et al*. (2001) observed that seed yield was recorded higher in cv. Pusa Bold (1900 kg ha^{-1}) as compared to Local cultivar (1470 kg ha^{-1}). Rana and Pachauri (2001) quoted that the cv. Bio 902 recorded higher seed yield (1670 kg ha^{-1}) ascompared to cv. TERI (OE) R 15 (1390 kg ha^{-1}).

Singh *et al.* (2002b) recorded significantly higher seed yield in cultivar RH30 (2390 kg ha^{-1}) over Varuna (2240 kg ha^{-1}). Similarly, Pal *et al*. (1996) reportedthat seed yield was higher in cvs. RH 30 and Laxmi over cv.Varuna. The varietaldifferences in seed yield were also reported by Dehghani, *et al.* (2008). Kumar *et al*. (2008) reported that the seed yield in Brassica spp. were found significantlygreater in B. carinata cv. Kiran (1685 kg ha^{-1}) as compared to *B. napus* cv. Hyola-401 (1441 kg ha^{-1}), *B. juncea* cv. Urvarshi (1402 kg ha^{-1}), *B. napus* cv. GSL-1(1369), *B. juncea* cv. Kranti (1300 kg ha^{-1}) and *B. campestris* cv. NDYS-2 (742 kg ha^{-1}).

2.1.9 Harvest index

Mamun *et al*. (2014) conducted an experiment and data revealed that harvest index showed significant difference due to variation in varieties, plant densities and their interactions. BARI Sarisha-13 produced the highest harvest index of 37.65%, which was statistically different from all other test varieties and the lowest (33.73%) was incurred from BARI Sarisha-15.

Akhter (2005) observed that variations in harvest index among the varieties were found statistically significant. The highest harvest index (31.73%) was recorded from BARI sarisha-10 that was similar (30.18%)

with the variety BARI sarisha-8. The lowest harvest index (27.79%) was recorded from BARI sarisha-7 that was also similar to BARI sarisha-11 (28.90%) and BARI sarisha-8.

Sultana *et al*. (2009) showed that SAU Sarisha-1 exhibited the highest value (37.10%) of harvest index and Improved Tori-7 showed the lowest harvest index (37.34%). SAU Sarisha-1 and Kollania showed statistically similar values of harvest index.

2.3 Interaction of planting techniques and variety on different crop characters

Khan and Agarwal (1985) conducted an experiment and found that ridge and furrow sowing was superior to conventional flat sowing for growth parameters and yield of *Brassica juncea*.

Shekhwat *et al*. (2012) conducted an experiment at Bhubaneshwar, line sowing of yellow sarson after land preparation produced maximum seed yield (870 kg ha^{-1}) with 40kg N ha^{-1}. Paira or utera is a method of cropping in which the sowing of next crop is done in the standing previous crop without any tillage operation. Mustard sowing under paira/utera in the rice field has shown its edge over line sowing and broadcasting (Sowing of seeds by broad casting the seeds in the field) in eastern parts of India. At Dholi, mustard sown with paira cropping recorded significantly higher seed yield (1212 kg ha^{-1}) over line sown and broadcast method, while these 2 methods yielded at par. At Bhubaneswar, significantly higher yield (887 kg ha^{-1}) of mustard was recorded when sown as utera crop over line and broadcast sown crop (AICRP-RM, 1999).

Chapter III
MATERIALS AND METHODS

The experiment was conducted during *rabi* season, November 2017 to February 2018 to find out the effect of different sowing methods and varieties on the yield of (*Brassica campestris*).

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^0 22'$ E longitude and 23°4l′ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28.

3.2 Climatic condition

The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during *rabi* season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September).

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture with pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in Appendix I.

3.4 Materials

3.4.1 Seed

The high yielding varieties of mustard are BARI Sarisha 14, BARI Sarisha 15 and BARI Sarisha 17 developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and was used as a experimental planting material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.4.2 Fertilizers

The recommended doses of urea as a source of Nitrogen (N), Triple super phosphate (TSP) as a source of phosphorus (P), Muriate of Potash (MP) as a source of Potash (K), Gypsum as a source of Sulpher (S) and Boric acid as a source of Boron (B) were added to the soil of experimental field.

3.5 Methods

3.5.1 Factors of the experiment

Factor A: Sowing methods

S_0 = Broadcast method
S_1 = Line to line space 20 cm
S_2 = Line to line space 25 cm
S_3= Line to line space 30 cm

Factor B: varieties

V_1 = BARI Sarisha 14
V_2 = BARI Sarisha 15
V_3 = BARI Sarisha 17

3.5.2 Treatment combinations

There are 12 treatment combinations of different sowing method and varieties used in the experiment under as following:

1. S_0V_1
2. S_0V_2
3. S_0V_3
4. S_1V_1
5. S_1V_2
6. S_1V_3
7. S_2V_1
8. S_2V_2
9. S_2V_3
10. S_3V_1
11. S_3V_2
12. TS_3V_3

3.5.3 Design and layout

The experiment consisted of 12 treatment combinations and was laid out Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 12 × 3 = 36. The unit plot size was 2.5 m × 1.25 m = 3.13 m^2. The distance between blocks was 1 m and distance between plots was 0.5 m.

3.5.4 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 25 October, 2017. According to the layout of the experiment the entire experimental area was divided into blocks and experimental plot for the sowing of rmustard seed. In addition, irrigation and drainage channels were made around the plot.

3.5.5 Fertilization

In this experiment fertilizers were used according to the recommendation of Bangladesh Agricultural Reserch Institute (BARI) which is mentioned as follows:

Name of Nutrients	Name of Fertilizers	Rate of Application (kg/ha)
Nitrogen (N)	Urea,	250
Phosphorus (P)	Triple Super Phosphate	160
Potash (K)	Muriate of Potash	110
Sulpher (S)	Gypsum	160
Boron (B)	Boric acid	7.5
Zinc (Zn)	Zinc Oxide	15

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, muriate of potash, gypsum and boric acid required per plot were calculated. The triple super phosphate, muriate of potash, gypsum, boric acid was applied during final land preparation. Half of urea was also applied in each experimental plot according to treatment and incorporated into soil before sowing seed. Rest of the urea was top dressed after 30 days of sowing (DAS).

3.5.6 Sowing of seed

Sowing was done on 1st November, 2017 as per treatment. Sowing, seeds were sown as per treatment in rows and broadcasting methods at a rate of 8 kg/ha. The seeds were covered with the soil and slightly pressed by hand, and applied little amount water for better germination of seeds.

3.5.7 Thinning and weeding

The optimum plant population was maintained by thinning excess of plants at 15 DAS. One weeding was don with khurpi was given on 25 DAS.

3.5.8 Irrigation

Two irrigations were applied at required times. First irrigation was given immediate after topdressing and second irrigation was applied 60 DAS with watering can. After irrigation when the plots were in optimum (joe) condition, spading was done uniformly and carefully to conserve the soil moisture for proper growth and development of plants.

3.5.9 Crop protection

As a preventive measure of aphid infestation, Malathion 57 EC @ 2 ml litre^{-1} of water was applied twice first at 25 DAS and second at 50 DAS.

3.5.10 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

3.5.11 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyse the yield and yield contributing characters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned creamy white in color. After collecting sample plants, harvesting was started on February 17 and completed on February 22, 2018. For yield calculation 1 m area was selected for harvesting. 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. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.5.12 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighted and subsequently converted into yield kg ha^{-1}.

3.6 Data collection

Ten (10) plants from each plot were selected at random and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

3.6.1 Days to 1st emergence of seedling

Days to 1st emergence of seedling were recorded by counting the number of days required from sowing date to start emergence of seedling of mustard plant in each plot.

3.6.2 Days to 50% emergence of seedling

Days to 50% emergence of seedling were recorded from sowing date to the date of 50% emergence of seedling of every entry.

3.6.3 Days to 100% emergence of seedling

Days to 100% emergence of seedling were recorded by counting the number of days required from sowing date to 100% emergence of seedling of mustard plant in each plot.

3.6.4 Population density

The data on population density were collected from $1m^{-2}$ for each plot. The number was counted population of mustard.

3.6.5 Plant height

Plant height in cm was measured five times at 10 days interval such as 25, 35, 45, 55 and 65 DAS. The height of the plant was measured by scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean value was calculated for each treatment.

3.6.6 Branches $plant^{-1}$

Primary branches $plant^{-1}$ was counted at harvest of mustard plants. Mean value of data were calculated and recorded.

3.6.7 Days to 1^{st} flowering

Days to 1^{st} flowering were recorded by counting the number of days required from sowing date to start flower initiation of mustard plant in each plot.

3.6.8 Days to 50% flowering:

Days to 50% flowering were recorded from sowing date to the date of 50% flowering of every entry.

3.6.9 Days to maturity

Days to maturity were recorded by counting the number of days required from sowing date to maturity of mustard plant in each plot.

3.6.10 Total dry matter

Total dry mater of plant at harvest was calculated by aggregating the dry matter weight of leaves, stems, roots, siliquae cover and other immature reproductive parts.

3.6.11 siliquae plant^{-1}

Number of total siliquae of ten plants from each unit plot was noted and the mean number was expressed as per plant basis.

3.6.12 Length of siliqua

The length of 10 siliquae from each sample was collected randomly and the mean number was expressed as per siliqua basis (cm).

3.6.13 Number of seeds siliqua^{-1}

Number of total seeds of ten randomly sampled siliquae from each plot was noted and the mean number was expressed as per siliqua basis.

3.6.14 Thousand seed weight

A composite sample was taken from the yield of ten plants. The thousand seeds of each plot were counted and weighed with a digital electric balance. The thousand seed weight was recorded in g.

3.6.15 Yield

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to t/ ha.

3.6.16 Stover yield

Dry weight of stover from harvested area of each plot was taken and then converted to ton hectare^{-1}.

3.6.17 Biological yield

Biological yield was calculated by summing up the total seed yield and stover yield.

3.6.18 Harvest index (%)

Harvest index was calculated by dividing the economic seed yield from the net plot by the total biological yield of seed and stover from the same area and multiplying by 100.

3.7 Data analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program. The mean values for all the parameters were calculated and the analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

.

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from the experiment have been are presented and discussed in this chapter. Data on growth, yield contributing characters of mustard have been presented in both Tables and Figures.

4.1 Days to 1st emergence of seedling

There was no significant variation in the case of days to 1st emergence of seedling. The maximum time required for the 1st emergence of seedling (2.67 days) was recorded from the treatment S0 (Broadcast method). Emergence of seedling in case of line to line space 25 cm (S_2) were the earliest in the 1st emergence of seedling (2.44 days) (Table 1), Appendix-111

There was significant difference among the varieties in the days to 1st emergence of seedlings. Delayed 1st emergence of seedling (3.25 days) was found in BARI Sarisha-15 and 1st emergence of seedling was the earliest (2.17 days) in BARI Sarisha-17, which was statistically similar to BARI Sarisha 14 (Table 2),Appendix-111

The combined effect of different sowing methods and different varieties on days to 1st emergence of seedling was found to be significant. Data in Table 3 Shows that, the days to 1st emergence of seedling was minimum (2 days) in S_0V_1, S_2V_1, and S_2V_3 while it was maximum (3.67 days) in S_0V_2 treatment, which was statistical similar with S_2V_2.

Table 1. Effect of sowing method on Days to 1st emergence of seedling, 50% emergence of seedling, 100% emergence of seedling and plant population per square meter of mustard

Treatments	Days to 1st emergence of seedling	Days to 50% emergence of seedling	Days to 100% emergence of seedling	Plant population (m^{-2})
S_0	2.67	4.78	6.56	117.30 a
S_1	2.56	4.67	6.33	66.33 b
S_2	2.44	4.56	6.22	56.78 c
S_3	2.56	4.67	6.33	54.44 c
$LSD_{(0.05)}$	NS	NS	NS	5.14
CV (%)	7.44	10.71	8.17	14.35

Where, S_0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm, S_3= Line to line space 30 cm

Table 2. Effect of variety on Days to 1st emergence of seedling, 50% emergence of seedling, 100% emergence of seedling and plant population per square meter of mustard

Treatments	Days to 1st emergence of seedling	Days to 50% emergence of seedling	Days to 100% emergence of seedling	plant population (m^{-2})
V_1	2.17 b	4.17 b	5.58 b	71.00 b
V_2	3.25 a	5.50 a	7.25 a	72.92 ab
V_3	2.25 b	4.33 b	6.25 ab	77.25 a
$LSD_{(0.05)}$	0.44	0.82	1.35	5.99
CV (%)	7.44	10.71	8.17	14.35

Where, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

Table 3. Interaction effect of sowing method and variety on Days to 1st emergence of seedling, 50% emergence of seedling, 100% emergence of seedling and plant population per square meter of mustard

Treatments	Days to 1st emergence of seedling	Days to 50% emergence of seedling	Days to 100% emergence of seedling	Plant population (m^{-2})
S_0V_1	2.00 c	4.33 b	6.00 c	118.00 ab
S_0V_2	3.67 a	5.67 a	7.33 a	113.00 b
S_0V_3	2.33 bc	4.33 b	6.33 bc	121.00 a
S_1V_1	2.33 bc	4.00 b	5.67 c	59.33 de
S_1V_2	3.00 ab	5.67 a	7.00 ab	69.67 c
S_1V_3	2.33 bc	4.33 b	6.33 bc	70.00 c
S_2V_1	2.00 c	4.00 b	5.33 c	54.67 def
S_2V_2	3.33 a	5.33 a	7.33 a	55.33 def
S_2V_3	2.00 c	4.33 b	6.00 bc	60.33 d
S_3V_1	2.33 bc	4.33 b	5.33 c	52.00 f
S_3V_2	3.00 ab	5.33 a	7.33 a	53.67 ef
S_3V_3	2.33 bc	4.33 b	6.33 bc	57.67 def
$LSD_{(0.05)}$	0.75	0.85	0.88	5.59
CV (%)	7.44	10.71	8.17	14.35

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Where,S0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm, S_3= Line to line space 30 cm, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

4.2 Days to 50% emergence of seedling

The different sowing methods show no significant variation in the days to 50% emergence of seedling. The maximum days of 50% emergence of seedling (4.78 days) was recorded from S0 (Broadcast method) treatment. Seed sowing on line-line space 25 cm (S_2) were the earliest in 50% emergence of seedling (4.56 days) (Table 1), Apendix-111.

There was significant difference among the varieties in the days to 50% emergence of seedling. Delayed 50% emergence of seedling (5.5 days) was found in BARI Sarisha-15 and 50% emergence of seedling was earliest (4.17 days) in BARI Sarisha-17, which was statistical similar with BARI Sarisha 14 (Table 2), Apendix-111.

The combined effect of different sowing methods and different varieties on days to 50% emergence of seedling was found to be significant (Table 3). The days to 50 %emergence of seedling was minimum (4.00 days) in $S1V_1$ and S_2V_1, while it was maximum (5.67 days) in S_0V_2 and S_1V_2 treatment, which was statistical similar with S_2V_2 and S_3V_2. Apendix-1V

4.3 Days to 100% emergence of seedling

The different sowing methods show no significant variation in the days to 100% emergence of seedling. The maximum days of 100% emergence of seedling (6.56 days) was recorded from S0 (Broadcast method) treatment. Seed sowing on line-line space 25 cm (S2) were the earliest in 100% emergence of seedling (6.22 days) (Table 1), Apendix-111.

There was significant difference among the varieties in the days to 100% emergence of seedling. Delayed 100% emergence of seedling (7.25 days) was found in BARI Sarisha-15 (V_2) and 100% emergence of seedling was earliest (5.58 days) in BARI Sarisha-17 (V_1) (Table 2). Apendix-111.

The combined effect of different sowing methods and different varieties on days to 100% emergence of seedling was found to be significant (Table 3). The days to 100% emergence of seedling was minimum (5.33 days) in $S2V_1$ and $S3V_1$, while it was maximum (7.33 days) in $S0V_2$ $S2V_2$ and $S3V_2$treatment.

4.4 Population density

There was significant variation observed on population density per square meter due to sowing method (Table 1). The highest plant population (35.44) was recorded from Broadcast method (S_0) and lowest plant population (54.44) recorded from line to line space 30 cm (S3), which was statistically similar with S2.

Significant variation was observed on population density throughout the growing period for different variety treatments (Table 2). The highest plant population (77.25) was observed in BARI Sarisha 17 (V_3). The lowest number of plant population (71.00) was observed in BARI Sarisha 14 (V_1).

The effect of sowing methods and variety on number of plant population was statistically significant (Table 3). The maximum total number of plant population (121.00) was found from $S0V_3$ (Broadcast method and BARI Sarisha 17) and minimum number of plant population (52.00) from $S3V_1$ (Line-line space 30 cm and BARI Sarisha-14).

4.5 Plant height

Different sowing method the height of mustard plant significantly influenced at 25, 35, 45, 55 and 65 days after sowing (DAS) (Fig. 1),Apendix-1V The tallest plant (15.63, 40.31, 68.90, 79.28 and 79.55 cm at 25, 35, 45, 55 and 65 DAS, respectively) was recorded with S0 treatment. In contrast, the shortest plant (14.20, 30.68, 59.49, 71.03, 71.98 cm at 25, 35, 45, 55 and 65 DAS, respectively) was recorded from S1 (Line-line space 20 cm). Khan et al.

(2000) and Sarkees (2013) also found significant variation in plant height of rapes and mustard at different sowing techniques.

There is significant difference among the variety in respect of plant height at 25, 35, 45, 55 and 65 days after sowing (DAS) (Fig. 2). The tallest plant (18.45, 38.65, 66.03, 80.00, 83.94 cm, at 25, 35, 45, 55 and 65 DAS, respectively) was produced with V_2 (BARI Sarisha-15) and shortest plant (14.68, 29.75, 59.66, 68.60 and 69.78 cm at 25, 35, 45, 55 and 65 DAS, respectively) was found in V_1 (BARI Sarisha-14). Ali and Rahman (1988) and Mondal et al. (1992) also found significant variation in plant height of different varieties of rapes and mustard.

The combined use of sowing method and variety had significant effect on plant height at 25, 35, 45, 55 and 65 days after sowing (DAS) (Table 4). The tallest plant (16.67, 46.48, 69.35, 87.39, 88.37 cm at 25, 35, 45, 55 and 65 DAS, respectively) was found in $_{S0V2}$ treatment combination, whereas the shortest plant (13.74, 24.35, 54.91, 64.57, 67.14 cm) was observed in S_1V_1 treatment combination.

4.6 branches plant^{-1}

Sowing methods were significantly influenced on number of branch per plant (Table 5). The maximum Number of branches per plant (7.61) was produced by S3, which was statistically identical with other treatment and S0 treatment was produced the lowest Number of branches per plant (4.50).

Number of branches per plant was significantly influenced by variety (Table 6). The BARI Sarisha-15 (V_2) had the highest number of branches per plant (7.56). However, the lowest number of branches per plant (5.32) was obtained from the BARI Sarisha-17 (V_3). Mamun *et al.* (2014) reported that BARI Sarisha-15 performed well in terms of branches plant^{-1} (6.14).

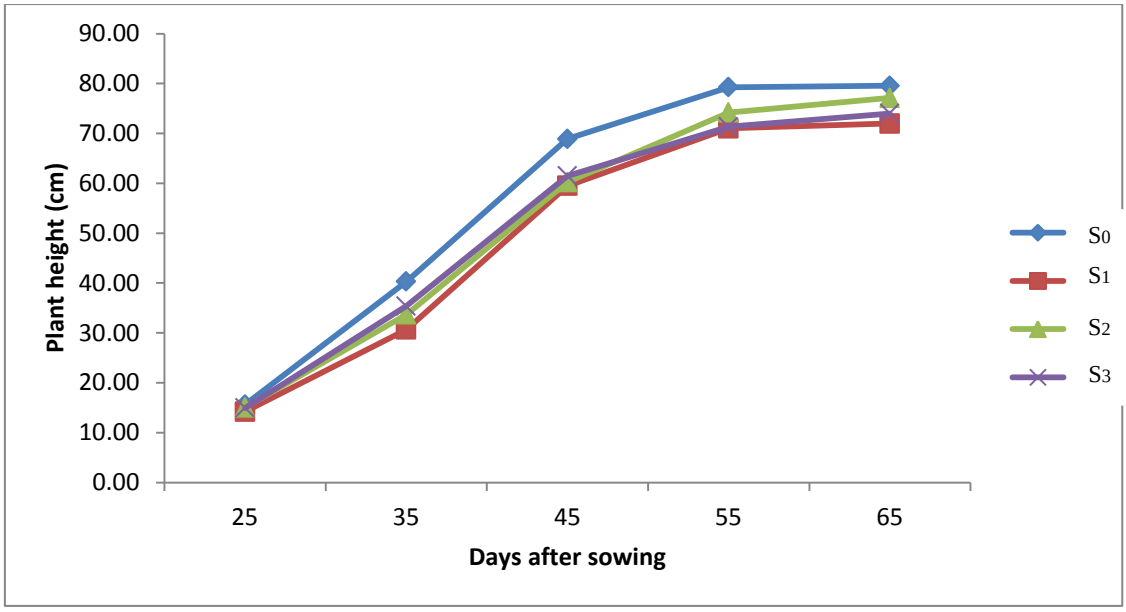

Fig.1. Effect of sowing method on plant height of mustard

Where, S_0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm, S_3= Line to line space 30 cm,

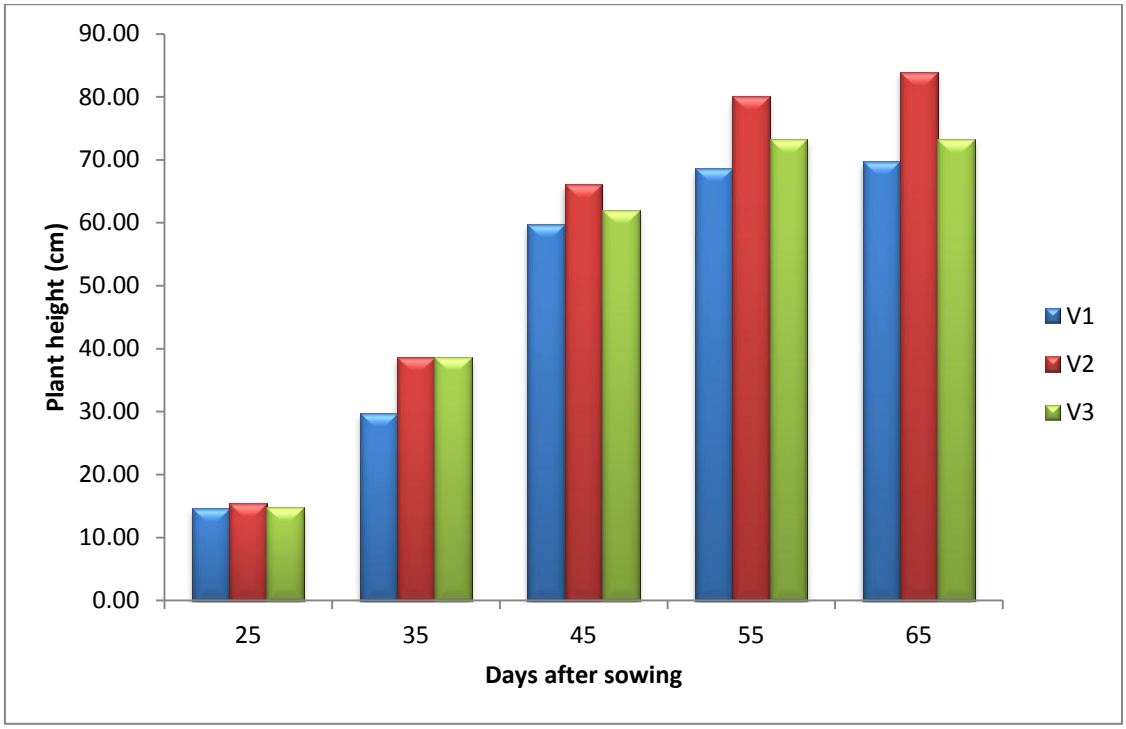

Fig. 2. Effect of variety on plant height of mustard

Where, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

Table 4. Interaction effect of sowing method and variety on plant height of mustard

Treatments	Plant height (cm)									
	25 DAS		35 DAS		45 DAS		55 DAS		65 DAS	
S_0V_1	15.58	abc	33.20	cd	68.62	a	75.23	bcd	76.55	cd
S_0V_2	16.67	a	46.48	a	69.35	a	87.39	a	88.37	a
S_0V_3	14.64	abc	41.25	ab	68.73	a	75.23	bcd	73.72	de
S_1V_1	13.74	c	24.35	e	54.91	d	64.57	e	67.14	e
S_1V_2	14.23	bc	34.99	cd	65.76	ab	78.54	b	80.78	bcd
S_1V_3	14.64	abc	32.71	cd	57.79	cd	68.72	cde	68.03	e
S_2V_1	14.51	abc	32.04	d	57.31	cd	68.74	cde	68.42	e
S_2V_2	15.89	ab	34.63	cd	62.71	abc	77.04	bc	85.25	ab
S_2V_3	14.71	abc	34.41	cd	60.64	bcd	76.75	bc	77.65	cd
S_3V_1	14.88	abc	29.41	de	57.81	cd	65.84	de	67.02	e
S_3V_2	15.02	abc	38.51	bc	66.19	ab	77.02	bc	81.36	abc
S_3V_3	14.88	abc	38.28	bc	60.42	bcd	72.45	bcde	73.64	de
$LSD_{(0.05)}$	1.84		5.26		6.66		8.40		6.76	
CV (%)	10.52		8.87		10.79		6.71		5.28	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Where, S_0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm, S_3= Line to line space 30 cm, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

Table 5. Effect of sowing method on number of branch per plant, dry weight, days to first flowering, 50% flowering and maturity of mustard

Treatments	branch plant^{-1}	Dry weight (g)	Days to first flowering	Days to50% flowering	Days to maturity
S_0	4.50 c	9.97 b	34.33 a	41.33 a	91.44 b
S_1	5.94 b	11.22 ab	35.89 a	43.33 a	94.33 a
S_2	6.81 ab	14.63 a	33.67 a	43.00 a	94.89 a
S_3	7.61 a	14.82 a	34.22 a	44.00 a	95.11 a
$LSD_{(0.05)}$	1.26	4.28	3.32	4.13	0.96
CV (%)	12.34	10.22	5.44	4.29	5.24

Where, $_{S0}$ = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm, S_3= Line to line space 30 cm

Table 6. Effect of variety on number of branch per plant, dry weight, days to first flowering, 50% flowering and maturity of mustard

Treatments	branch plant^{-1}	Dry weight (g)	Days to first flowering	Days to50% flowering	Day to maturity
V_1	5.78 b	10.67 b	34.00 a	41.00 a	93.00 b
V_2	7.56 a	15.64 a	36.25 a	45.25 a	93.92 ab
V_3	5.32 b	11.69 ab	33.33 a	42.50 a	94.92 a
$LSD_{(0.05)}$	1.29	4.60	4.34	5.00	1.71
CV (%)	12.34	10.22	5.44	4.29	5.24

Where, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

A significant variation in the number of branches per plant was found between the sowing method and variety (Table 7). The maximum number of branches per plant (9.57) was found in combined use of line-line space 30 cm with BARI Sarisha-15 treatment, whereas the lowest number of branches per plant (3.90) was found in broadcast method and BARI Sarisha-14 treatment.

4.7 Dry Matter weight plant^{-1} (g)

Dry matter (g) production was significantly affected by sowing method throughout the lifecycle (Table 5),Apendix-VThe maximum dry matter weight (14.82 g) was gained at S3 treatment, which was statistically similar with S_2 treatment and minimum dry matter weight (9.97 g) was recorded at S_0 treatment.

Dry matter (g) production was significantly influenced by variety throughout the lifecycle (Table 6). The maximum weight (15.64 g) was gained at BARI Sarisha-15 and minimum dry matter weight (10.67 g) was recorded at BARI Sarisha-14.

Dry matter weight (g) was significantly influenced by the interaction of sowing methods and variety (Table 7). The maximum dry matter (18.97 g) accumulation was recorded at the combination of line-line space 30 cm with BARI Sarisha-15 ($_{S3V2}$) and minimum dry matter (7.91 g) accumulation was observed at the combination of Broadcast method and BARI Sarisha-14 (V_1S_0)

Table 7. Interaction effect of sowing method and variety on number of branch per plant, dry weight, days to first flowering, 50% flowering and maturity of mustard

Treatments	Branch plant^{-1}		Dry weight (g)		Days to first flowering		Days to50% flowering		Day to maturity	
S_0V_1	4.67	cd	7.91	d	34.33	b	40.00	d	89.67	c
S_0V_2	4.93	cd	12.77	bcd	35.67	ab	44.00	c	90.33	c
S_0V_3	3.90	d	9.24	d	33.00	b	40.00	d	94.33	a
S_1V_1	5.97	bc	11.73	cd	35.67	b	44.00	c	93.00	b
S_1V_2	7.13	b	13.23	bcd	39.00	a	46.00	a	94.67	a
S_1V_3	4.73	cd	8.70	d	33.00	b	40.00	d	95.33	a
S_2V_1	5.97	bc	10.70	cd	33.00	b	40.00	d	94.67	a
S_2V_2	8.60	a	17.57	ab	35.00	b	45.00	b	95.33	a
S_2V_3	5.87	bc	15.63	abc	33.00	b	44.00	c	94.67	a
S_3V_1	6.50	b	12.33	bcd	33.00	b	40.00	d	94.67	a
S_3V_2	9.57	a	18.97	a	35.33	b	46.00	a	95.33	a
S_3V_3	6.77	b	13.17	bcd	34.33	b	46.00	a	95.33	a
$LSD_{(0.05)}$	1.30		4.82		3.18		0.91		1.12	
CV (%)	12.34		10.22		5.44		4.29		5.24	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Where,S0 = Broadcast method, S1 = Line to line space 20 cm, S2 = Line to line space 25 cm, S3= Line to line space 30 cm, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

4.8 Days required to 1st flowering

Days required to 1st flowering of mustard showed statistically non significant variation due to different sowing method (Table 5). The minimum days required to 1st flowering (33.67) was found from S2 treatment and the maximum days to 1st flowering (35.89) was recorded from S1 treatment.

Different mustard varieties showed significant variation in terms of days required to flowering. The minimum days required to 1st flowering (33.33) was recorded from V_3, while the maximum days (36.25) was obtained from V_2 (Table 6). BARI (2001) reported the highest days to 1st flowering (32 days) were found in Jamalpur-1 variety and lowest in BARI Sarisha-10.

Interaction effect of sowing method and mustard varieties showed significant differences on days required to flowering. The minimum days required to flowering (33.00) was observed from $S0V_3$, $S1V_3$, $S2V_1$, $S2V_3$ and $S3V_1$ and the maximum days required to 1st flowering (39.00) was found from $S1V_2$ treatment combination (Table 7).

4.9 Days to 50% flowering

The different sowing method shows no significant variation in the days to 50% flowering. The seed sowing of line-line space 30 cm (S3) required the maximum time of time of 50% flowering (44.00 days).the seed sowing of broadcast method (S0) were the earliest in flowering (41.33days) (Table 5).

There was not significantly varied among the varieties in the days to 50% flowering (Table 6). Delayed flowering (45.25 days) was found in BARI Sarisha-15 and flowering was earliest (41.00 days) in BARI Sarisha-14 (Table 5). This difference in flower initiation was due to its varietal characters. BARI (2001) reported the highest days to 1st flowering (32 days) were found in Jamalpur-1 variety and lowest in BARI Sarisha-10.

The combined effect of sowing method and varieties on days to 50% flowering was found to be significant Data in Table 7 Shows that, the days to 50% flowering was minimum (40 days) in $S0V_{1,}$ $S0V_{3,}$ $S1V_{3,}$ $S2V_1$ and $S3V_1$, while it was maximum (46.00days) in $S1V_2$.

4.10 Days required to maturity

Days required to maturity of mustard showed statistically significant variation due to different sowing methods. The minimum days required to maturity (91.44) was observed from S0, whereas the maximum days required to maturity (95.11) from S_3 (Table 5).

Different mustard varieties showed significant variation in terms of days required to maturity. The minimum days required to maturity (93.00) was observed from V_1, while the maximum days required maturity (94.92) was recorded from V_3 (Table 6).

Interaction effect of sowing method and mustard varieties showed significant differences on days required to maturity. The minimum days required to maturity (89.67) was found from $S0V_1$, whereas the maximum days (95.33) were recorded from $S1V_{3,}$ $S2V_{2,}$ $S3V_2$ and $S3V_3$treatment combination (Table 7).

4.11 Siliquae plant^{-1}

Number of siliquae per plant is one of the most important yield contributing characters in mustard. The sowing method showed significantly variation in the number of siliquae per plant (Table 8). The maximum number of siliquae per plant (69.07) was produced by S3 treatment and S0 produced the minimum number of siliquae per plant (28.87). Hossain *et al*. (2013) also stated that there was marked statistical variation in number of siliquae plant-1at different sowing technique.

There was a significant difference among the variety in the number of siliquae per plant (Table 9). The maximum number of siliqua per plant (68.59) was produced in V_2 treatment and the minimum number of siliquae per plant (47.38) was produced in V_3 treatment, which was statistically similar with V_1 treatment. Hossain *et al*. (1996) and Jahan and Zakaria (1997) also stated that there was marked statistical variation in number of siliquae plant^{-1}.

A significant variation was found in the treatment combinations of sowing method and variety on number of siliquae per plant (Table 10). The maximum number of siliquae per plant (94.30) was found in $S3V_2$, which was statistically similar with $S2V_1$, whereas the minimum number of siliquae per plant (24.27) was found in $S0V_3$ treatment combination, which was statistically similar with $S0V_1$.

4.12 Length of siliqua

The sowing method was not showed significant variation in the length of siliqua (Table 8). The maximum length of siliqua (4.30 cm) was produced by S1 treatment, whereas S0 produced the minimum length of silliqua (4.05).

There was a no significant difference among the variety in the length of silliqua (Table 9). The maximum length of silliqua (4.30) was produced in V_2 treatment. The minimum length of silliqua (4.13) was produced in V_1 treatment. Hussain et al. (2008) reported that BARI sharisha-8 performed better in terms of siliqua length. Hussain *et al*. (1996) observed the longest siliqua (8.07 cm) in BLN-900 and the shortest (4.83 cm) in Hyola-401.

Length of silliqua indicated a significant variation among the treatment combinations of sowing method and variety (Table 10). The maximum length of silliqua (4.46) was found in $S3V_2$, which was statistically similar with $S1V_2$ treatment combination, whereas the minimum length of silliqua (4.01) was found in$S0V_1$ treatment, which was statistically similar with $S0V_3$.

Table 8. Effect of sowing method on yield contributing characters of mustard

Treatments	Siliqua plant^{-1} (no.)	Length of siliquae (cm)	Seed siliqua^{-1}	1000 seed weight (g)
S_0	28.87 c	4.05 a	20.31 b	2.97 a
S_1	54.41 b	4.30 a	20.27 b	2.81 a
S_2	68.42 a	4.26 a	20.08 b	2.84 a
S_3	69.07 a	4.28 a	22.94 a	2.62 a
$LSD_{(0.05)}$	8.33	0.28	2.39	0.38
CV (%)	8.19	4.87	8.27	5.19

Where,S0 = Broadcast method, S1 = Line to line space 20 cm, S2 = Line to line space 25 cm, S3= Line to line space 30 cm,

Table 9. Effect of variety on number of yield contributing characters of mustard

Treatments	Siliqua plant^{-1} (no.)	Length of siliquae (cm)	Seed siliqua^{-1}	1000 seed weight (g)
V_1	49.61 b	4.13 a	18.85 b	2.98 a
V_2	68.59 a	4.30 a	23.12 a	2.58 b
V_3	47.38 b	4.23 a	20.73 ab	2.88 ab
$LSD_{(0.05)}$	11.80	0.52	2.82	0.37
CV (%)	8.19	4.87	8.27	5.19

Where, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

Table 10. Interaction effect of sowing method and variety on yield contributing characters of mustard

Treatments	Siliqua plant^{-1} (no.)		Length of siliquae (cm)		Seed siliqua^{-1}		1000 seed weight (g)	
S_0V_1	27.93	d	4.01	b	17.22	f	3.01	ab
S_0V_2	34.40	cd	4.11	ab	23.52	ab	2.92	abc
S_0V_3	24.27	d	4.02	b	20.18	cdef	2.99	ab
S_1V_1	54.70	b	4.14	ab	18.07	ef	3.05	a
S_1V_2	62.03	b	4.45	a	23.00	abc	2.54	def
S_1V_3	46.50	bc	4.29	ab	19.74	cdef	2.85	abc
S_2V_1	60.30	b	4.29	ab	18.71	def	3.09	a
S_2V_2	83.63	a	4.18	ab	20.93	bcde	2.47	ef
S_2V_3	61.33	b	4.30	ab	20.59	bcde	2.97	ab
S_3V_1	55.50	b	4.08	ab	21.40	bcd	2.76	bcd
S_3V_2	94.30	a	4.46	a	25.02	a	2.40	f
S_3V_3	57.40	b	4.30	ab	22.41	abc	2.69	cde
$LSD_{(0.05)}$	17.00		0.35		2.93		0.25	
CV (%)	8.19		4.87		8.27		5.19	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Where,S0 = Broadcast method, S1 = Line to line space 20 cm, S2 = Line to line space 25 cm, S3= Line to line space 30 cm, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

4.13 Seed per silliqua^{-1}

The sowing method showed variation in the number of seed per silliqua (Table 8). The maximum number of seed per silliqua (22.94) was produced by S3, whereas S2 produced the minimum number of seed per silliqua (20.08), which was statistically similar with S1 and S0 .

There was a significant difference among the variety in the number of seed per silliqua (Table 9). The maximum number of seed per silliqua (23.12) was produced in V_2 treatment. The minimum number of seed per silliqua (18.82) was produced in V_1 condition. Mondal *et al*. (1992) and Hossain *et al*. (1996) also reported that there was significant difference among the varieties with respect to number of seeds siliqua^{-1}.

Number of seed per silliqua indicated a significant variation among the treatment combinations of sowing method and variety (Table 5). The maximum number of seed per silliqua (25.02) was found in $S3V_2$ treatment combination, whereas the minimum number of seed per silliqua (17.22) was found in $S0V_1$ treatment.

4.14 Thousand Seed weight

Sowing methods was not significantly influenced on the thousand seed weight (Table 8). The maximum thousand seed weight (2.97 g) was produced by S0 produced and the lowest thousand seed weight (2.62 g). The result was supported by Sarker and Hassan (1988), Sharma and Kumar (1989) and Sarker *et al.* (2000).

The weight of thousand seed was significantly influenced by variety (Table 9). The highest thousand seed weight (2.98 g) was obtained from V_1 treatment. The lowest thousand seed weight (2.58 g) was obtained from V_2 treatment.

Thousand seed weight was significantly affected by both sowing method and variety (Table 10). The highest thousand seed weight (3.09 g) was found in $S2V_1$ treatment combination, whereas the lowest thousand seed weight (2.40 g) was found in $S3V_2$ treatment.

4.15 Seed yield (t/ha)

The seed yield of mustard per plot was converted into per hectare, and has been expressed in metric tons (Table 11). The different sowing method had effect on the yield of seed per hectare. The maximum yield of seed per hectare (1.11 t) was obtained from S0 (Broadcast method) treatment, whereas the minimum yield of seed per hectare (0.59 t) was obtained from S3 (Line to line space 30 cm). Hossain *et al*. (2013) and Sarkees (2013) also reported that sowing method had significant influence on seed yield.

The total yield of mustard varied significantly due to the application of different variety (Table 12). The highest yield of seed (0.95 t/ha) was obtained from V_2 (BARI Sarisha-15) while V_1 gave the lowest (072 t/ha) yield. Mendham *et al*. (1990) and Rahman (2002) also showed that seed yield was dissimilar due to varietal differences.

The combined effect of sowing method and variety was significant on yield of seed per hectare (Table 13). The highest yield of seed per hectare (1.16 ton) was obtained from $S0V_2$ (Broadcast method with BARI Sarisha-15) treatment combination. The lowest yield of seed per hectare (0.44 ton) was obtained from $S3V_0$ (Line-line space 30 cm and BARI Sarisha-17) treatment.

4.16 Stover yield (t/ha)

The stover yield of mustard per plot was converted into per hectare, and has been expressed in metric tons (Table 11). The different dose of sowing method had effect on the stover yield per hectare. The maximum yield of stover per hectare (3.43 t) was obtained from S0, treatment, whereas the minimum yield of stover per hectare (1.72 t) was obtained from S3.

Table 11. Effect of sowing method on the yield and yield contributing character of mustard

Treatments	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
S_0	1.11 a	3.43 a	4.54 a	24.73 b
S_1	0.82 bc	2.41 b	3.24 b	25.65 b
S_2	0.86 ab	2.17 b	3.03 bc	28.59 a
S_3	0.59 c	1.72 c	2.31 c	25.69 b
$LSD_{(0.05)}$	0.26	0.35	0.80	1.06
CV (%)	10.79	6.84	5.05	10.37

Where,S0 = Broadcast method, S1 = Line to line space 20 cm, S2 = Line to line space 25 cm, S3= Line to line space 30 cm

Table 12. Effect of variety on the yield and yield contributing character of mustard

Treatments	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
V_1	0.72 b	2.16 b	2.88 b	25.58 b
V_2	0.95 a	2.89 a	3.84 a	25.20 b
V_3	0.87 a	2.25 b	3.13 b	27.72 a
$LSD_{(0.05)}$	0.16	0.31	0.66	2.13
CV (%)	10.79	6.84	5.05	10.37

Where, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

Table 13. Interaction effect of sowing method and variety on the yield and yield contributing character of mustard

Treatments	Grain yield (t/ha)		Stover yield (t/ha)		Biological yield (t/ha)		Harvest index (%)	
S_0V_1	1.02	ab	3.49	ab	4.51	ab	22.69	cd
S_0V_2	1.16	a	3.92	a	5.08	a	22.97	bcd
S_0V_3	1.15	a	2.89	bc	4.04	bc	28.54	a
S_1V_1	0.70	de	1.94	def	2.64	ef	26.55	abc
S_1V_2	0.81	bcd	3.00	bc	3.81	bc	21.15	d
S_1V_3	0.95	abc	2.30	cde	3.25	cde	29.24	a
S_2V_1	0.70	de	1.85	def	2.55	ef	28.47	a
S_2V_2	1.08	a	2.59	cd	3.67	bcd	29.37	a
S_2V_3	0.81	cd	2.07	def	2.87	de	27.94	ab
S_3V_1	0.44	f	1.36	f	1.79	f	24.60	abcd
S_3V_2	0.76	cde	2.05	def	2.80	de	27.33	abc
S_3V_3	0.58	ef	1.76	ef	2.34	ef	25.15	abcd
$LSD_{(0.05)}$	0.20		0.69		0.84		4.60	
CV (%)	10.79		6.84		5.05		10.37	

In a column, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Where,S0 = Broadcast method, S1 = Line to line space 20 cm, S2 = Line to line space 25 cm, S3= Line to line space 30 cm, V_1 = BARI Sarisha 14, V_2 = BARI Sarisha 15, V_3 = BARI Sarisha 17

The total stover yield of mustard varied significantly due to the application of different variety (Table 12). The highest yield of stover (2.89 t) was obtained from V_2, while V_1 gave the lowest (2.16 t/ha) yield, which was statisticaly similar with V_3.

The combined effect of sowing method and variety was significant on yield of seed per hectare (Table 13). The highest yield of stover per hectare (3.92 tones) was obtained from $S0V_2$ treatment combination. The lowest yield of stover per hectare (1.36 tones) was obtained from $S3V_1$ treatment.

4.17 Biological yield (t/ha)

The different dose of sowing method had effect on the biological yield per hectare. The maximum biological yield per hectare (4.54 t) was obtained from S0 treatment, whereas the minimum yield of seed per hectare (2.31 t) was obtained from S3 treatment (Table 11).

The stover yield of mustard varied significantly due to the variety (Table 12). The highest yield of stover (3.84 t/ha) was obtained from V_2 while V_1 gave the lowest (2.88 t/ha) stover yield.

The combined effect of sowing method and variety was significant on biological yield per hectare (Table 13). The highest biological yield per hectare (5.08 tones) was obtained from $S0V_2$ treatment combination. The lowest biological yield per hectare (1.79 tones) was obtained from $S3V_1$ treatment.

4.18 Harvest index (%)

The different sowing method had effect on the harvest index of mustard. The maximum harvest index (28.59 %) was obtained with S2, and the minimum harvest index (24.73%) was obtained from S0 treatment (Table 11).

The harvest index varied significantly due to the application of different variety (Table 12). The highest harvest index (27.72%) was obtained from V_3 while V_2 gave the lowest (25.20 %) harvest index.

The combined effect of sowing method and variety was significant on harvest index (Table 13). The highest harvest index (29.37 %) was obtained from $S2V_2$ treatment combination. The lowest harvest index (21.15%) was obtained from $S1V_2$ treatment.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh during rabi season, November 2017 to February 2018 to examine the effect of different sowing methods and varieties on the yield of (*Brassica campestris*). The experiment comprised of two factors - the treatment consisted of four sowing methods viz. S_0 = Broadcast method, S_1 = Line to line space 20 cm, S_2 = Line to line space 25 cm and S_3= Line to line space 30 cm and three different varieties viz. V_1 = BARI Sarisha-17 V_2 = BARI Sarisha 15 and V_3 = BARI Sarisha 17. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

The different sowing methods show no significant variation in the days to 1st emergence of seedling, days to 50% emergence of seedling. And days to 100% emergence of seedling. The maximum time of 1st emergence of seedling (2.67 days) and days of 100% emergence of seedling (6.56 days) were recorded from S0 (Broadcast method) treatment. There was significant variation observed on population density per square meter due to sowing method. The highest plant population (35.44) was recorded from Broadcast method (S0). Different sowing method the height of mustard plant significantly influenced at 25, 35, 45, 55 and 65 days after sowing (DAS). The tallest plant (15.63, 40.31, 68.90, 79.28 and 79.55 cm at 25, 35, 45, 55 and 65 DAS, respectively) was recorded with S0 treatment. Sowing methods were significantly influenced on number of branch per plant. The maximum Number of branches per plant (7.61) was produced by S3. Dry matter production was significantly affected by sowing method throughout the lifecycle. The maximum dry matter weight (14.82 g) was gained at S3 treatment, Days required to 1st flowering, days to 50% flowering of mustard

showed statistically non significant variation due to different sowing method. The minimum days required to 1st flowering (33.67) was found from S2 treatment. The seed sowing of line-line space 30 cm (S3) required the maximum time of 50% flowering (44.00 days). Days required to maturity of mustard showed statistically significant variation due to different sowing methods. The minimum days required to maturity (91.44) was observed from S_0. The sowing method showed significantly variation in the number of siliquae per plant. The maximum number of siliquae per plant (69.07) was produced by S3 treatment. The sowing method was not showed significant variation in the length of siliqua. The maximum length of siliqua (4.30 cm) was produced by S1 treatment. The sowing method showed variation in the number of seed per silliqua. The maximum number of seed per silliqua (22.94) was produced by S3, Sowing methods was not significantly influenced on the thousand seed weight. The maximum thousand seed weight (2.97 g) was produced by S_0S0. The different sowing method had effect on the yield of seed per hectare. The maximum yield of seed per hectare (1.11 t) was obtained from S0 (Broadcast method) treatment. The different dose of sowing method had effect on the stover yield per hectare. The maximum yield of stover per hectare (3.43 t) was obtained from $S_{0,}$ treatment. The different method had effect on the biological yield per hectare. The maximum biological yield per hectare (4.54 t) was obtained from S0. The different sowing method had effect on the harvest index of mustard. The maximum harvest index (28.59 %) was obtained with S2

There was significant difference among the varieties in the days to 1st emergence of seedling, the days to 50% emergence of seedling and days to 100% emergence of seedling. Delayed 1st emergence of seedling (3.25 days), 50% emergence of seedling (5.5 days) and 100% emergence of seedling (7.25 days) were found in BARI Sarisha-15. Significant variation was observed on population density throughout the growing period for different variety treatments. The highest plant population (77.25) was observed in BARI Sarisha-17 (V_3). There is significant difference among the variety in respect of plant height at 25, 35, 45, 55 and 65 days after sowing (DAS). The tallest plant (18.45, 38.65, 66.03, and 80.00, 83.94

cm, at 25, 35, 45, 55 and 65 DAS, respectively) was produced with V_2 (BARI Sarisha-15). Number of branches per plant was significantly influenced by variety. The BARI Sarisha-15 (V_2) had the highest number of branches per plant (7.56). Dry matter (g) production was significantly influenced by variety throughout the lifecycle. The maximum weight (15.64 g) was gained at BARI Sarisha-15. Different mustard varieties showed significant variation in terms of days required to flowering. The minimum days required to 1st flowering (33.33) was recorded from V_3. There was not significantly varied among the varieties in the days to 50% flowering. Delayed flowering (45.25 days) was found in BARI Sarisha-15. Different mustard varieties showed significant variation in terms of days required to maturity. The minimum days required to maturity (93.00) was observed from V_1, There was a significant difference among the variety in the number of siliquae per plant. The maximum number of siliqua per plant (68.59) was produced in V_2 treatment. There was a no significant difference among the variety in the length of silliqua. The maximum length of silliqua (4.30) was produced in V_2 treatment. There was a significant difference among the variety in the number of seed per silliqua. The maximum number of seed per silliqua (23.12) was produced in V_2 treatment. The weight of thousand seed was significantly influenced by variety. The highest thousand seed weight (2.98 g) was obtained from V_1 treatment. The total yield of mustard varied significantly due to the application of different variety. The highest yield of seed (0.95 t/ha) was obtained from V_2 (BARI Sarisha-15). The total stover yield of mustard varied significantly due to the application of different variety. The highest yield of stover (2.89 t) was obtained from V_2, The stover yield of mustard varied significantly due to the variety. The highest yield of stover (3.84 t ha^{-1}) was obtained from V_2. The harvest index varied significantly due to the application of different variety. The highest harvest index (27.72%) was obtained from V_3.

The combined effect of different sowing methods and different varieties on all parameter was found to be significant. The days to 1st emergence of seedling was minimum (2 days) in $S0V_1$, $S2V_1$, and $S2V_3$. The days to 50 %emergence of seedling was minimum (4.00 days) in $S1V_1$ and $S2V_1$, The days to 100%

emergence of seedling was minimum (5.33 days) in $S2V_1$ and $S3V_1$. The maximum total number of plant population (121.00) was found from $S0V_3$ (Broadcast method and BARI Sarisha-17). The tallest plant (16.67, 46.48, 69.35, 87.39, 88.37 cm at 25, 35, 45, 55 and 65 DAS, respectively) was found in $S0V_2$ treatment combination. The maximum number of branches per plant (9.57) was found in combined use of line to line space 30 cm with BARI Sarisha-15 treatment. The maximum dry matter (18.97 g) accumulation was recorded at the combination of line-line space 30 cm with BARI Sarisha-15. The minimum days required to flowering (33.00) was observed from $S0V_3$, $S1V_3$, $S2V_1$, $S2V_3$ and $S3V_1$. The days to 50% flowering was minimum (40 days) in $S0V_1$, $S0V_3$, $S1V_3$, $S2V_1$ and $S3V_1$, The minimum days required to maturity (89.67) was found from $S0V_1$. The maximum number of siliquae per plant (94.30) was found in $S3V_2$, The maximum length of silliqua (4.46) was found in $S3V_2$, The maximum number of seed per silliqua (25.02) was found in $S3V_2$ treatment combination. The highest thousand seed weight (3.09 g) was found in $S2V_1$. The highest yield of seed ha^{-1} (1.16 ton) was obtained from $S0V_2$ (Broadcast method with BARI Sarisha-15) treatment combination. The highest yield of stover per hectare (3.92 tones) was obtained from $S0V_2$ treatment combination. The highest biological yield per hectare (5.08 tones) was obtained from $S0V_2$ treatment combination. The highest harvest index (29.37 %) was obtained from $S2V_2$ treatment combination.

From the above results it can be concluded that the variety BARI Sarisha-15 provided better yield than those of the other varieties and broadcast method provided better yield for most of the mustard varieties.

Considering the results obtained from the present experiment, further studies in the following areas may be suggested:

- Future study may be carried out with more varieties/genotypes, and
- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.

REFERENCES

Abdel. A. Z. E. (1973). The performance of yield and quality of radish as affected by plant population, planting method and ridge side direction under hot tropical conditions. In: Proc. Fourth Vegetables Res. Conf., Alexandria, Egypt [Cited from Horticulture, Abstr., 45(5): 3303, 1975].

Afroz, M. M., M. A. R. Sarkar, M. S. U. Bhuiya and A. K. Roy (2011). Effect of sowingdate and seed rate on yield performance of two mustard varieties. *J. Bangladesh Agric. Univ*., **9** (1): 5–8.

Ahmed, F., Karim, M.R. and Jahan, M.A. (1999). Effect of different management practices on the productivity and profitability of mustard under late sown condition. *Bangladesh J. Agril. Res*. 211 (3): 425-430.

Ahmed, M. (2008). Results of farm level socio-economic study on mustard production. *Bangladesh J. Agril. Res*. **13**(1): 20-23.

Aiken, R., Baltensperger, D., Krall, J., Pavlista, A. and Johnson, J. (2015). Planting methods affect emergence, flowering and yield of spring oilseed crops in the U.S. central high plains. Indust.Crops Products. 69: 273-277.

AIS (Agricultural Information Service). (2013). Krishi Diary (In Bangla). Agril. Inform. Ser. Khamarbari, Farmgate, Dhaka, Bangladesh. p.16.

Akhter, S.M.M. (2005). Effect of harvesting time on shattering, yield and oil content of rapeseed and mustard. M.S. Thesis, SAU, Dhaka, Bangladesh

Ali, M., Khalil, S.K., Ayaz, S. and Marwat, M.I. (1998). Phenological stages, flag leaf, plant height, and leaves per plant of corn influenced by phosphorus levels and plant spacing. Sarhad J. Agric. 14: 515-522.

Ali, M.H. and Rahman, A.M.M.D. (1986). Response of nitrogen in TS-72 (Kalyania) cultivar of Brassica campestris. *Bangladesh J. Agric*. 11(3): 83-86.

BARI (2000). Annual report 1999-2000. Oilseed Research Centre. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur.

BARI (2000).Annual report 1999-2000.Oilseed Research Centre.Bangladesh Agricultural Research Institute. Joydebpur, Gazipur

BARI (Bangladesh Agricultural Research Institute), (2001). Annual Report 2000-2001. Oilseed Research Centre. Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. p. 115-118.

BARI Oil Reasearch Centre (2001). Annual Report of 2000-2001. Oilseed Research Centre. Bangladesh Agril. Res. Inst. Joydebpur, Gazipur, Bangladesh.

BBS (Bangladesh Bureau of Statistics). (2011). Monthly Statistical Bulletin. (August). Stat. Div., Minis. Planning, Govt. Peoples Repub. Bangladesh, Dhaka.

Begum F., Hossain F. and Mondal M.R.I. (2012). Influence of Sulphur on morpho-physiological and yield parameters of rapeseed. *Bangladsh J. Agril. Res*. **37**(4): 645-652.

FAO (Food and Agriculture Organization). (2012). Production Year Book. Food and Agriculture Organization of the United Nations, Rome. Italy.

Hossain, M.A., Jahiruddin, M. and Khatun, F. (2012). Response of mustard (*Brassica*) varieties to Boron application. *Bangladesh J. Agril. Res*. **37**(1): 137-148.

Hossain, M.B., Alam, M.S., and Ripon, M.A. (2013). Effect of irrigation and sowing method on yield and yield attributes of mustard. Rajshahi University J. Life Earth Agric. Sci. 41: 65-70.

Hossain, M.F., Zakaria, A.K.M. and Jahan, M.H. (1996). Technical Report on variety Screening Adaptive Research Oilseeds. Rural Development Academy, Bogra, Bangladesh. pp. 6-34.

Islam, M.N. and Mahfuza S.N. (2012). Effect of harvesting stage on seed yield of mustard. A project report of Bangladesh Agricultural Research Institute, Agronomy Division, Joydebpur, Gazipur, Dhaka. pp. 1-2.

Jahan, M.H., and Zakaria, A.K.M. (1997). Growth and yield performance of different varieties of rapeseed, mustard and canola IN Level Barind Tract. *Progress Agric*. **8**(1&2): 144-152.

Jahan, M. H., and Zakaria, A. K. M. (1997). Growth and yield performance of different varieties of rapeseed, mustard and canola IN Level Barind Tract. *Prog Agric*. **8**(1&2): 144-152.

Karim, M.R., Ahmed, F. and Islam, R. (2000). Performance of some Brassicajuncea varieties/lines under on farm condition at Pabna. *Bangladesh J. Agril. Sci*. **27** (1): 157-158.

Khan G.M. and Agarwal S.K. (1985). Influence of sowing methods, moisture Stress and nitrogen levels on growth, yield components and seed yield of mustard. *Indian J. Agril. Sci*. **55**(5): 324–327.

Khan, M. J., R. A. Khattak and M. A. khan. (2000). Influence of sowing methods on the productivity of canola grown in saline field. *Pakistan J. Biological Sci.* **3**(4): 687-691.

Kumar, Rajesh, R. P. Singh and Yeshpal (2008).Yield and quality of Brassica species asinfluenced by different dates of sowing and varieties. *Pantnagar J. Res*., **6**(1): 6-11.

Kumari, A., R. P. Singh and Yeshpal (2012).Productivity, nutrient uptake and economicsof mustard hybrid (Brassica juncea) under different planting time and rowspacing. *Indian J. Agron*., **57** (1): 61-67.

Lallu, R. S., V.S. Baghel and S. B. L. Srivastava (2010). Assessment of mustardgenotypes for thermo tolerance at seed development stage. *Indian J. Plant.Physiol*., **15** (10): 36-43.

Laxminarayana, P. and Pooranchand (2000). Response of mustard varieties to time ofsowing in Northern Telangana. *J. Res., ANGRAU*, **28** (1&2): 75-77.

Mamun, F., Ali, M.H., Chowdhury, I.F., Hasanuzzaman, M. and Matin, M.A. (2014).Performance of rapeseed and mustard varieties grown under different planting density. *Sci. Agri*. **8**(2): 70-75.

Mamun, F., Ali, M.H., Chowdhury, I.F.,Hasanuzzaman, M. and Matin, M.A. (2014). Performance of Rapeseed and Mustard Varieties Grown Under Different Plant Density. *Sci. Agri*. 8(2): 70-75.

Masood, T., Giani, M.M. and khan, F.A. (1999). Path analysis of the major yield and quality characters in Brassica campestris. *Pakistan J. Anim. Pl. Sci*. **9**(1): 69-72.

Mendham, N.J., Russell, J. and Jarosz, N.K. (1990). Response to sowing time of three contrasting Australian cultivars of oilseed rape (*Brassica napus*). *J. Agric. Sci. Camb*. 114(3): 275-283.

Mondal, M.R.I. and Islam, M.A. (1993).Effect of seed rate and date on yield and yield components of rapeseed.*Bangladesh J. Agril.Sci*., **20**(1): 29-33.

Mondal, M.R.I. and Wahab, M.A. (2001).Production Technology of Oilseeds.Oilseed Res.Centre, Bangladesh Agril. Res.Isnt. Joydebpur, Gaziprur. pp. 6-24.

Mondal, M.R.I., Islam, M.A. and Khaleque, M.A. (1992). Effect of variety and planting date on the yield performance of mustard / Rape seed. *Bangladesh J. Agril. Sci.*, **19**(2): 181-188.

Rahman, M.M., Salam, M.U., Miah, M.G. and Islam, M.S. (1988). Effect of sowing time on the performance of mustard (SS-75). *Bangladesh J. Agric. Res*. **13**(1): 47-51.

Rahman, M.M. (2002). Status of Oilseeds and Future Prospects in Bangladesh. Paper presented in Review Workshop on the Impact of Technology Transfer on Oil Crops, Held at BARI on 29 April, 2002.

Rana, D. S. and D. K. Pachauri (2001). Sensitivity of zero erucic acid genotypes ofOleiferous Brassica to plant population and planting geometry. *Indian J. Agron*., **46** (4): 736-740.

Rashid, M. M., M. Moniruzzaman, M. M. Masud, P. K. Biswas and M. A. Hossain (2010).Growth parameters of different mustard (Brassica campestris L) varieties asaffected by different levels of fertilizers. Bull. Inst. Trop. Agr., Kyushu Univ.33: 73-81.

Sarkees, N.A. (2013). Response of growth, yield and oil of rapeseed to sowing method and seeding rate. *IOSR J. Agric. Sci. & V. Sci*. **3**(1): 01-06.

Shah, S.A. and K. Rahman (2009). Yield and growth response of rapeseed (*Brassica napus* L.) mutants to different seeding rates and sowing dates. *Pakistan J.Bot*., **41** (6): 2711-16.

Sharma, J. K., D. S. Ram Mohan Rao and D. P. Singh (1997).Effect of crop geometryand nitrogen on yield and attributes of Brassica species. *Indian J. Agron*.,**42** (2): 357- 360.

Sharma, M. L. (1992). Response of mustard (Brassica juncea) varieties to row spacing.*Indian J. Agron*., **37** (3): 593-514.

Shekhwat, k., Rathore, S.S., Premi, O.P., Kandpal, B.K. and Chauhan, J.S. (2012). Advances in Agronomic Management of Indian Mustard (*Brassica juncea* (L.) Czernj.Cosson): An Overview. *Intl. j. Agron*.2012: 1-14.

Singh, B.D. (2000). Plant Breeding, Kalyani Publisher. p. 574-597

Singh, Raj, M. Patidar and B. Singh (2001). Response of Indian mustard cultivars todifferent sowing time. *Indian J. Agron*., **46** (2): 292-295.

Singh, S. P., Singh, B., Prakash, R. and Pandry, D. (1999). A new approach to estimate of oil content in Brassica. Indian J. Agric. Sci. 9(9): 363-373.

Sultana, S., Amin, A.K.M.R. and Hassanuzzaman, M. (2009). Growth and yield of rapeseed (*Brassica campestris* L.) varieties as affected by levels of irrigation. American Eurasian J. Sci. Res. 4(1): 34-39

Thurling, N. (1974). Morphophysiological determinants of yield in rapeseed (B. campestries and B. napus). II. Yield components. *Australian J.Agril. Res*. 25: 711-721.

Tyagi, P. K., D. Singh, V. U. M. Rao and R. C. Tyagi (1995).Effect of sowing dates, plantdensities and varieties on yield and oil content of Indian mustard. *Haryana J. Agron*., 11 (2): 198-200.

Uddin, M. M., Samad, A., Khan, M. R., Begum, S., Hossain, K. and Khaleda, S. (1987). Variety × sowing date interaction in mustard and rapeseed. *Bangladesh J. Agric. Res*. **12**(2):55-60.

Yadav, R. N., SurajBhan and S. K. Uttam (1994a). Yield and moisture use efficiency ofmustard in relation to sowing date, variety and spacing in rainfed lands ofcentral Uttara Pradesh. *Indian J. Soil Cons*., **22** (3): 29-32.

Yeasmin, M. (2013). Effect of inflorescence-top cutting on the yield and yield attributes of mustard varieties under different sowing times. M.S. Thesis, SAU, Dhaka, Bangladesh.

Zakaria, A.K.M. and Jahan, M.H. (1997). Annual Report for the year of 1995-96.Banngladesh Rural Academy, Bogra, Bangladesh. pp. 25-35.

APPENDICES

Appendix I: Soil characteristics of the research plot of the department of Agricultural Botany of Sher-e-Bangla Agricultural University are analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Botany Research farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: SRDI

Appendix II: Analysis of variance of the data on days to 1st emergence of seedling, 50% emergence of seedling, 100% emergence of seedling and plant population per square meter of mustard as influenced by sowing methods and varieties

Source	Degrees of Freedom	Means square			
		Days to emergence of seedling	Days to 50% emergence of seedling	Days to 100% emergence of seedling	Plant population per square meter
Replication	2	0.194	0.583	0.028	42.361
Factor A	3	0.028*	0.074*	0.176*	7845.8*
Factor B	2	3.694*	6.333*	8.444*	123.03*
AB	6	0.139*	0.074*	0.148*	30.176*
Error	22	0.194	0.25	0.27	111.91

*significant at 5% level of probability

Appendix III: Analysis of variance of the data on plant height of mustard as influenced by sowing methods and varieties

Source	Degrees of Freedom	Means square				
		Plant height (cm)				
		25 DAS	35 DAS	45 DAS	55 DAS	65 DAS
Replication	2	2.643	2.618	11.731	112.78	32.872
Factor A	3	2.245*	146.15*	168.86*	131.36*	100.36*
Factor B	2	1.022*	260.65*	37.229*	393.99*	653.35*
AB	6	1.782*	18.237*	45.131*	24.114*	23.477*
Error	22	2.498	9.644	45.468	24.603	15.952

*significant at 5% level of probability

Appendix IV: Analysis of variance of the data on number of branch per plant, dry weight, days to first flowering, 50% flowering and maturity of mustard as influenced by sowing methods and varieties

Source	Degrees of Freedom	Means square				
		Number of branch per plant	Dry weight (g)	Days to first flowering	Days to50% flowering	Days to maturity
Replication	2	2.303	11.201	4.861	1.75	0.861
Factor A	3	15.957*	53.551*	8.176*	11.583*	25.963*
Factor B	2	16.831*	82.607*	28.028*	55.75*	11.028*
AB	6	1.406*	9.717*	4.176*	15.083*	4.435*
Error	22	0.589	8.11	3.528	3.386	4.437

*significant at 5% level of probability
NS- Non significant

Appendix V: Analysis of variance of the data on yield contributing characters of mustard as influenced by sowing methods and varieties

Source	Degrees of Freedom	Means square			
		Siliquae per plant	Length of siliqua	seed per siliqua	1000 seed weight
Replication	2	565.44	0.021	5.577	0.014
Factor A	3	3183.5*	0.12*	16.784*	0.194*
Factor B	2	1631*	0.083*	54.829*	0.502*
AB	6	195.28*	0.04*	2.846*	0.046*
Error	22	100.77	0.042	2.991	0.021

*significant at 5% level of probability

Appendix VI: Analysis of variance of the data on yield and yield contributing character of mustard as influenced by sowing methods and varieties

Source	Degrees of Freedom	Means square			
		Yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	2	0.125	0.903	1.625	14.04
Factor A	3	0.409*	4.706*	7.804*	25.294*
Factor B	2	0.17*	1.897*	3.004*	22.128*
AB	6	0.028*	0.193*	0.195*	23.127*
Error	22	0.014	0.168	0.244	7.366

*significant at 5% level of probability