EFFECT OF SOWING TIME ON GROWTH AND YIELD OF MUSTARD (*Brassica spp.*)

A THESIS

BY

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF SOWING TIME ON GROWTH AND YIELD OF MUSTARD (Brassica spp.)" 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 MD. ALI MULL RAJI Registration No. 12-04809 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 : June, 2018

Place: Dhaka, Bangladesh

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DEDICATED TO
MY
BELOVED PARENTS

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SAU, Dhaka

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ABSTRACT

The experiment was conducted during November 2017 to February 2018 to find out the effect of sowing time on growth and yield of mustard (*Brassica spp*). In this experiment, the treatments consisted of four different Sowing time viz. S_1 =1st sowing (1st November), S_2 =2nd sowing (11th November), S_3 =3rd sowing (21st November) and S_4= 4th sowing (1st December), and two varieties of mustard viz. V_1 = BARI Sarisha-16, V_2 = BARI Sarisha- 17. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. N, P, K, S, Zn and B were applied according to recommended doze. The collected data were statistically analyzed for evaluation of the treatment effect. The highest plant height was produced with BARI Sarisha-16. The maximum branches plant^{-1}, siliqua plant^{-1} and seeds silliqua^{-1} were recorded from BARI Sarisha-16. The maximum thousand seed weight was recorded from BARI Sarisha-16. The highest yield of seed (1.32 ton ha^{-1}) was obtained from BARI Sarisha-16. The tallest plant was recorded from the treatment with S_2= 2nd sowing (11th November). The maximum number of branches per plant, number of siliquae per plant, length of siliqua were found in 2nd sowing treatment (11th November). The maximum yield of seed (1.95 tha^{-1}) was obtained from 2nd sowing time treatment (11th November).The combinations of variety and sowing time had significant effect on almost all the parameters. The highest yield of seed (2.387tha^{-1}) was obtained from BARI Sorisha-16 and S_2 = 2nd sowing time (11th November) treatment combination. The highest yield of stover per hectare and biological yield per hectare was obtained from treatment combination of BARI Sarisha-16 and $S_{2=}$ 2nd sowing time.

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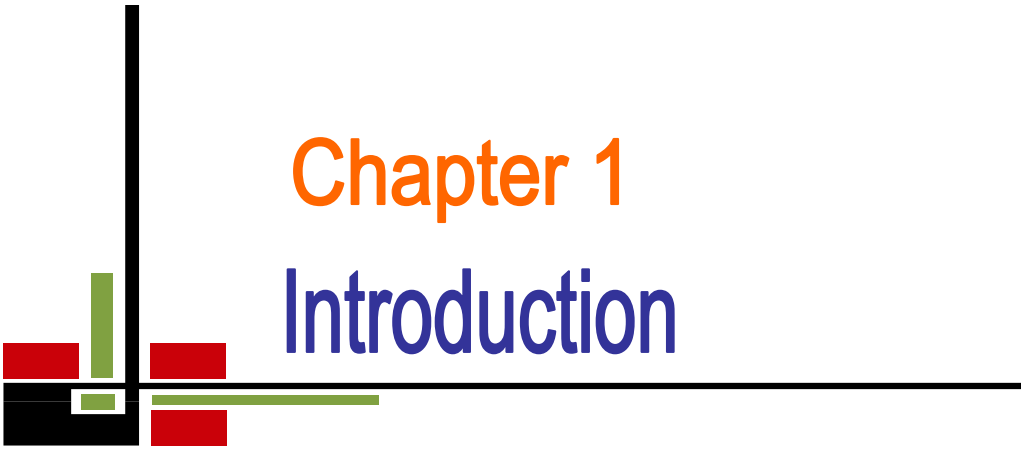
LIST OF ACRONYMS

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 hectare
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 1

Introduction

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* and *B. juncea 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).

Mustard is one of the most important oilseed crops throughout the world after soybean and groundnut (FAO, 2004). It has a remarkable demand for edible oil in Bangladesh. It occupies first position of the list in respect of area and production among the oilseed crops grown in this country (BBS, 2004). Oilseeds are important for the economy of Bangladesh. They constitute the most important group of crop next to cereals occupying 4.22% of the total cropped area (BBS, 2009). In the year 2011-12, the total oilseed production was 8.44 Mt and total area covered by oilseed crops was 7.23 ha^{-1} and yield 1.17 Mt ha^{-1}. In the year of 2011-12, mustard covered 4.83 ha^{-1} land and the production was 5.25 Mt and yield 1.09 Mt ha^{-1} (Krishi Diary, 2013).

Mustard seeds contain 40-45% oil and 20-25% protein (Mondal and Wahhab, 2001). Using local oil-extraction mechine average 33% oil may be extracted. Oil cake is a nutritious food item for cattle and fish, which is also used as a good

organic fertilizer. Dry mustard plants may be used as fuel. Rapeseed-mustard is grown more or less all over Bangladesh, but more particularly in the districts of Comilla, Tangail, Jessore, Faridpur, Pabna, Rajshahi, Dinajpur, Kushtia, Kishoregonj, Rangpur, Dhaka (BBS, 2012). Mustard is a cold loving crop and grows during Rabi (cold) season (October-February) usually under rainfed and low input condition in this country. Its low yield can be attributed to several factors, the nutritional deficiency, among others is highly important. There is very little scope of expansion for mustard and other oilseed acreage in the country, due to competition from more profitable alternative crops such as boro rice. The cultivation of mustard has to compete with other food grain crops have shifted to marginal lands of poor productivity.

Mustard crops are grown in diverse agro-climatic conditions under irrigated/ rainfed, timely/late-sown, saline soils and mixed cropping. Production potentiality of Bangladesh mustard can be fully exploited under these conditions with suitable agronomic practices and varieties. Among the different agronomic practices, optimum sowing time is very important for mustard production (Mondal and Islam, 1993; Mondal *et al*., 1999). Research findings have also shown that sowing date is one of the critical components affecting mustard crop productivity. It is one of the most important agronomic factor and non-monetary input which pave the way for better-use of time and play an important role to fully exploit the genetic potentiality of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. Sowing period information is needed for various other purposes like adjusting crop rotations; cropping patterns, crop growth simulations and climate change impact studies. Sowing time is also important in deciding the environmental conditions of crop, timing and rate of organ appearance while in crop growth analysis predicting of phenology is of prime importance. Since the temperature and solar radiation play an important role in partitioning of biomass between various organs of plant which is related to, and often governed by phenological phase of the plant and the way in which a crop develops can affect the yield and this therefore an aspect with which botanists are much concerned.

The crop is mainly grown during the winter season (October-March). The recommended sowing calendar for mustard varies across the major growing regions. Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield and different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability (Pandey *et al*., 1981). If the mustard is sown late, duration is reduced due to the high temperature during the reproductive phase with concomitant reduction in yield (Kumari *et al*., 2004). Some researchers demonstrated that the yield of mustard crop sown in second fortnight of September was significantly higher than that sown in first fortnight of October (Iraddi, 2008). In general, it was observed that the mustard crop sown after October 30th resulted in lower yields (Panwar *et al*., 2000; Singh *et al*., 2002a; Sonani *et al*., 2002; Panda *et al*., 2004b). Understanding of physiological and phenological causes of yield reduction with reference to date of sowing can help to develop strategies for improvement in the seed yield. Further, it will help in the assertion that productivity is constrained by development pattern and process physiology in response to environment.

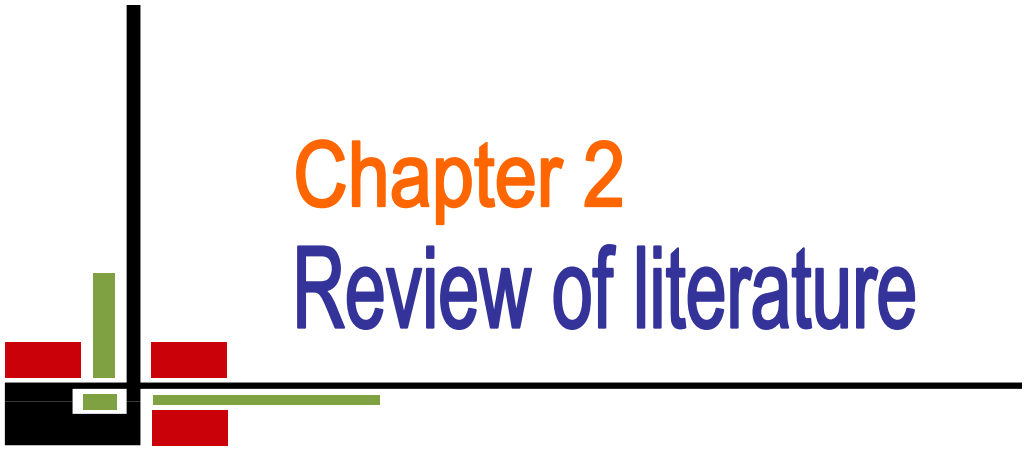
Among common cultivars BARI Sarisha-16 and BARI Sarisha-17 are the latest variety, and no field trail has been done by BRRI scientist considering the performance of BRRI Sarisha-16, BARI Sarisha-17 in different climatic zones.

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

i) To find out the effect of sowing times on growth and yield of BARI Sarisha-16 and BARI Sarisha-17.

ii) To know the suitable variety of mustard which will give the highest yield of mustard.

iii) To find out the appropriate sowing time of BARI Sarisha-16 and BARI Sarisha-17.



Chapter 2
Review of literature

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 time is one of the most important. A very limited works have been done involving the sowing time with the mustard (rape seed) varieties. Some of the work applicable to the present study has been reviewed below:

2.1 Effect of sowing date

Appropriate sowing date is the most important non-monetary input which contributes towards the improved yield of a crop. As different cultivars of mustard have different optimum sowing dates, this also indicates the flexibility in sowing dates for fitting a particular cultivar in multiple cropping systems. Moreover, response of different cultivars may differ under various sowing dates. Thus, optimum sowing date for a particular cultivar under consideration may play a great role in exploiting the yield potential of that cultivar.

2.1.2 Growth and development

The genetic potential of a plant is fully expressed only under optimum environment conditions, which depends upon various factors viz., temperature and radiation exposure, plant age, stage of development etc., under actual field conditions. However, environmental conditions change continuously and rarely the plant experiences optimum conditions at all stages of growth. Out of all possible environmental factors, radiation, temperature, water and nutrients have been recognized as the most important factors influencing course of plant growth and development.

2.1.2.1 Plant height (cm)

Tomar and Mishra (1991) at Tikamgarh (M.P.) reported that the plant height of mustard was significantly higher with 30th October (173.1 cm) sowing as compared to 10th November (162.9 cm) and 20th November (155.8 cm) sowings.

Kumar and Shaktawat (1992) at Udaipur (Rajasthan) revealed higher plant height with 8th September sowing (112.7 cm) as compared to 22nd September sowing (108.8 cm). Chandrakar and Urkurkar (1993) at Raipur (Chhattisgarh) reported that plant height was significantly higher with 23rd November sowing (158 cm) as compared to 14th December sowing (129 cm). Yadav *et al*. (1994b) at Kanpur (Uttar Pradesh) observed that crop sown on 5th October recorded significantly higher plant height (178 cm) as compared to 25th October (146 cm) sown mustard crop. Surekha and Reddy (1996) at Rajendranagar, Hyderabad emphasized that plant height was higher with 5th October sowing as compared to 5th and 20th November sowing. Shahidullah *et al*. (1997) at Dhaka (Bangladesh) conducted a field experiment and reported that plant height was higher with 16th November sowing as compared to 27th October sowing. Thakur and Singh (1998) at Kangra (Himachal Pradesh) revealed that plant height was significantly higher under 5th October sowing (193.2 cm) as compared to 19th November sowing (165.3 cm).

Butter and Aulakh (1999) at Bathinda (Punjab) reported that plant height was higher with early sowing of 25th October. Khichar *et al.* (2000) reported that greater plant height was recorded under 20th October sowing (185 cm) as compared to other sowings. Singh *et al*. (2001) revealed that mustard sown on second week of October recorded significantly higher plant height (188 cm) as compared to first week of November (171 cm). Singh and Singh (2002) at Faizabad (Uttar Pradesh) suggested that higher plant height was recorded with October sowing as compared to 29th October, 13th November, and 28th November sowing. Singh *et al.* (2002b) at Ludhiana (Punjab) quoted that early sowing on 10th and 30th October were recorded higher plant height as compared with 20th November and 10th December sowings. Kurmi (2002) at Titabar

(Assam) reported that greater plant height was observed with 17th November sowing (97 cm) as compared to 14th December (77 cm) sowing. Panda *et al*. (2004a) conducted a field experiment at IARI, New Delhi and reported that plant height was higher with 16th October sowing as compared to 31st October and 15th November sowing. Kumari *et al*. (2005) at Tirupati (A.P.) reported that the plant height was significantly higher (160.2 cm) with 1st October sowing as compared to 15th September (157.4 cm), 15th October (153.6 cm) and 1st November (143.9 cm) sowings.

Sharma *et al*. (2006) at Nagpur (Maharashtra) reported that the significantly greater plant height was observed at 75 DAS with 29th October sowing (160.6 cm) as compared to 22nd October (158.5 cm), 12th October (145.7cm) and 6th October (140.4 cm) sowings. Charak *et al*. (2006) revealed that the plant height at harvest was significantly higher under first week of September sowing (108.8 cm) as compared to second week of September (106.7 cm), third week of September (99.9 cm) and fourth week of September (98.1 cm) sowings. Bhuiyan *et al*. (2008) reported significantly higher plant height under 10th November sowing (115 cm) as compared to 30th October (105 cm), 20th November (104 cm), 20th October (100 cm), 30th November sowings. Shah *et al*. (2009) observed significantly higher plant height with 15th September (212.5 cm) sowing as compared to 25th September (203.8 cm), 5th October (183.2 cm), 15th October (188.3cm), 25th October (181.1 cm), 5th November (155.6 cm), and 15th November (126.1cm) sowings.

Lallu *et al*. (2010) revealed that November sowing caused the significant reduction in plant height (100.5 cm) as compared to October sowing (152.8 cm). Afroz, *et al*. (2011) at Mymensingh (Bangladesh) observed that significantly higher plant height was found under 10th November sowing (99.4 cm) as compared to 20th November (93.0 cm) and 30th November (78.0 cm) sowing. Aziz *et al*. (2011) at Khagrachari (Bangladesh) also reported that 15th November sown mustard crop produced the maximum plant height (162 cm) as compared to 25th November, 5th December and 15th December. Mondal *et a*l. (2011)

reported that plant height was significantly higher with 20th November sowing (104.2 cm) 20th October (102.9 cm) as compared to 10th November (100.7 cm), 1st November (100.1 cm) and 30th November (98.3 cm) sowings. Kumari *et al*. (2012) at Pantnagar (Uttarakhand) observed that 10th October sowing resulted into significantly higher plant height (217 cm) over 20th October sowing (208 cm) and 30th October sowing (187 cm).

2.1.2.2 Number of primary and secondary branches (plant^{-1})

Vasi *et al*. (1986) quoted that number of secondary branches (plant^{-1}) recorded higher under 27th September sowing (18.9) as compared to 18th October sowing (13.7). Tomar and Mishra (1991) reported that the number of primary and secondary branches of mustard crop (5.93, 9.75) was significantly greater with 30th October sowing as compared to 10th November (5.39, 8.15) and 20th November (4.52, 6.12) sowings. Kumar and Shaktawat (1992) reported that number of primary and secondary branches recorded higher with 22nd September sowing (6.9 and 13.6 branches plant^{-1}) as compared to 8th September sowing (6.3 and 12.2 branches plant^{-1}).

Choudhary and Thakuria (1994) at Karimganj (Assam) revealed that number of secondary branches were significantly higher with 15th November sowing (12 plant^{-1}) as compared to 5th December sowing (3 plant^{-1}). Yadav *et al*. (1994b) observed that number of primary and secondary branches (plant^{-1}) were significantly higher under 5th October (6.9 and 13.4 cm) sown crop as compared to 25th October (5.4 and 11.2). Surekha and Reddy (1996) reported that the crop sown on 5th October recorded higher number of primary and secondary branches as compared to 5th and 20th November sowing.

Bhatnagar *et al*. (1997) quoted that number of primary branches (plant^{-1}) recorded higher with 15th October sowing (9.2 plant^{-1}) as compared to 30th November sowing (5.9 plant^{-1}). Shahidullah *et al*. (1997) at Dhaka (Bangladesh) reported that 27th October sowing recorded higher number of primary and secondary branches (plant^{-1}) as compared to 6th or 16th November sowing. Reddy

and Kumar (1997) at Jagtial (Andhra Pradesh) observed that number of primary branches recorded higher with 4th October sowing (4.6 plant^{-1}) as compared to 5th November sowing (3.5 plant^{-1}). Thakur and Singh (1998) reported that number of primary and secondary branches (plant^{-1}) recorded higher under 5th October sowing (6.7, 14.1) as compared to 19th November sowing (5.5, 7.7). Buttar and Aulakh (1999) quoted that the number of secondary branches (plant^{-1}) were higher with early sowing of 25th October.

Singh *et al*. (2001) reported that crop sown on third week of October recorded significantly higher number of primary branches (5.87 plant^{-1}) as compared to first week of November sowing (4.57 plant^{-1}). Singh *et al*. (2002b) reported that number of primary and secondary branches (plant^{-1}) were higher with 10th and 30th October sowing as compared to 20th November to December sowing. Kurmi (2002) conducted a experiment and quoted that number of primary and secondary branches (plant^{-1}) recorded higher in 17th November sowing (4, 9) as compared to December (3, 6) sowing. Shivani and Kumar (2002) emphasized that crop sown on 25th September and 5th October recorded significantly higher number of primary and secondary branches than 15th October, 25th October and 4th November sown crop. Singh and Singh (2002) suggested that number of primary and secondary branches (plant^{-1}) recorded higher with 14th October sowing as compared to 29th October, 13th November and 28th November sowing.

Kumar *et al*. (2004) at Bawal (Haryana) quoted that crop sown on 21st October recorded higher number of primary and secondary branches (plant^{-1}) as compared to 7th and 17th October sowing. Panda *et al.* (2004a) suggested that delayed sowing beyond 16th October reduced the number of primary and secondary branches (plant^{-1}). Sharma *et al*. (2006) at Nagpur (Maharashtra) reported that the significantly higher number of branches was observed at 75 DAS with 29th October sowing (10.4 plant^{-1}) as compared to 22nd October (10.1 plant^{-1}), 12th October (9.27 plant^{-1}) and 6th October (8.64 plant^{-1}) sowings.

Kumar *et al*. (2008) reported that the number of branches plant^{-1} were significantly greater in mustard were with 30th September (22.2 plant^{-1}) sowing

as compared to 15th October (19.7 plant^{-1}), 30th October (16.6) and 14th November (14.3 plant^{-1}) sowings. Bhuiyan *et al*. (2008) reported that significantly higher primary branches in 20th October (6.85 plant^{-1}), as compared to 30th October (6.72 plant^{-1}), 20th November (6.25 plant^{-1}), 10th November (6.22 plant^{-1}) and 30th November (6.20 plant^{-1}) sowings.

Lallu *et al*. (2010) observed that November sowing caused the significant reduction in total number of branches (21.4 plant^{-1}) as compared to October sowing (31.6 plant^{-1}). Afroz *et al*. (2011) observed that significantly higher branches were found in 10th November sowing (2.94 plant^{-1}) as compared to 20th November (2.50 plant^{-1}) and 30th November (1.89 plant^{-1}) sowings. Kumari *et al*. (2012) observed that 10th October sowing recorded significantly higher primary and secondary branches plant^{-1} (7.8, 19.9) over 20th October sowing (7, 17.6) and 30th October sowing (6.4, 14.1).

2.1.3 Yield attributes and yield

2.1.3.1 Number of siliquae (plant^{-1})

Tomar and Mishra (1991) observed that the number of siliquae were significantly greater with 30th October (199.8 plant^{-1}) sowing as compared to 10th November (169.6 plant^{-1}) and 20th November (149.9 plant^{-1}) sowings. Kumar and Shaktawat (1992) reported that mustard sown on 22nd September recorded higher number of siliquae (169.0 plant^{-1}) as compared to 8th September (151.7 plant^{-1}) sown crop. Kurmi and Kalita (1992) observed that number of siliquae was recorded higher with 17th November (192.1 plant^{-1}) sowing as compared to 2nd December (150.4 plant^{-1}) sowing. Chandrakar and Urkurkar (1993) reported that the number of siliquae were recorded higher under 23rd November sowing (146 plant^{-1}) compared to 14th December sowing (74 plant^{-1}).

Choudhary and Thakuria (1994) observed that number of siliquae was recorded significantly higher under 15th November sowing (224 plant^{-1}) as compared to 5th December sowing (50 - 81 plant^{-1}). Reddy and Kumar (1997) suggested that the number of siliquae (plant^{-1}) were recorded higher under 4th October sowing

(142) compared to 5 November sowing (93). Similarly, Yadav *et al*. (1994a) reported that crop sown on 5 October recorded significantly higher number of siliquae (454 plant^{-1}) as compared to 25 October sowing (264 plant^{-1}).

Surekha and Reddy (1996) observed that the number of siliquae (plant^{-1}) was recorded higher with 5th October sowing as compared to 5th and 20th November sowings. Shahidullah *et al.* (1997) reported that the number of siliquae (plant^{-1}) was decreased with delay in sowing from 27th October to 6th and 16th November.

Thakur and Singh (1998) quoted that number of siliquae (plant^{-1}) was recorded higher with 5th October sowing (268.6) as compared to 19th November sowing (172.9). Zekatte (1999) conducted a field experiment at the Perloja Research Station, Lithuania on sandy loam soil and reported that early spring sown mustard crop produced more siliquae plant^{-1} (63.7 – 66.0). Buttar and Aulakh (1999) reported that the number of siliquae (plant^{-1}) was recorded highest in early sowing (25th October). Singh *et al*. (2001) reported that the number of siliquae (plant^{-1}) was recorded significantly higher under third week of October sowing (209) as compared to first week of November sowing (173). Singh *et al.* (2002b) observed that number of siliqua (plant^{-1}) was higher in 10 and 30 October sowings compared to 20 November and 10 December sowings. Shivani and Kumar (2002) emphasized that crop sown on 25th September and 5th October recorded higher number of siliquae (plant^{-1}) as compared to 15th October, 25th October and 4th November sowing. Kurmi (2002) conducted a field experiment and quoted that number of siliquae (plant^{-1}) recorded higher with 17th November sowing (104) as compared to 14th December sowing (86).

Panda *et al.* (2004a) emphasized that delayed sowing beyond 16th October reduced the number of siliquae (plant^{-1}). Kumar *et al*. (2004) quoted that the number of siliquae (plant^{-1}) were recorded higher when mustard crop sown on 21st October as compared to 7th and 14th October. Charak *et al*. (2006) reported that the number of siliquae (plant^{-1}) in toria crop were significantly higher with first week of September sowing (130.9) as compared to second week of September (129.2), third week of September (126.1) and fourth week of

September (116.1) sowings. Sharma *et al*. (2006) reported that the significantly higher siliquae (plant^{-1}) were observed with 29th October sowing (139.7) as compared to 22nd October (129.1), 12th October (103.1) and 6th October (97.1) sowings.

Kumar *et al*. (2008) reported that the number of siliquae (plant^{-1}) in mustard were found significantly greater under 30th September (201) as compared to15th October (197), 30th October (175) and 14th November (170) sowings.

Bhuiyan *et al*. (2008) reported that significantly higher number of siliquae (plant^{-1}) were observed in 30th October (85) sowing as compared to 20th October (84), 10th November (77), 20th November (77), and 30th November (66) sowings. Lallu *et al*. (2010) observed that November sown mustard crop resulted into significant reduction in siliquae (plant^{-1}) as compared to October sowing (plant^{-1}).

Afroz *et al*. (2011) quoted that significantly higher siliquae (plant^{-1}) were found in 10th November sowing (161.2) as compared to 20th November (148.0) and 30th November (128.9) sowings. Aziz *et al*. (2011) reported that 15 November sown mustard crop produced the maximum number of siliquae (254 plant^{-1}) as compared to 25 November, 5 December and 15 December. Mondal *et al*. (2011) reported that number of siliquae (plant^{-1}) were significantly higher with 1st November (97) as compared to 20th October (86), 10th November (71.0), 20th November (57.3) and 30th November (69.7) sowings. Kumari *et al*. (2012) suggested that 10th October sowing recorded significantly higher number of siliquae (323 plant^{-1}) over 20th October sowing (302 plant^{-1}) and 30th October sowing (238 plant^{-1}).

2.1.3.2 Number of seeds (siliqua^{-1})

Singh *et al*. (2001) reported that the number of seeds siliqua^{-1} were higher with third week of October sowing (13.6) as compared to first week of November sowing (11.8).

Singh et al. (2002b) observed that the number of seeds (siliqua^{-1}) were higher in 10th and 30th October sowing as compared to 20th November and 10th December sowing. Kurmi (2002) suggested that the number of seeds (siliqua^{-1}) were recorded higher with 17th November sowing (17) as compared to 14th December sowing (14). Singh *et al*. (2002a) quoted that crop sown on 5th October resulted into higher number of seeds (13 siliqua^{-1}) as compared to 5th November sowing (11 siliqua^{-1}). Shivani and Kumar (2002) reported that sowings on 25th September and 5th October resulted into significantly higher number of seeds (siliqua^{-1}) as compared to 15th October, 25th October and 4th November sowings.

Charak *et al.* (2006) reported that the number of seeds (siliqua^{-1}) in toria crop were significantly higher with first week of September sowing (16.2) as compared to second week of September (16.0), third week of September (15.9) and fourth week of September (13.1) sowings.

Kumar et al. (2008) observed that the number of seeds (siliqua^{-1}) in mustard were significantly higher with 30th September (18) sowing as compared to15th October (16), 30th October (15) and 14th November (14) sowings. Bhuiyan *et al*. (2008) reported that the number of seeds (siliqua^{-1}) were found significantly higher in 30th October (24) sowing as compared to 20th October (21.3), 10th November (22.8), 20th November (21.8), and 30th November (18.8) sowings.

Afroz *et al*. (2011) observed significantly higher number of seeds (siliqua^{-1}) under 20th November sowing (18.4) as compared to 10th November (16.7) and 30th November (16.1) sowings. Aziz *et al.* (2011) reported that 15th November sown mustard crop produced more seeds (13.4 siliqua^{-1}) as compared to 25th November, 5th December and 15th December sowings. Mondal *et al*. (2011) reported that number of seeds (siliqua^{-1}) were significantly higher with 1st

November (21.8) as compared to 20th October (19.1), 10th November (20.5), 20th November (18.3) and 30th November (16.9) sowings. Kumari *et al*. (2012) observed that 10th October sowing recorded significantly higher number of seeds (14.2 siliqua^{-1}) over 20th October sowing (13.4 siliqua^{-1}) and 30th October sowing (11.4 siliqua^{-1}).

2.1.3.3 1000-seed weight (g)

Singh *et al*. (2001) observed that crop sown on third week of October recorded higher 1000- seeds weight (4.51 g) as compared to first week of November sowing (3.77 g). Singh *et al*. (2002a) observed that mustard sown on 5th October resulted into significantly higher 1000-seeds weight (5.7 g) as compared to 5th November sown crop (4.4 g).

Singh *et al*. (2002b) revealed that 1000-seeds weight was recorded higher in 10th and 30th October sowings as compared to 20th November and 10th December sowing. Shivani and Kumar (2002) suggested that 1000-seeds weight was recorded higher under 25th September and 5th October sowing as compared to 15th October, 25th October and 4th November sowing. Panda *et al*. (2004a) observed that delay in sowing beyond 16th October reduced 1000-seeds weight.

Charak *et al*. (2006) reported that the 1000-seeds weight in toria crop was significantly higher with first week of September sowing (3.63 g) as compared to second week of September (3.58 g), third week of September (3.57 g) and fourth week of September (3.12 g) sowings. Sharma *et al*. (2006) reported that the significantly higher 1000-seeds weight was observed with 29th October sowing (4.90 g) as compared to 22nd October (4.81 g), 12th October (4.48 g) and 6th October (4.38 g) sowings.

Kumar *et al*. (2008) reported that the 1000-seeds weight in mustard was found significantly higher with 30th September (4.42 g) as compared to15th October (4.13 g), 30th October (3.58 g) and 14th November (3.29 g) sowings.

Bhuiyan *et al*. (2008) reported that 1000-seeds weight was found significantly higher under 30th October (3.80 g) sowing as compared to 20th October (3.68 g), 10th November (3.68 g), 20th November (3.28 g), and 30th November (3.24 g) sowings. Lallu *et al* (2010) at Kanpur (U.P.) observed that November sowing caused the significant reduction in 1000-seeds weight (3.5 g) as compared to October sowing (4.8 g).

In Mymensingh (Bangladesh), Afroz *et al*. (2011) observed that 1000-seeds weight was found significantly higher in 20th November sowing (20.0 g) as compared to 10th November (18.1 g) and 30th November (17.9 g) sowings.

Similarly, Aziz *et al*. (2011) reported that 15 November sown mustard crop produced the higher 1000–seeds weight (3.87 g) as compared to 25 November, 5 December and 15 December sowings. Mondal *et al*. (2011) observed that 1000-seeds weight was significantly higher with 1st November and 20th October (3.70 g) as compared to 10th November (3.30 g), 20th November (3.00 g) and 30th November (2.80 g) sowings. Kumari *et al*. (2012) observed that 10th October sowing resulted into significantly higher 1000-seeds weight (4.25 g) over 20th October sowing (3.78 g) and 30th October sowing (3.42 g).

2.1.3.4 Seed yield

Tomar and Mishra (1991) reported that the seed yield of mustard crop was significantly greater with 30th October (8.44 q ha-1) sowing as compared to 10th November (6.88 q ha^{-1}) and 20th November (5.97 q ha^{-1}) sowings. Jadhav and Singh (1992) observed that seed yield was significantly higher with 18th October sowing (1360 kg ha^{-1}) as compared to 17th November sowing (750 kg ha^{-1}).

Kumar and Shaktawat (1992) quoted that the mustard sown on 22nd September exhibited higher seed yield (1370 kg ha^{-1}) as compared to 8th September sowing (1157 kg ha^{-1}).

Chandrakar and Urkurkar (1993) reported that seed yield was recorded higher with 23rd November sowing (1154 kg ha^{-1}) as compared to 14th December

sowing (661 kg ha^{-1}). Chaudhary and Thakuria (1994) reported that the mustard cultivar TM 2 recorded significantly higher seed yield (1262 kg ha^{-1}) when sown on 15th November as compared to 5th December sowing (219 kg ha^{-1}). Yadav *et al*. (1994a) reported that the seed yield was found higher with 5th October sowing (14.2 q ha^{-1}) as compared to 25th October sowing (11.1q ha^{-1}).

Kumar and Singh (2003) at Patna (Bihar) reported that there was a significant decreased in the seed yield with the early sowing date. The greater seed yield was observed with 20th to 25th October sown crop (1735 kg ha^{-1}). Sihag *et al.* (2003) at Bikaner (Rajasthan) and observed that the higher seed yield was obtained in 15th October sowing (2150 kg ha^{-1}). Kumar *et al.* (2004) emphasized that greater seed yield of 2980 kg ha^{-1} was observed when the mustard crop was shown on 21st October and seed yield increased by 6.5% and 3.5% over that planted on 7th and 14th October respectively. Panda *et al.* (2004a) quoted that delayed sowing after 16th October reduced the seed yield. The crop sown on 16th October resulted into higher seed yield (1945 kg ha^{-1}) than the crops sown on 31st October (1556kg ha^{-1}) and 15th November (872 kg ha^{-1}).

Kumari *et al.* (2005) revealed that 24th October sown crop recorded higher seed yield than 8th November sown. Kumari *et al*. (2005) reported that the significantly higher seed yield with 1st October sowing (602 kg ha^{-1}) as compared to 15th October (559 kg ha^{-1}), 1st November (432 kg ha^{-1}) and 15th September (331 kg ha^{-1}) sowings in mustard crop. Charak *et al.* (2006) reported that the seed yield in toria crop was significantly higher with first week of September sowing (1.73 t ha^{-1}) as compared to second week of September (1.15 t ha^{-1}), third week of September (1.12 t ha^{-1}) and fourth week of September (0.97 t ha^{-1}) sowings.

Sharma *et al*. (2006) revealed that the seed yield was significantly higher with 29th October sowing (14.1 q ha^{-1}) as compared to 22nd October (13.4 t ha^{-1}), 12th October (8.67 t ha^{-1}) and 6th October (4.83 t ha^{-1}) sowings.

Kumar *et al*. (2008) emphasized that the seed yield in mustard was significantly higher with 30th September (1740 kg ha^{-1}) sowing as compared to 15th October (1511 kg ha^{-1}), 30th October (1131 kg ha^{-1}) and 14th November (909 kg ha^{-1}) sowings. Bhuiyan *et al*. (2008) reported significantly higher seed yield with 30th October (1.86 t ha^{-1}) sowing as compared to 20th October (1.59 t ha^{-1}), 10th November (1.56 t ha^{-1}), 20th November (1.52 t ha^{-1}), 30th November (1.47 t ha^{-1}) sowings.

Shah and Rahman (2009) conducted a field experiment and observed that the seed yield was found significantly higher with 25th September (3657 kg ha^{-1}) sowing as compared to 5th October (2856.3B), 15th October (2393.5C), 15th September (1736 kg ha^{-1}), 25th October (1336 kg ha^{-1}) , 5th November (1058 kg ha^{-1}), and 15th November (548 kg ha^{-1}) sowings. Lallu *et al.* (2010) observed that mustard sown in November caused the significant reduction in seed yield (11.7 g plant^{-1}) as compared to October sowing (19.7 g plant^{-1}). Adak *et al.* (2011) observed that the seed yield in mustard was significantly higher with 15th October sowing (2.86 t ha^{-1}) as compared to 30th October (2.3 t ha^{-1}) sowing.

Biswas *et al.* (2011) at Modipuram (Meerut) revealed that the seed yield was found significantly higher with 10th October sowing (2.28 t ha^{-1}) as compared to 17th October (2.20 t ha^{-1}), 24th October (1.81 t ha^{-1}), 1st November (1.69 t ha^{-1}), 8th November (1.37 t ha^{-1}) and 15th November (1.07 t ha^{-1}) sowings. Afroz *et al.* (2011) observed that significantly higher seed yield was found in 10th November sowing (2.77 t ha^{-1}) as compared to 20th November (2.70 t ha^{-1}) and 30th November (2.69 t ha^{-1}) sowings. Similarly, Aziz *et al.* (2011) reported that 15 November sown mustard crop produced the maximum seed yield (2.75 t ha^{-1}) as compared to 25th November, 5th December and 15th December. Mondal *et al.* (2011) suggested that seed yield was significantly higher with 1st November (1.72 t ha^{-1}) as compared to 20th October (1.53 t ha^{-1}), 10th November (1.44 t ha^{-1}), 20th November (1.40 t ha^{-1}) and 30th November (1.32 t ha^{-1}) sowings. Kumari *et al*. (2012) observed that 10th October sowing recorded significantly higher seed yield (1.93 t ha^{-1}) over 20th October sowing (1.73 t ha^{-1}) and 30th October

sowing (1.36t ha^{-1}). Tomar *et al.* (1991) reported significant variation in seed yield among different sowing dates of *B. napus* and revealed that 30th March sown crop resulted into significantly higher seed yield (2432 kg ha^{-1}) as compared to 14th April (1943 kg ha^{-1}), 29th April (619 kg ha^{-1}) and 14th May (9.43 kg ha^{-1}) sown crops.

2.1.3.5 Stover yield

Bhuiyan *et al.* (2008) reported that stover yield was found significantly higher with 20th October (6.06 t ha^{-1}) sowing, as compared to 30th October (5.98t ha^{-1}), 10th November (5.40 t ha^{-1}), 20th November (5.04 t ha^{-1}), and 30th November (4.80 t ha^{-1}) sowings. Afroz *et al.* (2011) observed that significantly higher stover yield was found in 10th November sowing (1.53 t ha^{-1}) as compared to 20th November (1.48 t ha^{-1}) and 30th November (1.41 t ha^{-1}) sowings. Mondal *et al.* (2011) reported that stover yield was significantly higher with 1st November (4.15 t ha^{-1}) as compared to 20th October (3.60 t ha^{-1}), 10th November(3.33), 20th November (3.20 t ha^{-1}) and 30th November (3.10 t ha^{-1}) sowings.

2.2 Effect of variety on different crop characters

2.2.1 Plant height

Ahmed *et al.* (2008) 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) over cv. 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 in rape seed 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) at Kanpur (U.P) observed that among different mustard genotypes, plant height of genotype RGN-152 was significantly higher (184.7 cm) as compared to other genotypes in normal sowing and in late sown condition cv. RGN- 145 exhibited significantly higher (118.5 cm) plant height.

Rashid *et al*. (2010) in a field experiment observed that the variety BARI Sharisa-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. BARI Sarisha-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 spp.* 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.

Islam *et al.* (2012) found that the number of primary branches plant^{-1} was higher (4.02) in the variety SS-75 and lower (2.1) in the variety BARI Sharisa-5 under poor management, the higher number of primary branches plant^{-1} was found in BARI Sharisha-6 (5.5) and lower in BARI Sharisa-8 under higher management. The highest number of primary branches plant^{-1} was 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 Hyole-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 secondary branches (plant^{-1}) was recorded higher in cv. Vaibhav (5.9 and 13.7) as compared to 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) observed that 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. was significantly 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 significantly higher 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^{-1}followed 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 (2000) observed that cv. Kranti recorded significantly 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 significantly higher 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 higher in 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). In Mymensingh (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 (286 plant^{-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-900 and 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*. 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^{-1}among 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^{-1} contributes considerably towards the final seed yield. The number of seeds siliqua^{-1} differed 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 Boron application. The average number of seeds pod^{-1} ranged from 12.00 to 20.67 and 13.22 to 27.44 in the Boron untreated and treated plots, respectively. The maximum average number of seeds pod^{-1}(27.44) was recorded in Boron treated BARI Sarisha- 8.

Sharma (1992) observed that number of seeds (siliqua^{-1}) recorded significantly 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 number of 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}).

Rana 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}) in *Brassica 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. carinata cv. 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}) was found in cv. BARI Sarisha-6 (20.6) as compared to cv. BARI Sarisha-9 (13.5). Kumari *et al.* (2012) observed that hybrid DMH-1 recorded significantly higher number of seeds (13.8 siliqua^{-1}) over hybrid NRCHB-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 higher in 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 significantly higher 1000-seeds weight (6.5 g) followed by cvs. Varuna (5.6 g) and Laxmi (5.3g). Sharma *et al.* (1992) concluded that 1000-seeds weight recorded significantly higher 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) compared to cv. TERI (OE) R 15 (2.18 g). Singh et al. (2001) observed that the cv. Pusa Bold 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-seeds weight 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

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*. (1993) 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.

Mendham *et al.* (1990) showed that seed yield was variable due to varietal difference in species of *B. napus*. Similar findings were noticed by Sonani and patel (2002).

2.1.8 Stover yield

Hossain *et al*. (2012) reported that BARI Sarisha 8 *(Brassica napus*) had the maximum response to Boron 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 Boron 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. Thakur *et al*. (1998) 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*. (1992) 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 that mustard 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}) as compared to cv. TERI (OE) R 15 (1390 kg ha^{-1}).

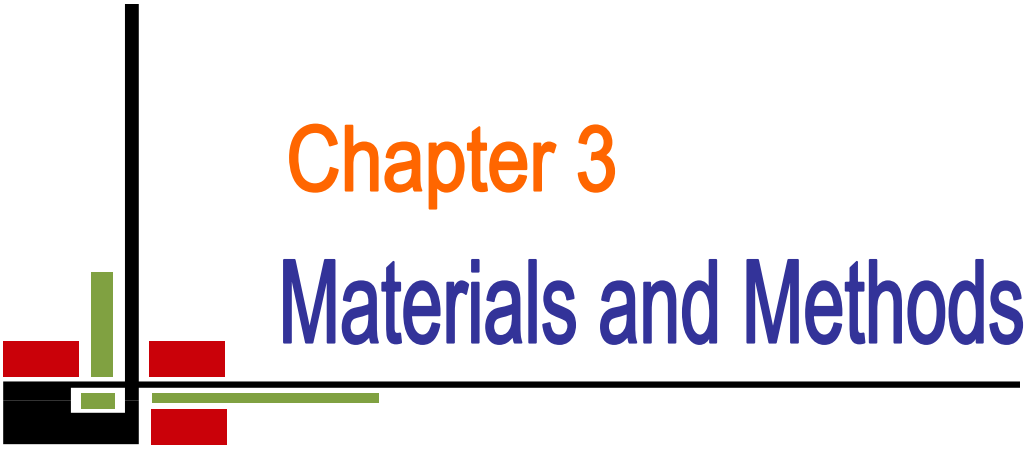
Singh *et al.* (2002b) recorded significantly higher seed yield in cultivar RH30 (2390 kg ha^{-1}) over Varuna (2240 kg ha^{-1}). Similarly, Shivani *et al*. (2002) reported that seed yield was higher in cvs. RH 30 and Laxmi over cv.Varuna. The varietal differences in seed yield were also reported. Kumar *et al*. (2008) reported that the seed yield in *Brassica spp*. were found significantly greater in Boron application. 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 (37.34%) of harvest index and Improved Tori-7 showed the lowest harvest index (37.10%). SAU Sarisha-1 and Kollania showed statistically similar values of harvest index.



Chapter 3

Materials and Methods

Chapter III
MATERIALS AND METHODS

The experiment was conducted during rabi season, November 2017to February2018 to find out the effect of sowing time and varieties on growth and yield of mustard.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at 90°22′ E longitude and 23º4l′ 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) in Appendix III.

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 areBARI Sarisha 16 and BARI Sarisha 17 developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and was used as anexperimental planting material. The seed

was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur

3.5 Methods

3.5.1 Treatments and their combinations

Factor A: varieties
V_1 = BARI Sarisha-16
V_2 = BARI Sarisha-17

Factor B: Sowing time
S_1= 1st sowing (1stNovember)
S_2= 2ndsowing (11thNovember)
S_3= 3rdsowing (21st November)
S_4= 4th sowing (1st December)

There are 8 treatment combinations of different sowing time and varieties used in the experiment under as following:

1.V_1S_1 5.V_2S_1
2.V_1S_2 6.V_2S_2
3.V_1S_3 7.V_2S_3
4.V_1S_4 8.V_2S_4

3.5.2 Design and layout

The experiment consisted of 8 treatment combinations and was laid out Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 8× 3 = 36. The unit plot size was 2.5 m × 1.25 m = 3.13 m^2. The distance between blockswas 1 m and distance between plotswas 0.5 m.

3.5.3 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 10 October, 2017. According to the layout of the experiment the entire experimental area was divided into blocks and experimental plot for the sowing of mustard seed. In addition, irrigation and drainage channels were made around the plot.

3.5.4 Fertilization

In this experiment fertilizers were used according tothe recommendation of Bangladesh Agricultural Research 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, gypsumand 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 experimentaland incorporated into soil before sowing seed. Rest of the urea was top dressed after 30 days of sowing (DAS).

3.5.5 Sowing of Seeds

Sowing was done as per treatment. Sowing seeds were sown as per treatment in broadcasting method 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.

3.5.6 Thinning and weeding

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

3.5.7 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.

3.5.8 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.

3.5.9 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.

3.5.10Harvesting 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 15 and completed on March15, 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.

3.5.11 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 kgha^{-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 Plant height

Plant height in cm was measured five times at 10 days interval such as 10, 20, 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.

3.6.2 Leaves plant^{-1}

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

3.6.3 Branches plant^{-1}

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

3.6.4 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.

3.6.5 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).

3.6.6 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.

3.6.7Thousand seeds 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 seeds weight was recorded in g.

3.6.8 Yield

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to tha^{-1}.

3.6.9Stover yield

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

3.6.10Biological yield

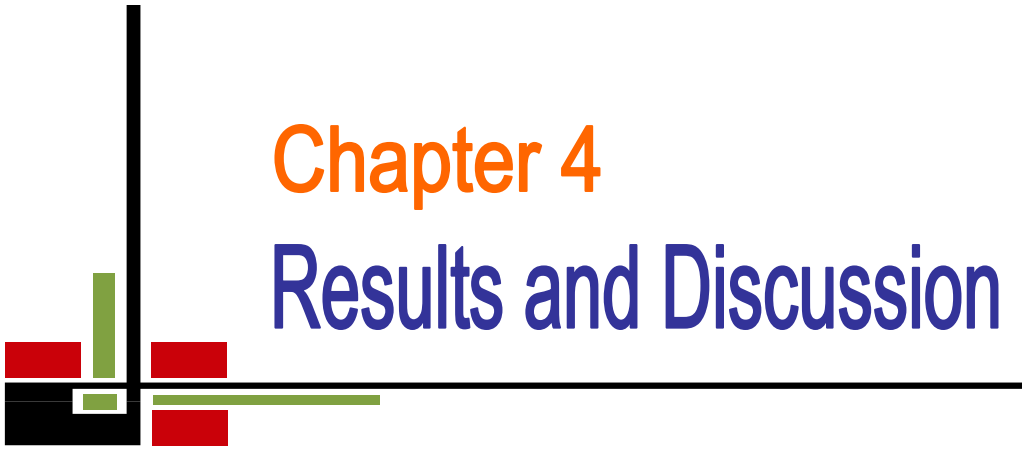
Biological yield was calculated by summing up the total seed yield andstover yield.

3.6.11Harvest 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 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

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

4.1 Plant height

There is significant difference among the variety in respect of plant height at 30, 45, 60 and 75 days after sowing (DAS) (Fig. 1). The tallest plant (72.01, 101.27, 141.17 and 160.20 cm at 30, 45, 60 and 75 DAS, respectively) was produced with V_1 (BARI Sarisha-16) and shortest plant (38.60, 64.47, 73.29, and 73.26 cm at 30, 45, 60 and 75 DAS, respectively) was found in V_2 (BARI Sarisha-17). Ali and Rahman (1988) and Mondal *et al*. (1992) also found significant variation in plant height of different varieties of rapes and mustard.

The height of mustard plant significantly influenced by different sowing time at 30, 45, 60 and 75 days after sowing (DAS) (Fig. 2). The tallest plant (59.35, 57.36, 111.81 and 118.77 cm at 30, 45, 60 and 75 DAS, respectively) was recorded with S_2 treatment (2^{nd} sowing time). In contrast, the shortest plant (50.61, 76.55, 100.5, 113.8 cm at 30, 45, 60 and 75 DAS, respectively) was recorded from S_4 (4^{th} sowing).

The combined use of variety and sowing time had significant effect on plant height at 30, 45, 60 and 75 DAS (Table 4). The tallest plant (77.04, 106.00, and 146.70, 163.70 cm at 30, 45, 60 and 75 DAS, respectively) was found in V_1S_2 treatment combination, whereas the shortest plant (36.41, 56.78, 68.90 and 71.30 cm) was observed in V_2S_4 treatment combination.

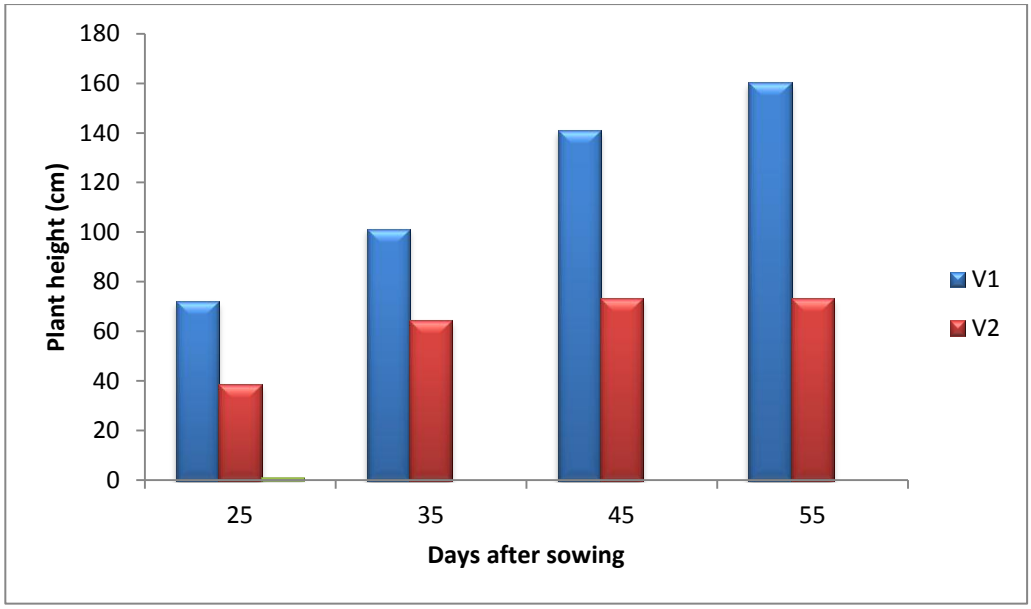


Fig. 1. Effect of variety on plant height of mustard

Where, V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17

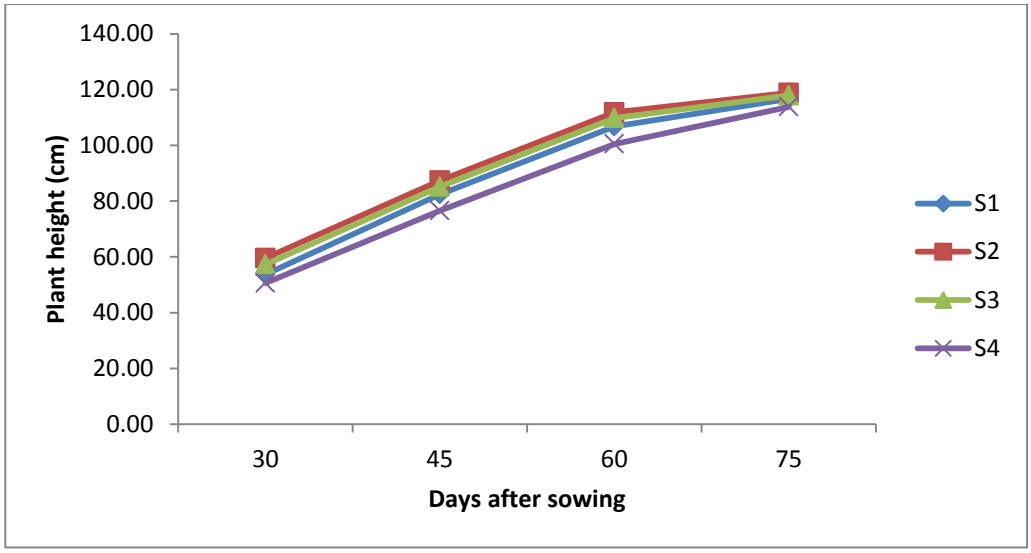


Fig. 2. Effect of sowing time on plant height of mustard

S_1 = 1st sowing(1st November) , S_2 = 2nd sowing(11th November), S_3 = 3rd sowing(21st November), S_4= 4th sowing(1st December).

Table 1. Interaction effect of variety and sowing time on plant height of Mustard

treatments	Plant height			
	30 DAS	45 DAS	60 DAS	75 DAS
V_1S_1	70.09 b	98.74 bc	141.20 a	159.60 b
V_1S_2	77.04 a	106.00 a	146.70 a	163.70 a
V_1S_3	76.12 a	104.10 ab	144.70 a	161.20 ab
V_1S_4	64.81 c	96.32 c	132.10 b	156.30 c
V_2S_1	37.43 e	66.19 d	72.45 cd	73.64 d
V_2S_2	42.03 d	68.71 d	76.92 c	73.84 d
V_2S_3	38.51 de	66.19 d	74.89 c	74.53 d
V_2S_4	36.41 e	56.78 e	68.90 d	71.30 e
LSD(0.05)	3.96	6.56	5.54	2.57
CV(%)	8.31	8.01	5.95	4.75

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, V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17 and S_1 =1st sowing(1st November),S_2 = 2nd sowing(11th November), S_3 = 3rd sowing (21st November), S_4=4th sowing(1st December).

4.2 Branches plant^{-1}

According to table 2 the BARI Sarisha-16 (V_1) had the highest number of branches per plant (10.9). However, the lowest number of branches per plant (5.32) was obtained from the BARI Sarisha-17 (V_2). Mamun *et al.* (2014) reported that BARI Sarisha-15 performed well in terms of branches plant^{-1} (6.14).

Sowing times were significantly influenced on number of branch per plant (Table 2). The maximum Number of branches per plant (9.19) was produced by $S_{2,}$ which was statistically identical with other treatment and S_4 treatment produced the lowest Number of branches per plant (6.15).

A significant variation in the number of branches per plant was found between the variety and sowing time (Table 2). The maximum number of branches per plant (11.62) was found in combined use of BARI Sarisha-16 with 2nd sowing time (V_1S_2), which was statistically similar with V_1S_1, V_1S_3 whereas the lowest number of branches per plant (4.23) was found in BARI Sarisha-17 with 4th sowing time
(V_2S_4) which was statistically similar with V_2S_3.

4.3 Siliquae plant^{-1}

The maximum number of siliqua per plant (192.83) was produced in V_1 treatment and the minimum number of siliquae per plant (62.48) was produced in V_2 treatment (Table 2). Hossain *et al*. (1996) and Jahan and Zakaria (1997) also stated that there was marked statistical variation in number of siliquae plant^{-1}.

Table 2. Effect of variety, sowing time and their interaction on the yield contributing characters of mustard

Treatments	Number of branch per plant		Siliquae per plan(No.)		Length of siliquae (cm)	
Effect of variety						
V_1	10.09		192.83		3.95	
V_2	5.32		62.48		4.25	
CV(%)	12.48		8.51		5.91	
Effect of sowing time						
S_1	7.81	ab	132.90	b	4.07	a
S_2	9.19	a	144.60	a	4.35	a
S_3	7.66	ab	127.50	b	4.02	b
S_4	6.15	b	105.60	c	3.97	c
LSD(0.05)	2.21		11.12		0.20	
CV(%)	12.48		8.51		5.91	
Interaction effect of variety and sowing time						
V_1S_1	10.06	a	198.30	b	3.90	c
V_1S_2	11.62	a	215.00	a	4.03	bc
V_1S_3	10.62	a	196.30	b	3.97	bc
V_1S_4	8.06	b	161.70	c	3.90	c
V_2S_1	5.57	cd	67.40	de	4.23	b
V_2S_2	6.77	bc	74.23	d	4.67	a
V_2S_3	4.70	d	58.67	ef	4.07	bc
V_2S_4	4.23	d	49.60	f	4.03	bc
LSD(0.05)	1.68		12.17		0.28	
CV(%)	12.48		8.51		5.91	

Where, V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17 and S_1 = 1st sowing(1st November), S_2 = 2nd sowing(11th November), S_3 = 3rd sowing(21st November), S_4= 4th sowing(1st December)

Number of siliquae per plant is one of the most important yield contributing characters in mustard. The sowing time showed significantly variation in the number of siliquae per plant (Table 2). The maximum number of siliquae per plant (144.6) was produced by S_2 treatment and S_4 produced the minimum number of siliquae per plant (105.6).

A significant variation was found in the treatment combinations of variety and sowing time on number of siliquae per plant (Table 2). The maximum number of siliquae per plant (215.00) was found in V_1S_2, which was followed by V_1S_1 and V_1S_3, whereas the minimum number of siliquae per plant (49.6) was found in T_0V_3 treatment combination, which was statistically similar with V_2S_4.

4.4 Length of siliqua

The maximum length of silliqua (4.25) was produced in V_2 treatment. The minimum length of silliqua (3.95) was produced in V_1 treatment (table 2). 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.

The sowing time was showed significant variation in the length of siliqua (Table 2). The maximum length of siliqua (4.35 cm) was produced by S_2 treatment, whereas S_4 produced the minimum length of silliqua (3.97).

Length of silliqua indicated a significant variation among the treatment combinations of variety and sowing time (Table 2). The maximum length of silliqua (4.67 cm) was found in V_2S_2, whereas the minimum length of silliqua (3.90 cm) was found in V_1S_1 and V_1S_4 treatment.

4.5 Seed per silliqua

The maximum number of seed per silliqua (22.87) was produced in V_2 treatment. The minimum number of seed per silliqua (17.21) was produced in V_1 condition (table 3).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}.

The sowing time showed variation in the number of seed per silliqua (Table 3). The maximum number of seed per silliqua (22.93) was produced by S_2, whereas S_4 produced the minimum number of seed per silliqua (17.44).

Number of seed per silliqua indicated a significant variation among the treatment combinations (Table 3). The maximum number of seed per silliqua (24.86) was found in V_2S_2 treatment combination, whereas the minimum number of seed per silliqua (13.81) was found in V_1S_4 treatment, which was statistically similar with V_1S_1 and V_1S_3.

4.6 Thousand Seed weight

The highest thousand seed weight (2.88 g) was obtained from V_1 treatment. The lowest thousand seed weight (2.80 g) was obtained from V_2 treatment (Table 3).

Sowing times were significantly influenced on the thousand seed weight (Table 3). The maximum thousand seed weight (2.97 g) was produced by S_2 and the lowest thousand seed weight (2.70 g) was produced by S_4.

Thousand seed weight was significantly affected by both variety and sowing time (Table 3). The highest thousand seed weight (2.99 g) was found in V_2S_2 treatment combination, which was statistically similar with V_2S_3 and V_1S_2 whereas the lowest thousand seed weight (2.69 g) was found in V_2S_4 treatment

Table 3. Effect of variety, sowing time and their interaction on the number of seed per siliquae and 1000 seed weight of mustard

Treatments	Number of seed per siliquae (No.)		1000 seed weight (g)	
Effect of variety				
V_1	17.21		2.88	
V_2	22.87		2.8	
CV (%)	9.41		5.33	
Effect of sowing time				
S_1	20.56	ab	2.89	ab
S_2	22.93	a	2.97	a
S_3	19.25	bc	2.94	a
S_4	17.45	c	2.70	b
LSD(0.05)	3.25		0.20	
CV(%)	9.41		5.33	
Interaction effect of variety and sowing time				
V_1S_1	16.97	c	2.93	ab
V_1S_2	21.00	b	2.95	a
V_1S_3	17.07	c	2.91	ab
V_1S_4	13.81	c	2.71	c
V_2S_1	24.15	ab	2.85	b
V_2S_2	24.86	a	2.99	a
V_2S_3	21.42	ab	2.97	a
V_2S_4	21.06	b	2.69	c
LSD(0.05)	3.30		0.10	
CV(%)	9.41		5.33	

Where, V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17 and S_1 = 1st sowing time , S_2 = 2nd sowing time, S_3 = 3rd sowing time, S_4= 4th sowing time

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4.7 Seed yield (tha^{-1})

The highest yield of seed (1.48 t ha^{-1}) was obtained from V_1 (BARI Sarisha-16) while V_2 gave the lowest (1.15 t ha^{-1}) yield. The probable reason of this difference might be due to higher number of pod length, number of seeds pod^{-1}.

The different sowing time had effect on the yield of seed per hectare (Table 4). The maximum yield of seed per hectare (1.95 t) was obtained from S_2 (2nd sowing time) treatment, whereas the minimum yield of seed per hectare (0.62 t) was obtained from S_4 (4th sowing).

The combined effect of variety and sowing time was significant on yield of seed per hectare (Table 4). The highest yield of seed per hectare (2.39 t) was obtained from V_1S_2 (BARI Sarisha-16 and 2nd sowing time) treatment combination. The lowest yield of seed per hectare (0.44 t) was obtained from V_2S_4 (BARI Sarisha-17 and 4th sowing time).

4.8 Stover yield (tha^{-1})

The total stover yield of mustard was statistically non significant due to the application of different variety (Table 4). The highest yield of stover (3.06 tha^{-1}) was obtained from V_1, while V_2 gave the lowest (2.45 tha^{-1}) yield.

The stover yield of mustard per plot was converted into per hectare, and has been expressed in metric tons (Table 4). The different dose of sowing time had effect on the stover yield per hectare. The maximum yield of stover per hectare (3.52 t) was obtained from S_2, treatment, which was statistically similar with S_3 treatment, whereas the minimum yield of stover per hectare (1.72 t) was obtained from S_4.

Table 4. Effect of variety, sowing time and their interaction on the yield and yield contributing characters of mustard

Treatments	Yield (tha^{-1})		Stover yield (tha^{-1})		Biological yield (tha^{-1})		Harvest index (%)	
Effect of variety								
V_1	1.48		3.06		4.53		31.43	
V_2	1.15		2.34		3.50		31.32	
CV (%)	8.63		11.94		5.64		7.36	
Effect of sowing time								
S_1	1.86	a	2.79	ab	4.66	ab	40.03	a
S_2	1.95	a	3.52	a	5.47	a	35.57	ab
S_3	0.84	b	2.78	a	3.61	b	23.95	bc
S_4	0.62	b	1.72	b	2.33	c	22.64	c
LSD(0.05)	0.6676		1.257		1.026		12.46	
CV(%)	8.63		11.94		5.64		7.36	
Interaction effect of variety and sowing time								
V_1S_1	2.05	ab	3.20	ab	5.25	ab	39.03	a
V_1S_2	2.39	a	3.93	a	6.32	a	37.77	ab
V_1S_3	0.69	ef	3.36	ab	4.05	c	17.02	bc
V_1S_4	0.81	def	1.72	d	2.53	d	31.89	c
V_2S_1	1.68	abc	2.38	cd	4.06	c	41.34	a
V_2S_2	1.50	bcd	3.11	bc	4.62	bc	32.56	ab
V_2S_3	0.98	def	2.19	bc	3.17	c	30.89	ab
V_2S_4	0.44	f	1.71	d	2.15	d	20.49	abc
LSD(0.05)	0.71		0.75		1.18		20.30	
CV(%)	8.63		11.94		5.64		7.36	

Where, V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17 and S_1 =1st sowing, S_2 = 2nd sowing, S_3 = 3rd sowing, S_4= 4th sowing

The combined effect of variety and sowing time was significant on yield of stover per hectare (Table 4). The highest yield of stover per hectare (3.93 t) was obtained from V_1S_2 treatment combination. The lowest yield of stover per hectare (1.72 t) was obtained from V_2S_4 treatment, which was statistically similar with V_1S_4.

4.9 Biological yield (tha^{-1})

The biological yield of mustard was statistically non significant due to the different variety (Table 4). The highest yield of biological yield (4.54 tha^{-1}) was obtained from V_1 while V_2 gave the lowest (3.49 tha^{-1}) biological yield.

The different dose of sowing time had significant effect on the biological yield per hectare. The maximum biological yield per hectare (5.47 t) was obtained from S_2 treatment, whereas the minimum biological yield per hectare (2.33 t) was obtained from S_4 treatment (Table 4).

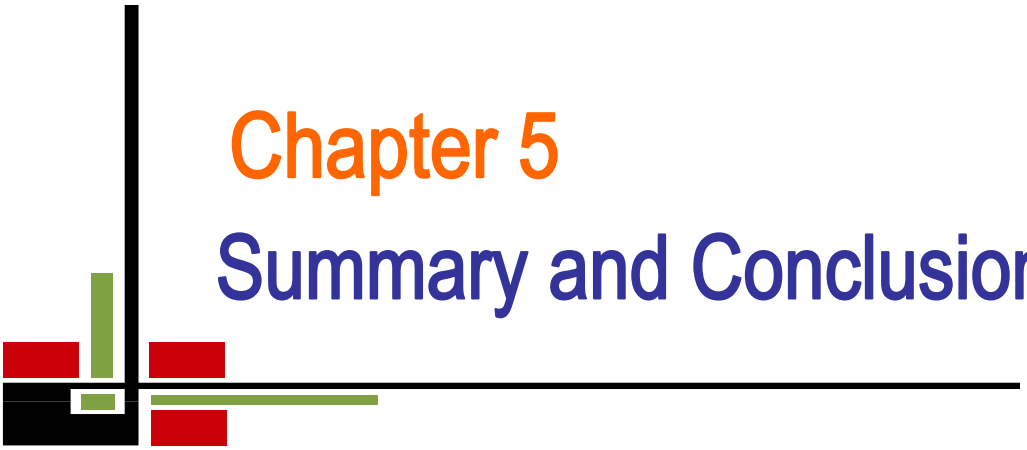
The combined effect of variety and sowing time was significant on biological yield per hectare (Table 4). The highest biological yield per hectare (6.32 tones) was obtained from V_1S_2 treatment combination. The lowest biological yield per hectare (2.15 tones) was obtained from V_2S_4 treatment, which was statistically similar with V_1S_4.

4.10 Harvest index (%)

The harvest index varied due to the application of different variety (Table 4). The highest harvest index (31.42%) was obtained from V_2 while V_1 gave the lowest (31.32 %) harvest index.

The different sowing time had significant effect on the harvest index of mustard. The maximum harvest index (40.03 %) was obtained with S_1, and the minimum harvest index (22.49%) was obtained from S_4 treatment (Table 4).

The combined effect of variety and sowing time was significant on harvest index (Table 4). The highest harvest index (41.34 %) was obtained from V_2S_1 treatment combination, which was statistically similar with V_1S_1. The lowest harvest index (31.89%) was obtained from V_1S_4 treatment.



Chapter 5

Summary and Conclusion

Chapter V

SUMMARY AND CONCLUSION

The experiment was undertaken during November 2017 to February 2018 to find out the effect of sowing time on growth and yield of mustard. In this experiment, the treatment consisted of four different sowing times viz. S_1 = 1st sowing, S_2 = 2nd sowing, S_3 = 3rd sowing and S_4=4th sowing, and two varieties of mustard viz. V_1 = BARI Sarisha-16, V_2 = BARI Sarisha-17. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replicatatins. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that significant variation among the treatments in respect majority of the observed parameters.

According to varietal difference maximum plant height (72.01, 101.27, 141.17 and 160.20 cm at 30, 45, 60 and 75 DAS, respectively) was produced with V_1 (BARI Sarisha-16). The BARI Sarisha-16 (V_1) had the highest number of branches per plant (10.9). The maximum number of siliqua per plant (192.83) was produced in V_1 treatment. The maximum length of silliqua (4.25) was produced in V_2 treatment. The maximum number of seed per silliqua (22.87) was produced in V_2 treatment. The highest thousand seed weight (2.88 g) was obtained from V_1 treatment. The highest yield of seed (1.32 tha^{-1}) was obtained from V_1 (BARI Sarisha-16). The highest yield of stover (3.06 tha^{-1}) was obtained from V_1. The highest yield of biological yield (4.37 tha^{-1}) was obtained from V_1. The highest harvest index (33.01%) was obtained from V_2.

Different sowing time showed statistically significant difference on different parameters. The tallest plant (59.354, 57.36, 111.81 and 118.77 cm at 30, 45, 60 and 75 DAS, respectively) was recorded with S_2 treatment (2nd sowing time). The maximum number of branches per plant (9.19), number of siliquae per plant (144.6), length of siliqua (4.35 cm) was produced with S_2. the maximum number of seed per silliqua (22.93), thousand seed weight (2.97 g) was produced in S_2. The maximum yield of seed per hectare (1.95 t) was obtained from S_2 (optimum time) treatment. The maximum yield of stover per hectare (3.52 t) was obtained from S_2, treatment. The maximum biological yield per hectare (5.47 t) was

obtained from S_2 treatment. The maximum harvest index (40.03 %) was obtained with S_1.

The combinations of variety and sowing time had significant effect on almost all parameter. The tallest plant (77.04, 106.00, 146.70, and 163.70 cm at 30, 45, 60 and 75 DAS, respectively) was found in V_1S_2. The maximum number of branches per plant (11.62) and number of siliquae per plant (215.00) was found in BARI Sarisha-16 with 2nd sowing time (V_1S_2) treatment. The maximum length of silliqua (4.67 cm) was found in V_2S_2. The maximum number of seed per silliqua (24.86) was found in V_2S_2 treatment combination. The highest thousand seed weight (2.99 g) was found in V_2S_2 treatment combination. The highest yield of seed per hectare (2.387 t) was obtained from V_1S_2 (BARI Sarisha-16 and 2nd sowing time) treatment combination. The highest yield of stover per hectare (3.93 t) was obtained from V_1S_2 treatment combination. The highest biological yield per hectare (6.32 t) was obtained from V_1S_2 treatment combination. The highest harvest index (41.34 %) was obtained from V_2S_1 treatment combination.

Considering the above results, it may be summarized that growth, seed yield contributing parameters of mustard is positively correlated with varieties and sowing time. Therefore, the present experimental results suggest that the combined use of BARI Sarisha-16 with 2nd sowing time along with recommended doses of other fertilizer would be beneficial to increase the seed yield. Under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required to substantiate further with different varieties of rapeseed and mustard.
3. It needs to conduct more experiments with sowing time whether can regulate the morphological characters, yield and seed quality of mustard.

References

REFERENCES

Adak, Tarun, Narjary Bhaskar and N. V. K. Chakravarty (2011). Response of *Brassica* to micro environment modification under semi-arid agro ecosystem. *Indian J. Agric. Sci.,* **81 (8)**: 744–50.

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

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.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.

Aziz, M. A., Remi Chakma, M. Ahmed, A. K. M. M. Rahman and K. Roy, (2011). Effect of sowing dates on the growth, development and yield of mustard in the hilly areas. *J. Exp. Bio. Sci.,* **2 (1)**: 33-36.

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

BBS. (2004). Monthly Statistical Bulletin of Bangladesh of Bureau Statistics (BBS) Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh

BBS. (2009). Monthly Statistical Bulletin of Bangladesh of Bureau Statistics (BBS) Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh.

BBS. (2012). Monthly Statistical Bulletin of Bangladesh of Bureau Statistics (BBS)Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh.Beech, D.F. and Norm.

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.

Bhatnagar, G. S., M. K. Porwal and P. C. Chaplet (1997). Response of mustard to sowing dates and irrigation regimes in mahi command area of Rajasthan. *Indian J. Agric. Res.*, **31 (2)**: 101-104.

Bhuiyan M.S., M.R.I. Mondol, M.A. Rahaman, M.S. Alam and A.H.M.A. Faisal (2008). Yield and yield attributes of rapeseed as influenced by date of planting. *Int. J. Sust. Crop Prod.*, **3 (3)**: 25-29.

Biswas, Chinmay, Ravindra Singh and P. K. Vijaya (2011). Dynamics of white rust disease in mustard (*Brassica juncea*) in relation to date of sowing and weather parameters. *Indian J. Agric. Sci.,* **81 (12)**: 1187–90.

Butter, G. S. and C. S. Aulakh (1999). Effect of sowing date nitrogen and row spacing on growth yield attributes and yields of Indian mustard. *Indian J. Agron.*, **44 (4)**:813-815.

Chandrakar, B. L. and J. S. Urkurkar (1993). Performance of mustard varieties to dates of sowing in rice fallow. *Indian J. Agron.*, **38 (1)**: 143-144.

Charak, A. S., R. C. Dadheech and G.S. Chouwan (2006). Growth and productivity of toria *(Brassica rapa* var. *dichotoma)* as influenced by Sowing time and row spacing and nitrogen levels. *Indian J. Agric. Sci.*, **76 (11)**: 685-7.

Choudhary, J. K. and R. K Thakuria (1994). Response of Indian mustard (*Brassica juncea*) and toria (*Brassica campestris*) to sowing date under rainfed conditions. *Indian J. Agron.*, **39 (4)**: 687-688.

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

FAO. (2004). FAOSTAT database of Agriculture (Crops). http://www.fao.org.

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.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.

Iraddi, V. S. (2008). Response of Mustard (Brassica juncea L. Czernj and Cosson) Varietis to Date of Sowing and Row Spacing in Northern Transition Zone of Karnataka. Abstracts of Thesis Accepted for the Award of Post-Graduate Degree in the Univ. of Agricultural Sci.s, Dharwad. Karnataka J. Agric.Sci., **21 (4)**: 44- 46.

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.

Jadhav, S. N. and N. P. Singh (1992). Water use and soil moisture extraction pattern of mustard (*Brassica juncea*) under varying sowing dates, insect pest control measures and irrigation. *Indian J. Agron.*, **37 (1)**: 198-200.

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.

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.

Khichar, M. L., Y. C. Yadav, O. P. Bishnoi and Ramniwas (2000). Radiation use efficiency of mustard as influenced by sowing dates, plant spacings and cultivars. *J. Agromet.,* **2 (1)**: 97-99.

Krishi Dairy (2013). Agriculture Information Service (AIS), Department of Agriculture Extension, Khamarbari, Dhaka-1215. pp. 17-25.

Kumar, Anil, Bikram Singh, Yashaial and J. S. Yadav (2004). Effect of sowing time and crop geometry on tetra loculor Indian mustard under southwest Haryana. *Indian J. Agric.Sci.*, **74 (11)**: 594-596.

Kumar, Rajendra and M. J. Shaktawat (1992). Effect of limited water supply, nitrogen and time of sowing on production of rapeseed (*Brassica napus*). *Indian J. Agron.*, **37 (4)**: 853-855.

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.

Kumar, S. D. and R. D. Singh (2003). Indian mustard (*Brassica juncea* L.) seed yield as influenced by seedling date, spacing and N levels. *J. Appli. Biol.*, **13 (1/2)**: 139-146.

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

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.

Kumari, C. Radha and D.S. Koteswararao (2005). Effect of land treatments and dates of sowings on growth parameters of mustard (*Brassica juncea*). *J.Oilseeds Res.* **22 (1)**: 188-189

Kumari, Radha C., D.S. Koteswararao and U. Obulamma (2004). Impact of sowing dates and land treatments on Indian mustard (Brassica juncea) in nontraditional areas of Andhra Pradesh. Madras Agric.J., **91 (7-12)**: 374-377.

Kurmi, K. (2002). Influence of sowing date on the performance of rapeseed and mustard varieties under rainfed situation of Southern Assam. *J. Oilseeds Res.,* **19 (2)**: 197-198.

Kurmi, K. and M. M. Kalita (1992). Effect of sowing date, seed rate and method of sowing on growth, yield and oil content of rapeseed (*Brassica juncea*). *Indian J. Agron.*, **37 (3)**: 595-597.

Lallu, R. S., V.S. Baghel and S. B. L. Srivastava (2010). Assessment of mustard genotypes 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.

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., F**.** Begum and I. M. Saiyed (2011). Effect of planting dates on seed and oil yield of rapeseed (*Brassica campestries* L.) genotype BCYS-03. *SAARC J. Agric.*, **9 (1)**: 85-93.

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.

Mondal, R. I., B, M., Hydar-Ali, M. K. and Akbar, M. A. (1999).Response of rapeseed genotype Dhali to seed rate and seeding date. Bangladesh J. Agril. Res. **24(1)**: 83-90.

Panda, B. B., S. K. Bandyopadhyay and Y. S. Shivay (2004a). Effect of irrigation level, sowing dates and varieties on growth, yield attributes, yield, consumptive water use and water use efficiency of Indian mustard (Brassica juncea). Indian J. Agric. Sci., **74 (6)**: 331-342.

Pandey, B. P., S. K. Sirvastava, and R.S. Lal (1981). Genotype and environment interaction in lentil. LENS, 8: 14-17.

Panwar, K. S., S. K. Sharma and R. K. Nanwal (2000). Influence of sowing times on the yield of different mustard cultivars (Brassica spp.) under conserved soil moisture conditions. Indian J. Agric. Sci., **70 (6)**: 398-399.

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.

Reddy, M. D. and Avil Kumar (1997). Effect of dates of sowing on performance of mustard varieties in non-traditional areas of Andhra Pradesh. *J. Oilseeds Res.*, **14 (2)**: 207-209.

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.

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.

Shahidullah, M., U. Islam, M. A. Karim and M. Hussian (1997). Effect of sowing dates and varieties on yield and yield attributes of mustard. *Bangladesh J. Sci. and Industrial Res.,* **9** (1): 39-41.

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

Sharma, S. K., S. N. Mendhe, Harsha Kolte, G. R. Rajput and M. D. Yenpreddewar (2006). Effect of sowings and irrigation management on

growth and yield of mustard (*Bressica juncea*). *J. Soils and Crop*, **16 (4)**: 455-459.

Shivani and Sanjeev Kumar (2002). Response of Indian mustard (*Brassica juncea*) to sowing date and row spacing in mid hills of Sikkim under rainfed conditions. *Indian J. Agron.*, **47 (3)**: 405-410.

Singh, S. K. and Ghanshyam Singh (2002). Response of Indian mustard (*Brassica juncea*) varieties to nitrogen under varying sowing dates in eastern Uttar Pradesh. *Indian J. Agron.*, **47 (2)**: 242-248.

Singh, Angrej, K. K. Dhingra, Jagroop Singh and M. P. Singh (2002b). Effect of sowing time and plant density on growth, yield and quality of Ethopian mustard (Brassica carihata L. Br.). J. Res., **39 (4)**: 471-475.

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

Sonani, V. V., P. T. Patel and G. G. Patel (2002). Performance of mustard under different dates of sowing in Bhal and Coastal Agro-climatic zone of Gujarat. J. Oilseeds Res., **19 (1):** 122.

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

Surekha, E. and R. G. Reddy (1996). Performance of mustard varieties under different dates of sowing. *J.Oilseeds Res.,* **13 (1)**: 70-73.

Thakur, K. S. and C. M. Singh (1998). Performance of *Brassica* species under different dates of sowing in mid hills of Himachal Pradesh. *Indian J. Agron.*, **43 (3)**:464-468.

Tomar, R. K. S. and G.L. Mishra (1991). Influence of sowing dates and nitrogen on theyield of Indian mustard (Bressica juncea). J. Oilseeds Res., 8 (2): 210-214.

Vasi, M., Arvind Kumar and A.K. Rastogi (1986). Effect of soiwnf dates on rapeseed varieties. *Indian J. Agron.* **31 (1)**: 1-4.

Yadav, R. N., Suraj Bhan and S. K. Uttam, (1994b). Effect of sowing variety and plant population on growth and yield of rainfed Indian mustard (*Brassica juncea*). *Indian J. Agron.*, **39 (4)**: 682-684.

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.

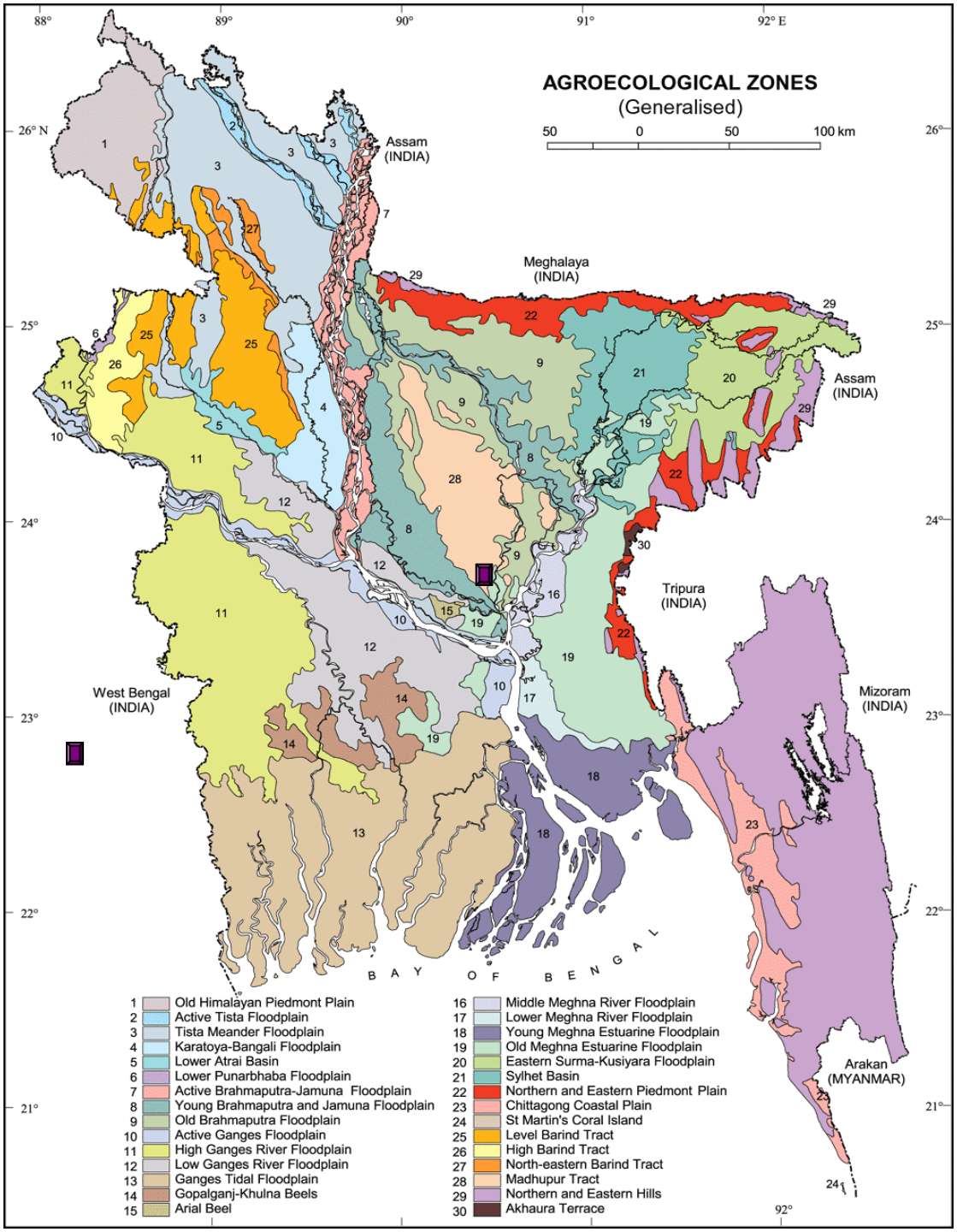
Zakaria, A.K.M. and Jahan, M.H. (1997). Annual Report for the year of 1995-96.Banngladesh Rural Academy, Bogra, Bangladesh. pp. 25-35.

Zekatte, V. (1999). Dependence of white mustard crops on sowing time and rate on light soils. *Zemdirbyste Mokslo Darbai,* **66**: 1

Appendices

APPENDICES

Appendix I: Map showing the experimental sites under study.



Appendix II: 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: SRD

Appendix III. Monthly average air temperature, total rainfall, relative humidity and sunshine hours of the experimental site during the period from November 2017 to February 2018.

Year	Month	Average Air temperature (^{0}C)			Total rainfall (mm)	Average RH (%)	Total Sun shine hours
		Maximum	Minimum	Mean			
2017	November	29.7	20.1	24.9	5	65	192.20
	December	26.9	15.8	21.35	0	68	217.03
2018							
	January	24.6	12.5	18.7	0	66	171.01
	February	27.1	15.8	21.05	09	66	168.60

Source: Dhaka Metrological Centre (Climate Division)