PERFORMANCE OF RAPESEED AND MUSTARD VARIETIES WITH DIFFERENT PLANTING TECHNIQUES

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CERTIFICATE

This is to certify that the thesis entitled **"PERFORMANCE OF RAPESEED AND MUSTARD VARIETIES WITH DIFFERENT PLANTING TECHNIQUES"** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of apiece of *bonafide* research work carried out by **LAILA JANNATUL FERDOUS, Registration No. 08-02746** under my supervision and 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: 23.02.16

Place: Dhaka, Bangladesh

(Prof. Dr. Parimal Kanti Biswas)
Supervisor

DEDICATED TO
MY
PARENTS AND TEACHERS WHO
LAID THE FOUNDATION OF MY
SUCCESS

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PERFORMANCE OF RAPESEED AND MUSTARD VARIETIES WITH DIFFERENT PLANTING TECHNIQUES

ABSTRACT

The field experiment was conducted at the Agronomy Field of Sher-e- Bangla Agricultural University (SAU), Dhaka in the Rabi season (November-February) of 2013-2014 to evaluate the performance of varieties on different planting techniques of rapeseed and mustard. The treatment comprised of two planting techniques and five varieties. The two planting techniques were conventional method of sowing (P_1) and sowing in puddle soil (P_2). Five different varieties were Improved Tori-7 (V_1), BARI Sarisha-13 (V_2), BARI Sarisha-15 (V_3), BARI Sarisha-16 (V_4) and SAU SR-03 (V_2). The experiment was laid out in a Split Plot Design with three replications. The experiment focused on the performance of rapeseed and mustard varieties to determine the suitability of cultivation in different condition to fit the crop into the cropping pattern. Results indicated that the seed yield of mustard varied with varietal difference. But there was no significant difference between the two planting techniques for most of the parameters. The planting techniques affect significantly for the siliqua length. It was found that higher siliqua length was found in the conventional technique of planting. The growth behavior of the five studied varieties was different. The variety Improved Tori-7 showed the highest yield than the other studied varieties, which is 14.29% higher than the variety BARI Sarisha-16. The variety BARI Sarisha-16 showed the highest yield response (2.39 t ha^{-1}) with conventional technique that statistically similar with the variety Improved Tori-7 (2.38 t ha^{-1}) with conventional well as puddled soil condition. The interaction effect of conventional technique with BARI Sarisha-16 gives 0.42% higher yield return than puddle soil sowing with Improved Tori-7. Thus, it is concluded that the variety Improved Tori-7 can be well suited with both techniques and BARI Sarisha-16 could be grown with conventional method of sowing (P_1V_4) for higher yield output.

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LIST OF ACRONYMS

ACRONYMS

AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
C.V.	Coefficient of Variation
cv.	Cultivar
DAS	Days after sowing
E	East
et al.	*et alibi* (and others)
etc.	*et cetra* (and so on)
FAO	Food and Agriculture Organization
HI	Harvest index
HYV	High yielding variety
i.e.	id est (that is)
LSD	Least significant difference
N	North, Nitrogen
SAU	Sher-e-Bangla Agricultural University

UNIT

%	Percentage
^0C	Degree Celsius
cm	Centimeter
g	Gram
ha	Hectare
kg	Kilogram
m	Meter
t	Ton

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Rapeseed-Mustard (*Brassica spp.* L.) commonly known as mustard in Bangladesh, is a cool season, thermo sensitive as well as photosensitive crop (Ghosh and Chatterjee, 1988). Edible oil plays a key role as a source of high energy component of food in human nutrition. Vegetable fat obtained from plant sources is safe for consumption for its cholesterol free nature. Bangladesh is facing chronic shortage of edible oil for several decades. *Brassica* oil crop is the most important group that supplies substantial quality of edible oil in Bangladesh. It accounts for 59.4% of total oil seed production in the country (AIS, 2010). Bangladesh is running a short of 60-75% of the demand of edible oil (Rahman, 2002). Annually, about 0.17 million tons of edible oil is produced in the country, meeting around 30% of our demand. The country has to import more or less 1.9 million tons of edible oil. In 2007-08, around 1,35,328 million taka was spent for the import of 1.92 million tons of edible oil. Among the edible oil cultivation in 2008-09, rapeseed and mustard occupies more than 65.91% and sesame occupies 9.23% of the total oilseed area being the largest and the second largest oilseed crop respectively (Akbar, 2011). 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).

Rapeseed and mustard is the major oilseed crop of Bangladesh both on the basis of its total cultivated area and production respectively. In 2004-05 to 2008-09, it was cultivated in 227,000 ha, producing 199,000 metric tons of seed with an average yield of 878 kg ha^{-1} (Akbar, 2011). The average yield of rapeseed-mustard in this country is 739 kg ha^{-1} whereas the world average yield of mustard is 1575 kg ha^{-1} (FAO, 2011). The average per hectare yield of mustard in this country is alarmingly very poor compared to that of advanced countries like Germany, France, UK and Canada producing 6667 kg ha^{-1}, 5070 kg ha^{-1}, 3264 kg ha^{-1}, 3076 kg ha^{-1} respectively (FAO, 2003). Annual requirement of edible oil is about 5 lakh metric tonnes. The internal production of edible oil can meet up only less than one-third of the annual requirement (Mondal and Wahhab, 2001). The major reasons for low yield of rapeseed-mustard in Bangladesh are due to lack of high yielding variety, appropriate population density and inadequate knowledge of sowing time, sowing methods and proper management practices etc (Mamun *et al.*, 2014). The area under mustard is declining due to late harvesting of high yielding T. *aman* rice and increased cultivation of *boro* rice loosing in an area of 104 thousand hectare and production 68 thousand tons of mustard and rapeseed in last ten years (Anon., 2006). Yield and its development process depend on genetic, environmental and agronomic factors as well as the interaction between them. Therefore, there is a scope to increase the yield level of rapeseed-mustard by using HYV seed and by adopting proper management practices like spacing, irrigation, seed rate, fertilizer application etc.

There is a great scope of increasing yield of rapeseed-mustard by selecting high yielding varieties and improving management practices (Bhuiyan *et al.,* 2011). The ex-post-facto analysis of secondary data pertaining to front line demonstrations (FLDs) in rapeseed-mustard conducted under 'Integrated scheme on Oilseeds, Pulses, Oilpalm and Maize (ISOPOM)' revealed 22.7% yield advantage by adoption of improved varieties may be possible (Dutta, 2014). Time of sowing is very important for rapeseed-mustard production (Rahman *et al.,* 1988; Mondal and Islam, 1993 and Mondal *et al.,* 1999). 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 rapeseed-mustard and other oilseed acreage in the country, due to competition from more profitable alternative crops such as boro rice. The cultivation of rapeseed-mustard has to compete with other food grain crops have shifted to marginal lands of poor productivity.

With the increasing growth rate of population, the demand of edible oil is increasing day by day. It is, therefore, highly accepted that the production of edible oil should be increased considerably to fulfill the demand of the country. Sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield and to fit the cropping pattern between Aman and Boro rice. Farmers mostly grow the traditional variety (degenerated) of Tori-7 as Maghi sarisha from long past for its shorter duration (70-80 days) characteristics with average yield of 750 kg ha^{-1}. This variety is advantageous to grow as catch crop between Aman and Boro rice with minimum input and tillage practices. There is ample scope of replacing the traditional farmers varieties by the short duration yellow seeded variety, having yield capacity of 1.50-1.65 t ha^{-1} and can easily be grown in the Aman-Mustard-Boro cropping system with 2-3% increased oil content for yellow seed without hampering existing Boro rice cultivation. In such situation, sowing time of Rapeseed and mustard should definitely be done by late October to early November that frequently affected by rainfall and make challenge of better productivity of the pattern. On the other hand, it is also seen that grain yield reduced gradually with the advancement of delay of sowing. Rapeseed and mustard can be cultivated by seedling as reported by Verma and Gorai, 2013. Therefore, the proposed study was undertaken to find out the suitability of alternate planting method of rapeseed and mustard to fit it in the promising and widely used cropping pattern Aman-Mustard-Boro of Bangladesh.

This piece of research work is frame to achieve the following objectives:

- To compare the performance of rapeseed and mustard varieties.
- To determine the suitability of cultivating rapeseed and mustard in different condition.
- To find out the possibility of cultivating rapeseed and mustard under adverse climatic condition to fit in cropping pattern.

Chapter II
Review of Literature

CHAPTER II
REVIEW OF LITERATURE

Rapeseed is an 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 planting technique is one of the most important. A very little work has been done involving the planting technique with the mustard/rapeseed varieties. Some of the work applicable to the present study has been reviewed below:

2.1 Effect of planting technique on different crop characters

2.1.1 Plant height

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

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

Sarkees (2013) conducted an experiment at Karda-Rasha /College of Agriculture, Erbil to evaluate the effect of different seeding rates using drill-row and broadcasting sowing methods on growth, seed and oil yields of rapeseed (*Brassica napus* L.) cv. Pactol. The tallest plants were produced in the drill-row sown plots. (129.5 cm), while the shortest plants were produced with broadcasting sowing (115.2 cm) , this result is in agreement with Khan *et al.* (2000) that the plants of broadcasting sowing are shorter (109.7 cm) than plants of drill sowing method (118.0 cm).

Hossain *et al.* (2013) carried out an experiment at Agronomy field laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, to study the effect of irrigation and sowing method on yield and yield attributes of mustard. Sowing method had significant effect on plant height. Line sowing produced the tallest plant (96.51 cm) and the shortest one (94.26 cm) was found at broadcast method.

2.1.2 Number of primary branches plant^{-1}

Hossain *et al.* (2013) reported that sowing method had significant effect on the production of total branches plant^{-1}. Line sowing method produced the highest number of branches plant^{-1} (8.42). The lowest number of total branches plant^{-1} (8.03) was observed in the broadcast method.

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

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

2.1.3 Number of siliquae plant^{-1}

The number of siliqua per plant is an important yield contributing character of oil seed rape. Several studies suggest that a higher number of siliquae plant^{-1}

has the greatest effect on seed yield on rape and mustard (Mendham *et al.*, 1981; Thurling, 1974; Rahman *et al.*, 1988).

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

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

Sarkees (2013) reported that individual plants of drill-row sowing produced a higher number of siliquae than those of broadcasting sowing (130.0) and (107.1) respectively.

2.1.4 Length of siliqua

Hossain *et al.* (2013) observed that siliqua length was not significantly influenced by sowing method. Numerically, the longest siliqua (5.69 cm) was found at line sowing method and the shortest one was obtained from broadcasting method.

2.1.5 1000-seed weight

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

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

According to Hossain *et al.* (2013) the weight of 1000-seed was not influenced by sowing method. The maximum weight of 1000-seed (3.49 g) was obtained from line sowing method and the minimum weight of 1000-seed (3.43 g) was found in broadcasting method.

2.1.6 Seed yield

Khan *et al.* (2000) found that the maximum grain yield of 1119 kg ha^{-1} was obtained when crop was grown on ridges which were significantly higher than rest of sowing methods. There were no significant differences between furrow and drill sowing methods observed. The lowest yield was obtained when the seed was broadcasted.

Sarkees (2013) reported that maximum total yield of 1091.9 kg ha^{-1} was obtained when crop was grown by drill-row sowing, which was significantly higher (140.9%) than broadcasting method.

According to Hossain *et al.* (2013) sowing method had significant influence on seed yield. The highest seed yield (1.69 t ha^{-1}) was found from line sowing. Whereas, the lowest seed yield (1.46 t ha^{-1}) was exhibited from the broadcasting method.

At Shillongani, broadcast method was found to be more successful. Significantly higher seed yield of toria (*Brassica rapa* var. toria) was harvested in broadcast sowing over other practices. Toria broadcast at dough stage along with 80□kg□N ha^{-1} gave the highest yield (AICRP-RM, 2007).

Khan and Muendel (1999) reported that broadcast seeding appeared the worst treatment for seed yield and also resulted with heavy growth of *Avena sativa* (oats) in weed dry weights of 1274 and 1498 g m^{-2} respectively.

2.1.7 Stover yield

Hossain *et al.* (2013) found significant influence on stover yield due to sowing method. The line sowing method produced the highest stover yield (2.85 t ha^{-1}). The lowest stover yield (2.66 t ha^{-1}) was found in broadcasting method.

2.1.8 Biological yield

Khan *et al.* (2000) studied the result of biological yield as affected by different sowing methods. Maximum biological yield was observed in ridge sowing method (26390 kg ha^{-1}) which was at par to drill sowing method (27900kg ha^{-1}). The lowest biological yield was found in furrow and broadcast method (25885 and 26065 kg ha^{-1} respectively).

2.2 Effect of variety on different crop characters

2.2.1 Plant height

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

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

Zakaria and Jahan (1997) observed that Dhali gave the tallest plant height (142.5 cm) which was similar with Sonali (139.5) and Japrai (138.6cm). 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), Jessore (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 (175cm), 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 (134.4cm) in the variety J-5004, which was identical with SS-75 and was significantly taller than JS-72 and Tori-7.

2.2.2 Primary branches $plant^{-1}$

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

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

BARI (2000) found that the number of primary branches/plant was higher (4.02) in the variety SS-75 and lower (2.1) in the variety BARI Sharisa-5 under poor management under medium management, the higher number of primary branches $plant^{-1}$ 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 Hhole-401 and BARI sarisha-8 varieties

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

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

Mondal and Islam (1993) reported that variety had significant effect on plant height. They found the highest plant height (134.4 cm) on the variety J-5004, which was identical with SS-75 and was significantly taller than JS-72 and Tori-7.

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^{-1} in 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^{-1} was 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.

2.2.4 Siliqua length

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

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

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

Hossain *et al.* (1996) stated that the varieties of rapeseed differed significantly in respect of siliqua length. The longer siliqua was found in hybrid BGN-900 (7.75cm) 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 B application. The average number of seeds pod^{-1} ranged from 12.00 to 20.67 and 13.22 to 27.44 in the B untreated and treated plots, respectively. The maximum average number of seeds pod^{-1} (27.44) was recorded in B treated BARI Sarisha- 8.

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.

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 siliqua stage.

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

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

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

Afroz et al. (2011) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from November 2007 to March 2008 to study the effect of sowing date and seed rate on the yield and yield components of two mustard varieties. The highest seed yield (1.53 t ha-1) was recorded in 10 November sowing and the lowest one was achieved in 30 November sowing. Seed rate had also significant effect on plant height, branches plant-1, pods plant-1, effective pods plant-1, pod length, no. of seeds pod-1 and seed yield.

2.1.8 Stover yield

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

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

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

2.1.9 Harvest index

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

Akhter (2005) observed that variations in harvest index among the varieties were found statistically significant. The highest harvest index (31.73%) was recorded from BARI sarisha-10 that was similar (30.18%) with the variety BARI sarisha-8. The lowest harvest index (27.79%) was recorded from BARI sarisha-7 that was also similar to BARI sarisha-11 (28.90%) and BARI sarisha-8.

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

2.3 Interaction of planting techniques and variety on different crop characters

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

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

Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The research was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field is located at 23^0 77' N latitude and 90^0 33' E longitude at a height of 9 meter above the sea level (BCA, 2004). The land was medium high and well drained.

3.2 Climate

The area had sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). The average maximum and minimum temperature during the experiment was 29.78^0C and 5.21^0C, respectively. The humidity varied from 48.66% to 64.02%. The day length ranged between 10.5 and 11.0 hours and rainfall occurred during the experimentation. The weekly average rainfall, air temperature and relative humidity of the site during the experimental period were presented in Appendix II.

3.3 Soil

The soil of the experimental site belongs to the agro-ecological region of "Madhupur Tract" (AEZ No. 28). It was Deep Red Brown Terrace soil and belonged to "Noda" soil series. The top soil is silty clay loam in texture. Organic matter content was very low (0.82%) and soil p^H varied from 5.47-5.63.

3.4 Experimental materials

Seeds of five rapeseed varieties namely Improved Tori-7 and BARI sarisha-13, BARI Sarisha-15 and BARI Sarisha-16 were collected from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Gazipur. SAU SR-03 was collected from Sher-e-Bangla Agricultural University, Dhaka. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90% for all the varieties.

3.5 Experimental treatments

The experimental treatments are as follows:

A. **Factor** -1. Planting techniques

(i) Conventional method (P_1)

(ii) Puddle soil (P_2)

B. **Factor**-2. Variety: 5

(i) Improved Tori 7 (V_1)

(ii) BARI Sarisha 13 (V_2)

(iii) BARI Sarisha15 (V_3)

(iv) BARI Sarisha 16 (V_4)

(v) SAU SR-03 (V_5)

3.6 Experimental design and lay out:

The experiment was laid out in a Split Plot Design with three replications having planting techniques in the main plots and variety in the sub-plots. There were 10 treatment combinations. The total numbers of unit plots were 30. Factorial arrangements of treatments within the plot were made at random. The unit plot size was 2.5 m x 2.4 m. The distance between two adjacent unit plots was 0.5m and distance between two replications or between two blocks was 1m.

3.7 Crop husbandry

3.7.1 Land preparation

The experimental field was ploughed with power tiller and rotavator. Subsequent cross ploughing was done followed by laddering to make the land level. All weeds, stubbles and residues were removed from the field.

3.7.2 Fertilization

The experimental plots were fertilized with a recommended dose of 250-170-85-150-5-15 kg ha^{-1} of N, P_2O_5, K_2O, S, *Zn* and Boron, respectively from their sources of Urea, TSP, MP, Gypsum and Zinc Sulphate respectively. The half of urea and the whole amount of other fertilizers applied as basal during final land preparation and the rest urea as top dressing before flowering.

3.7.3 Germination test

Germination test was done before sowing the seeds in the field. Filter paper were placed on petridishes and the papers were soaked with water. Seeds were distributed at random in petridish. Data on emergence were collected and converted to percentage basis by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for germination}} \times 100$$

3.7.4 Sowing of seeds

Seeds were sown on 5^{th}November, 2013 maintaining 30cm row spacing in each plot. Sowing was done continuously in rows. Puddle soil was maintained by applying water to the respective plots followed by laddering before sowing.

3.7.5 Weeding and thinning

The experimental plots were found to be infested with different kinds of weeds, viz. Bathua (*Chenopodium album* L.), Durba (*Cynodon dactylon*), Nut sedge (*Cyperus rotundus* L.), Biskatali (*Polygonum hydropiper* L.), Goose grass (*Eleusine indica*) etc. Weeding was done manually with 'nirani' as per treatment. Two hand weeding were done for each treatment; first weeding was done at 15 days after sowing followed by second weeding at 15 days after first weeding.

Thinning was done in all the unit plots with care to maintain a constant plant population on each row. Finally plants were kept at 5 cm distance in rows.

3.7.6 Irrigation

Irrigation was given in the respective plots to ensure puddle soil. First irrigation was given at 15 days after sowing (DAS) and the second irrigation was given at 50-55(DAS) following flood method in all the plots.

3.7.7 Application of pesticides

Crops were attacked by aphids (*Lipaphis erysimi*. K). It was controlled by spraying Malathion 57 EC at the rate of 2 ml/litre of water. The spraying was done in the afternoon while the pollinating bees were away from the field.

3.8 Harvesting and processing

The experimental crop was harvested at maturity when 80% of the siliquae turned straw yellowish in color. Harvesting was done in the morning to avoid shattering. Excluding the boarder lines plants were harvested from the center of each plot at ground level with the help of a sickle for grain and stover yield. Prior to harvesting, ten plants were sampled randomly from each plot, bundled separately, tagged and brought to a clean cemented threshing floor from which different yield parameters were recorded. The crop was sun dried properly by spreading them over floor and seeds were separated from the siliquae by beating the bundles with the help of bamboo sticks.

The seeds thus collected were dried in the sun for reducing the moisture in the seed to about 9% level. The stovers were also dried in the sun. Seed and stover yield were recorded. The biological yield was calculated as the sum of the seed yield and stover yield.

3.9 Sampling and data collection

Ten sample plants were selected at random from each plot. Plant height, number of branches per plant, number of siliquae per plant, siliqua length, number of seeds siliqua^{-1}, weight of thousand seeds and shelling percentage were recorded separately. From each plot the weight of the grain and straw were taken. Biological yield and the harvest index were calculated from these data.

The parameters studied in the experiment were as follows:

i. Plant height at 30, 45, 60 and 75 DAS and at harvest (cm).
ii. Plant dry weight at 30 and 45 DAS and 60 DAS.
iii. Number of leaves plant $^{-1}$
iv. Number of branches plant $^{-1}$
v. Number of siliquae plant $^{-1}$
vi. Length of siliqua
vii. No. of seeds siliqua^{-1}
viii. Weight of 1000 seeds
ix. Shelling percentage

x. Grain yield

xi. Stover yield

xii. Harvest index

xiii. Biological yield

3.10 Data collection procedure

i. Plant height

The height of randomly selected ten plants was measured from ground level (stem base) to the tip of the plant. Mean plant height was calculated and expressed in cm.

ii. Number of leaves plant^{-1}

Ten plants were collected randomly from each plot. Number of leaves plant^{-1} was counted from each plant sample and then averaged at 30, 45 and 60 days after sowing (DAS).

iii. Dry weight of plant

Ten plants were collected randomly from each plot leaving the harvest area and sampled plants at 30, 45 and 60 days after sowing (DAS). The sample plants were oven dried for 72 hours at 70°C and then dry weight plant^{-1} was determined.

iv. Number of branches plant^{-1}

The number of branches of ten randomly sampled plants were counted and recorded. Average value of ten plants was recorded as number of branches per plant.

v. Number of siliquae plant^{-1}

Siliqua of ten plants was counted and divided by ten which indicated the number of siliquae plant^{-1}.

vi. Length of siliqua

Length of ten siliquae collected randomly from sampled plants the mean length was recorded.

vii. Number of seeds siliqua^{-1}

The number of seeds was counted by splitting ten siliquae which were sampled from sample plants and then mean value was determined.

viii. Weight of 1000 seeds

Thousand seeds were randomly counted from the total seeds of each sample. Then the weight was taken by a digital balance. The 1000-seed weight was recorded in gram.

ix. Shelling percentage

The weight of 10 siliquae and the grains of 10 siliquae were taken from each treatment and the mean results were recorded. Shelling percentage was calculated by the following formulae:

$$\text{Shelling percentage (\%)} = \frac{\text{Weight of seeds (g)}}{\text{Weight of siliquae (g)}} \times 100$$

x. Grain yield

The mean grain weight was taken by threshing the plants of each sample area and then converted to kg ha^{-1} in dry weight basis.

xi. Stover yield

The stover weights were calculated after threshing and separation of grain from plant of sample area and then expressed in kg ha^{-1} on dry weight basis.

xii. Harvest index

The harvest index was calculated by the ratio of grain yield to biological yield and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Grainyield}}{\text{Biologicalyield}} \times 100$$

xiii. Biological Yield

Biological yield (sun dried) is the summation of seed yield and stover yield per hectare.

Biological yield = Grain yield + Stover yield

3.11 Statistical analysis

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Plant height at different days after sowing

4.1.1 Effect of planting techniques

No significant variation of plant height was found due to planting techniques of rapeseed-mustard (Appendix III and Table 1). Numerically higher plant height found in the conventional technique of planting and lower plant height was found in puddle soil.

The result was in contradiction with the findings of Khan *et al.* (2000) who reported that changes of planting technique significantly influenced the plant height.

Hossain *et al.* (2013) also disagreed with this finding who showed that sowing method had significant effect on plant height.

Table1. Effect of planting techniques on plant height at different growth duration of rapeseed-mustard

Treatments	Plant height (cm) at different DAS				
	30	45	60	75	At harvest
P_1	25.05	87.24	100.07	108.61	111.19
P_2	19.82	79.10	98.14	101.9	103.85
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV %	25.25	17.13	8.73	3.49	4.32

P_1= Conventional method, P_2 = Puddle soil, NS = Not Significant

4.1.2 Effect of varieties

Significant variation of plant height was found due to varietal differences (Appendix III and Table 2). The results revealed that at 30 DAS, the tallest plant (24.25 cm) was obtained from the BARI Sarisha-16 which was statistically similar with Improved Tori-7 and BARI Sarisha-15 and the shortest plant height (21.07 cm) was obtained from SAU SR-03 that similar to BARI Sarisha-13 (21.63 cm). At 45 DAS the tallest plant height (109.4 cm) was obtained from BARI Sarisha-16 and the shortest plant height (74.47 cm) was obtained from Improved Tori-7. At 60 DAS the tallest plant height (139.2 cm) was obtained from BARI Sarisha-16 and the shortest plant height (90.82 cm) was obtained from BARI Sarisha-15 which was statistically similar with BARI Sarisha-13. At 75 DAS the tallest plant height (147.7 cm) was obtained from BARI Sarisha-16 and the shortest plant height (85.30 cm) was obtained from Improved Tori-7 which was statistically similar with BARI Sarisha-13. At harvest the tallest plant height (150.4 cm) was obtained from BARI Sarisha-16 and the shortest plant height (87.80 cm) was obtained from Improved Tori-7, which was statistically similar with BARI Sarisha-13. Such variation at plant height among the varieties during their growth might be due to their varietal characteristics. Roy (2007) also found Improved Tori-7 as the shortest plant height. BARI (2002) reported that BARI sarisha-11 was taller (120-130 cm) than that of other varieties.

Ali and Rahman (1986) found significant variation on plant height of different varieties of rapeseed and mustard. Akhter (2005) also found similar result for plant height. Similar variation at plant height among rapeseed/mustard varieties was also reported by many scientists (Ahmed *et al.*, 1999; Zakaria and Jahan 1997; Hossain *et al.*, 1996; Mondal *et al.*, 1992 and Roy, 2007). Yeasmin (2013) disagreed with this finding. She founds that varietal effect was insignificant on plant height.

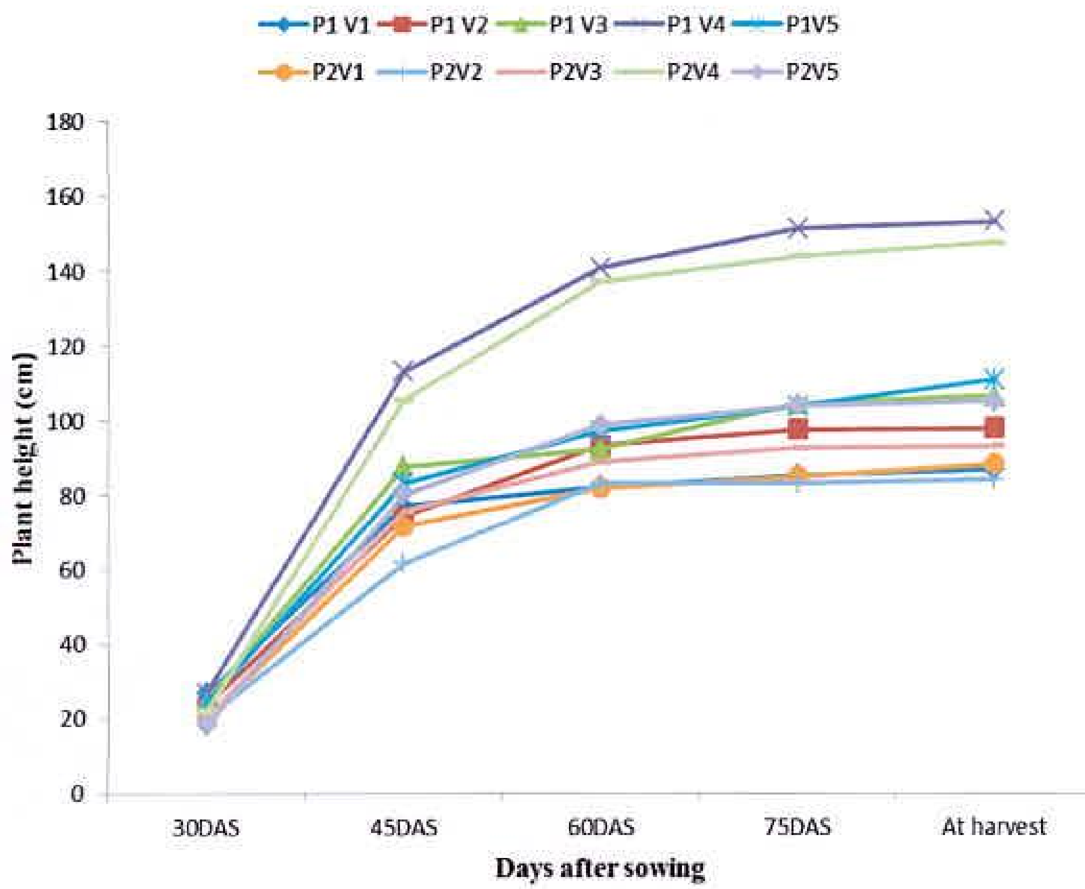
Table 2. Effect of varieties on plant height at different growth duration of rapeseed-mustard

Treatments	Plant height (cm) at different DAS				
	30	45	60	75	At harvest
V_1	23.00 ab	74.47 c	82.24 d	85.30 c	87.80 d
V_2	21.63 b	68.12 d	88.37 cd	90.46 c	91.14 cd
V_3	22.29 ab	81.90 b	90.82 c	98.70 b	100.0 bc
V_4	24.25 a	109.4 a	139.2 a	147.7 a	150.4 a
V_5	21.07 b	81.90 b	97.96 b	104.0 b	108.3 b
$LSD_{(0.05)}$	2.617	5.759	6.524	6.200	9.357
CV (%)	9.53	5.66	5.35	4.81	7.11

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

4.1.3 Interaction effect of planting techniques and varieties

There was a significant variations in plant height observed due to interaction among planting techniques and varieties at 30, 45, 60 and 75 DAS and at harvest (Appendix III and Figure 1). At 30 DAS, the longest plant height (26.67 cm) was obtained from conventional planting with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with Improved Tori-7 (26.49 cm), BARI Sarisha-13 (23.3 cm) and BARI Sarisha-15 (24.68 cm). The shortest plant height (18.01 cm) was obtained from seeds sowing on puddle soil with SAU SR-03 (24.68 cm) which was statistically similar with the interaction of seeds sowing on puddle soil with Improved Tori-7(19.51 cm), BARI Sarisha-13 (19.89 cm) and BARI Sarisha-15 (19.89 cm). At 45 DAS, the longest plant height (113.2cm) was obtained from conventional sowing interaction with BARI Sarisha-16 that similar to puddle soil sowing with BARI Sarisha-16 (105.7 cm). The shortest plant height (61.82 cm) was obtained from interaction of puddle soil sowing with BARI Sarisha-13. At 60 DAS, the longest plant height (140.9 cm) was obtained from conventional sowing with BARI Sarisha-16 which was at par with puddle soil sowing interact with BARI Sarisha-16 (137.4 cm). The shortest plant height (82.10 cm) was obtained from puddle soil sowing interact with Improved Tori-7 that similar to puddle soil sowing with BARI Sarisha-13 (83.27 cm) and conventional sowing with Improved Tori-7 (82.37 cm), which was statistically similar with puddle soil sowing with BARI Sarisha-15. At 75 DAS, the longest plant height (151.4 cm) was obtained from conventional sowing with BARI Sarisha-16 that similar to puddle soil sowing with BARI Sarisha-16 (144.1 cm). The shortest plant height (83.25 cm) was obtained from puddle soil sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with Improved Tori-7 (85.13 cm) and conventional sowing with Improved Tori-7 (85.47 cm).



P_1= Conventional method, P_2= Puddle soil, V_1 = Improved tori-7, V_2= BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4= BARI Sarisha-16 and V_5 = SAU SR-03.

Figure 1. Interaction effect of planting techniques and varieties on plant height at different growth duration of rapeseed-mustard ($LSD_{0.05}$ = 3.701, 8.144, 9.226, 8.769 and 13.23 at 30, 45, 60 and 75 DAS and at Harvest, respectively)

At harvest the longest plant height (153.2 cm) was obtained from conventional sowing with BARI Sarisha-16 that similar to puddle soil sowing with BARI Sarisha-16 (147.6 cm). The shortest plant height (84.29 cm) was obtained from puddle soil sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with Improved Tori-7 (88.63 cm) and conventional sowing with Improved Tori-7 (86.97 cm).

4.2 Number of leaves plant^{-1}

4.2.1 Effect of planting techniques

The number of leaves plant^{-1} was significantly influenced by the planting techniques at 45 DAS (Appendix IV and Table 3). At 45 DAS, the higher number of leaves plant^{-1} (28.59) was obtained from conventional method of planting. The lower number of leaves plant^{-1} (24.81) was obtained from puddle soil sowing.

Table 3. Effect of planting techniques on number of leaves plant^{-1} at different growth duration of rapeseed-mustard

Treatments	Number of leaves plant^{-1} at different DAS		
	30	45	60
P_1	7.20	28.59 a	29.71
P_2	6.41	24.81 b	26.92
$LSD_{(0.05)}$	NS	3.513	NS
CV (%)	8.21	8.375	12.78

P_1 = Conventional method, P_2 = Puddle soil, NS = Not Significant

No significant variation of number of leaves plant^{-1} was found due to planting technique of mustard at 30 DAS and 60 DAS.

4.2.2 Effect of varieties

The number of leaves plant^{-1} was significantly influenced by the varieties at 45 DAS and 60 DAS (Appendix IV and Table 4). At 45 DAS, the highest number of leaves plant^{-1} (32.97) was obtained from BARI Sarisha-15 which was statistically similar with SAU SR-03(32.00) and Improved Tori-7 (28.73). The lowest number of leaves plant^{-1} (16.63) was obtained from BARI Sarisha-13. At 60 DAS, the highest number of leaves plant^{-1} (32.27) was obtained from SAU SR-03 which was statistically similar with all other treatments except BARI Sarisha-13 that showed the lowest number of leaves plant^{-1} (18.37).

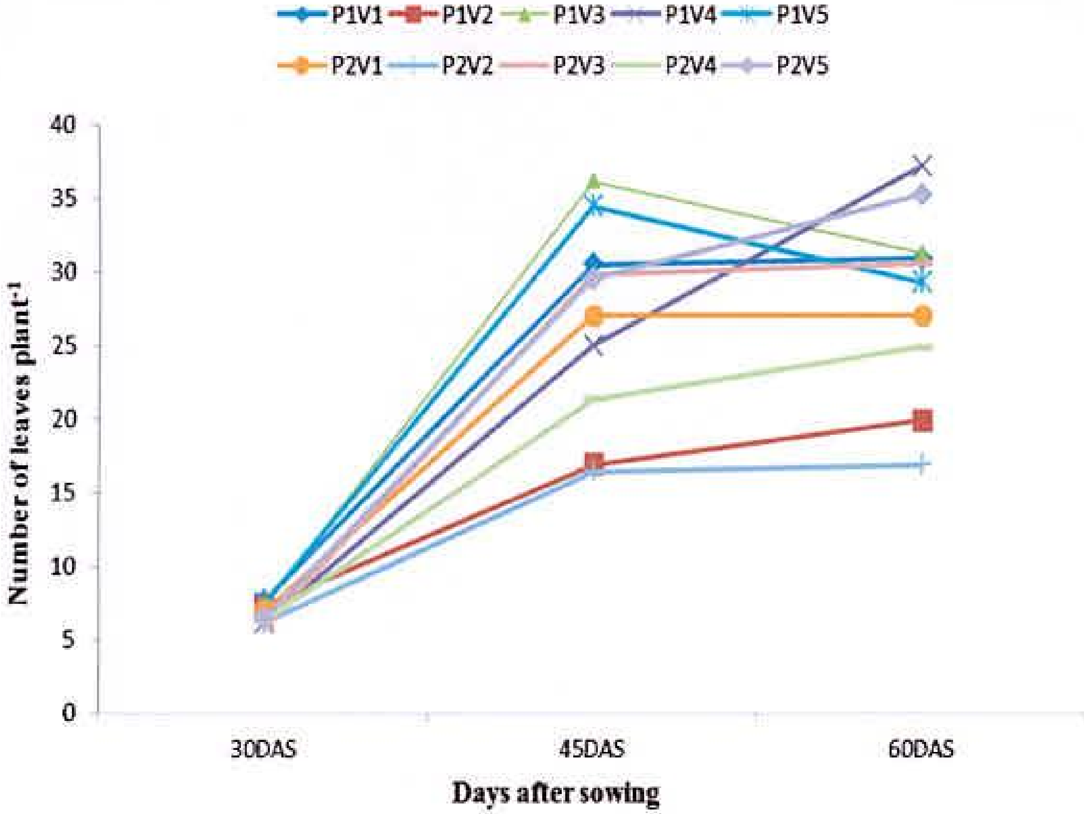
Table 4. Effect of varieties on number of leaves plant^{-1} at different growth duration of rapeseed-mustard

Treatments	No. of leaves plant^{-1} at different DAS		
	30	45	60
V_1	7.33	28.73 ab	28.97 a
V_2	6.77	16.63 c	18.37 b
V_3	6.63	32.97 a	30.93 a
V_4	6.32	23.17 b	31.03 a
V_5	6.97	32.00 a	32.27 a
$LSD_{(0.05)}$	NS	5.943	3.508
CV (%)	12.44	18.19	10.12

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03, NS = Not significant

4.2.3 Interaction effect planting techniques of and varieties

There was a significant variation in number of leaves plant^{-1} observed due to interaction among planting techniques and varieties at different days after sowing (Appendix IV and Figure 2). At 30 DAS, the highest number of leaves plant^{-1} (7.67) was obtained from conventional sowing with Improved Tori-7 which was statistically similar with the interaction of conventional sowing with



P_1= Conventional method, P_2= Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 2. Interaction effect of planting techniques and varieties on no of leaves plant^{-1} at different growth duration of rapeseed-mustard ($LSD_{0.05}$ =1.465, 8.405 and 4.961 at 30, 45 and 60 DAS respectively)

BARI Sarisha-13, BARI Sarisha-15 and SAU SR-03 as well as with the interaction of puddle soil sowing with Improved Tori-7, BARI Sarisha-16 and SAU SR-03. The lowest number of leaves plant^{-1} (5.93) was obtained from the interaction of puddle soil sowing with BARI Sarisha-15. At 45 DAS, the highest number of leaves plant^{-1} (36.13) was obtained from conventional sowing with BARI Sarisha-15 which was statistically similar with the interaction of conventional sowing with Improved Tori-7 and SAU SR-02 and was also statistically similar with the interaction of puddle soil sowing with

BARI Sarisha-15 and SAU SR-03. The lowest no. of leaves plant^{-1} (16.40) was obtained from puddle soil sowing with BARI Sarisha-13.

At 60 DAS, the highest number of leaves plant^{-1} (37.20) was obtained from conventional sowing with BARI Sarisha-16 and which was statistically similar with the interaction of puddle soil sowing with SAU Sarisha-2. The lowest number of leaves plant^{-1} (24.87) was obtained from puddle soil sowing with BARI Sarisha-16 which was statistically similar with the interaction of puddle soil sowing with Improved Tori-7 (27.00) and also similar to conventional with SAU SR-03 (29.27).

4.3 Plant dry weight

4.3.1 Effect of planting techniques

Table 5. Effect of planting techniques on plant dry weight at different growth duration of rapeseed-mustard

Treatments	Plant dry weight (g) at different DAS		
	30	45	60
P_1	4.53 a	20.54	47.15
P_2	3.19 b	16.71	37.25
$LSD_{(0.05)}$	2.162	NS	NS
CV (%)	35.67	38.39	37.37

P_1 = Conventional method, P_2 = Puddle soil, NS = Not Significant

The plant dry weight was significantly influenced by the planting techniques at 30 DAS (Appendix V and Table 5) where the higher plant dry weight (4.53 g) was obtained from conventional method of planting. The lower dry weight (3.19 g) was obtained from seeds sowing in puddle soil condition.

4.3.2 Effect of varieties

The plant dry weight was significantly influenced by the varieties at different days after sowing (Appendix V and Table 6). At 30 DAS, the highest plant dry weight (4.86 g) was obtained from BARI Sarisha-16 and which was statistically similar with Improved Tori-7 and BARI Sarisha-13. The lowest plant dry weight (3.51 g) was obtained from SAU Sarisha-2 that similar to BARI Sarisha-15 (3.31 g). At 45 DAS, the highest plant dry weight (27.09 g) was obtained from BARI Sarisha-16.

Table 6. Effect of varieties on plant dry weight at different growth duration of rapeseed-mustard

Treatments	Plant dry weight (g) at different DAS		
	30	45	60
V_1	3.80 ab	17.80 bc	45.29 ab
V_2	3.81 ab	14.43 c	38.44 b
V_3	3.31 b	13.36 c	31.89 b
V_4	4.86 a	27.09 a	58.05 a
V_5	3.51 b	20.45 b	37.31 b
$LSD_{(0.05)}$	1.074	4.829	14.260
CV (%)	22.75	21.18	27.61

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

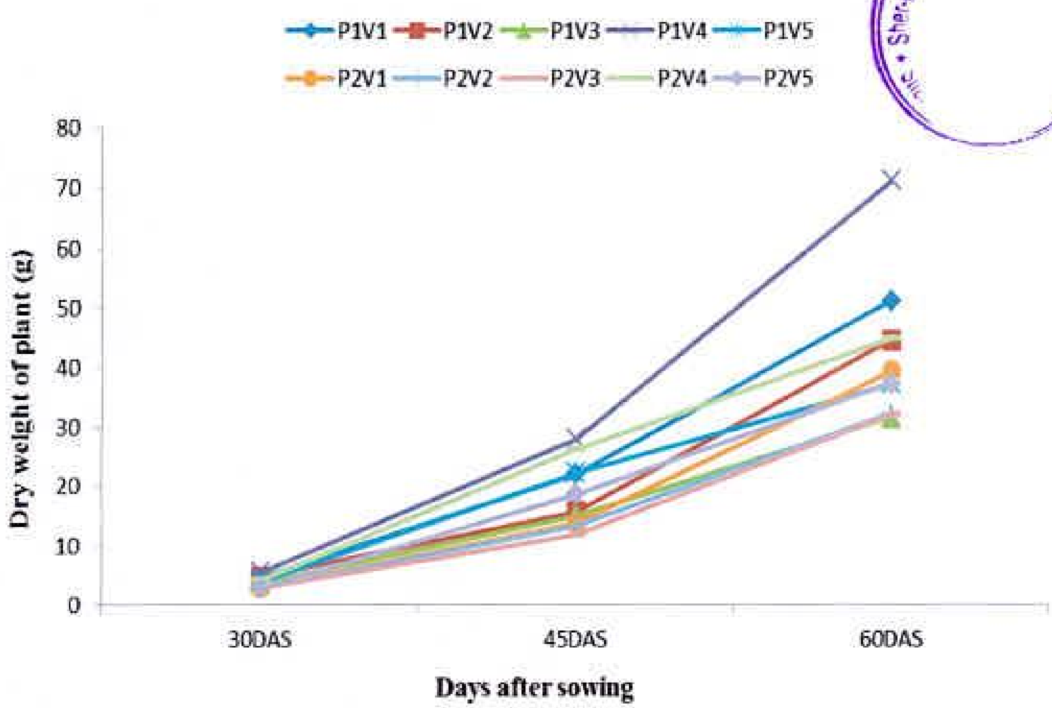
The lowest plant dry weight (13.36 g) was obtained from BARI Sarisha-15 which was statistically similar with BARI Sarisha-13 (14.43 g) and Improved Tori-7 (17.80 g). At 60 DAS, the highest plant dry weight (58.05 g) was obtained from BARI Sarisha-16 and which was statistically similar with Improved Tori-7 (45.29g) and the lowest plant dry weight (31.89 g) which was statistically similar with Improved Tori-7 (45.29 g), BARI Sarisha-13 (38.44 g) and SAU SR-03 (37.51 g).

This result was similar with the findings of Roy (2007) who pointed out that lowest dry weight in Improved Tori-7.

4.3.3 Interaction effect of planting techniques and varieties

There was a significant variation in plant dry weight was observed due to interaction among planting techniques and varieties at different days after sowing (Appendix V and Figure 3).

At 30 DAS, the highest plant dry weight (5.50 g) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with BARI Sarisha-13 (4.74 g), Improved Tori-7 (4.58 g) and SAU SR-03 (4.02 g); puddle soil sowing with BARI Sarisha-16 (4.23 g). The lowest plant dry weight (2.83 g) was obtained from puddle soil sowing with BARI Sarisha-15.



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 3. Interaction effect of planting techniques and varieties on dry weight of plant at different growth duration of rapeseed-mustard ($LSD_{0.05}$ = 1.519, 6.829 and 20.160 at 30, 45 and 60 DAS respectively)

At 45 DAS, the highest plant dry weight (27.92 g) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of puddle soil sowing BARI Sarisha-16 (26.26 g), conventional sowing with Improved Tori-7 (22.00 g) and SAU SR-03 (22.26 g). The lowest plant dry weight (11.81 g) was obtained from puddle soil sowing with BARI Sarisha-15 that was similar to puddle soil sowing with BARI Sarisha-13 (13.25 g) and was obtained from puddle soil sowing with Improved Tori-7 (13.60 g). At 60 DAS, the highest plant dry weight (71.19 g) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with Improved Tori-7 (51.16 g). The lowest plant dry weight (31.60 g) was obtained from conventional sowing with BARI Sarisha-15.

4.4 Number of branches plant^{-1}

Number of branches plant^{-1} is the result of genetic make up of the crop and environmental condition which plays a remarkable role towards the final seed yield of the crop (Sana *et al.*, 2003).

4.4.1 Effect of planting techniques

No significant variation of number of branches plant^{-1} was found due to planting techniques of mustard (Appendix VI and Table 7). Numerically higher number of branches per plant at 45, 60, 75 DAS and at harvest was observed in the conventional planting technique and the lower number of branches plant^{-1} was obtained from the puddle soil sowing.

Sarkees (2013) agreed with this finding who reported no significant differences among sowing methods for number of branches of plant.

But the result was in contradiction with the findings of Hossain *et al.* (2013) who reported that sowing method had significant effect on the production of total branches plant^{-1}.

Table 7. Effect of planting techniques on number of branches plant^{-1} at different growth duration of rapeseed-mustard

Treatments	No. of branches plant^{-1} at different DAS			
	45	60	75	At harvest
P1	5.47	4.40	5.17	4.31
P2	4.52	4.13	4.92	4.30
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	21.65	30.85	17.74	18.88

P_1= Conventional method, P_2 = Puddle soil, NS = Not Significant

4.4.2 Effect of varieties

The number of branches plant^{-1} was significantly influenced by different varieties at 45, 60, 75 DAS and at harvest (Appendix VI and Table 8).

At 45 DAS, the highest number of branches plant^{-1} (6.40) was obtained from BARI Sarisha-15, which was statistically similar with SAU SR-03 (6.17) and the lowest number of branches plant^{-1} (3.83) was obtained from BARI Sarisha-13, which was statistically similar with BARI Sarisha-16 (3.90) and Improved Tori-7 (4.67). At 60 DAS the highest number of branches plant^{-1} (4.73) was obtained from BARI Sarisha-15, which was statistically similar with BARI Sarisha-16 (4.50), SAU SR-03(4.43) and Improved Tori-7 (4.30). The lowest number of branches plant^{-1} (3.37) was obtained from BARI Sarisha-13, which was statistically similar with Improved Tori-7 (4.30), SAU SR-03 (4.43) and BARI Sarisha-16 (4.50). At 75 DAS, the highest number of branches plant^{-1} (5.63) was obtained from BARI Sarisha-15, which was statistically similar with SAU SR-03 (5.63) and Improved Tori-7 (5.23). The lowest number of branches plant^{-1} (4.32) was obtained from BARI Sarisha-16, which was statistically similar with BARI Sarisha-13 (4.40).

At harvest the highest number of branches plant^{-1} (5.20) was obtained from SAU SR-03, which was statistically similar with BARI Sarisha-15 (4.80) and BARI Sarisha-16 (4.47) and the lowest number of branches plant^{-1} (2.92) was obtained from the variety BARI Sarisha-13.

Jahan and Zakaria (1997) reported that the local varieties, Tori and Sampad produced the highest number of primary branches plant^{-1} (4.07), which was disagreed with this finding. The minimum number of primary branches plant^{-1} of 2.90 was found in Jatarai which was identical to BARI Sarisha-8. Similar report was also found by Hossain *et al.* (1996). The above findings were not in conformity with the result of this finding. But it is partially conform that the variety affect significantly on the number of branches plant^{-1}. Roy (2007) and Akhter (2005) also in conformity with this findings. .

Table 8. Effect of varieties on number of branches plant^{-1} at different growth duration of rapeseed-mustard

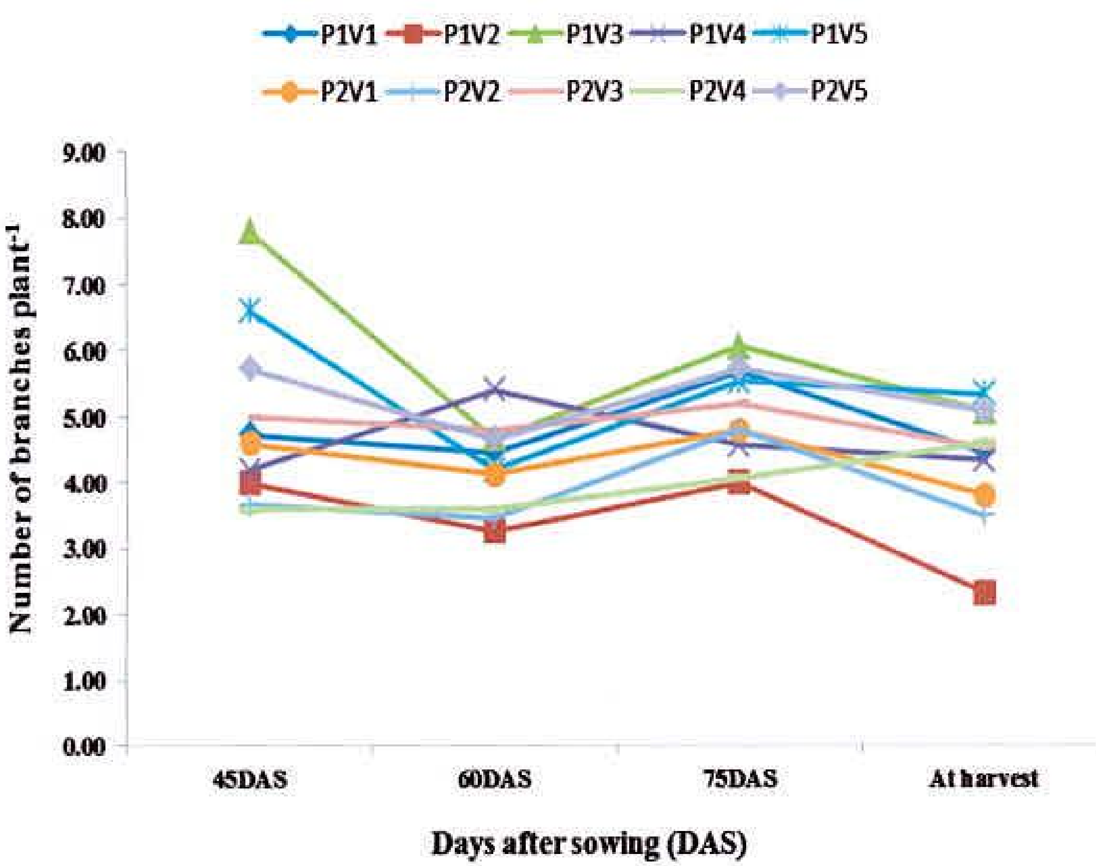
Treatments	No. of branches plant^{-1} at different DAS			
	45	60	75	At harvest
V1	4.67 b	4.30 ab	5.23 a	4.13 b
V2	3.83 b	3.37 b	4.40 b	2.92 c
V3	6.40 a	4.73 a	5.63 a	4.80 ab
V4	3.90 b	4.50 ab	4.32 b	4.47 ab
V5	6.17 a	4.43 ab	5.63 a	5.20 a
$LSD_{(0.05)}$	1.097	1.251	0.792	1.030
CV (%)	17.94	23.94	12.83	19.56

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

4.4.3 Interaction effect of planting techniques and varieties

There was a significant variation in number of branches plant^{-1} was observed due to interaction among planting techniques and varieties at different days after sowing (Appendix VI and Figure 4). At 45 DAS, the highest number of branches plant^{-1} (7.80) was obtained from conventional sowing with BARI Sarisha-15, which was statistically similar with the interaction of conventional sowing and SAU SR-03 (6.60). The lowest number of branches plant^{-1} (3.60) was obtained from puddle soil sowing with BARI Sarisha-16, which was statistically similar with puddle soil sowing with BARI Sarisha-13 (3.67) and conventional sowing with Improved Tori-7 (4.00)

At 60 DAS, the highest number of branches plant^{-1} (5.40) was obtained from conventional sowing with BARI Sarisha-16, which was statistically similar with puddle soil sowing with BARI Sarisha-15 (4.80) and with the interaction of conventional sowing with BARI Sarisha-15 (4.67) and with Improved Tori-7 (4.47) and the lowest number of branches plant^{-1} (3.27) was obtained from conventional sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-16 (3.60).



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2= BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 4. Interaction effect of planting techniques and varieties on no. of branches plant^{-1} at different growth duration of rapeseed-mustard ($LSD_{0.05}$ = 1.551, 1.769, 1.120 and1.456 at 45, 60, 75 DAS and at harvest respectively)

At 75 DAS, the highest number of branches plant^{-1} (6.07) was obtained from conventional sowing with BARI Sarisha-15, which was statistically similar with SAU SR-03 (5.53) and with the interaction of puddle soil sowing with SAU SR-03 (5.73), BARI Sarisha-15 (5.20) and the lowest number of branches plant^{-1} (4.00) was obtained from conventional sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-16 (4.07). At harvest the highest number of branches plant^{-1} (5.33) was obtained from conventional sowing with SAU SR-03, which was statistically similar with the interaction of conventional sowing with BARI Sarisha-15 (5.07), Improved Tori-7 (4.47), BARI Sarisha-16 and also with the interaction of puddle soil sowing with SAU SR-03 (5.07), BARI Sarisha-15 (4.53), BARI Sarisha-16 (4.60) and the lowest number of branches per plant (2.33) was obtained from conventional sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-13 (3.50).

4.5 Number of siliquae plant^{-1}

Number of siliquae plant^{-1} is the result of genetic make up of the crop and environmental conditions (Sana *et al.*, 2003). It is an important yield contributing character which has a great effect on final yield.

4.5.1 Effect of planting techniques

No significant variation of number of siliquae plant^{-1} was found due to planting techniques of mustard (Appendix VII and Table 9). Numerically higher number of siliquae plant^{-1} at 60, 75 DAS and at harvest was observed in the conventional planting technique and the lower number of siliquae plant^{-1} was obtained from puddle soil sowing.

Hossain *et al.* (2013); Sarkees (2013) and Nigussie *et al.*, (1996) disagreed with this finding. They reported that sowing method had significant effect on the production of total siliquae plant^{-1}.

Table 9. Effect of planting techniques on number of siliquae plant^{-1} at different growth duration of rapeseed-mustard

Treatments	Siliquae number plant^{-1} at different DAS		
	60	75	At harvest
P_1	82.95	103.54	118.11
P_2	75.48	87.68	109.52
$LSD_{(0.05)}$	NS	NS	NS
CV (%)	55.96	26.47	20.80

P_1= Conventional method, P_2 = Puddle soil, NS = Not Significant

4.5.2 Effect of varieties

The number of siliquae plant^{-1} was significantly influenced by different varieties at 60, 75 DAS and at harvest (Appendix VII and Table 10). This was due to the variation in genetic makeup of different varieties affecting number of siliquae plant^{-1}. At 60 DAS, the highest number of siliquae plant^{-1} (104.7) was obtained from BARI Sarisha-16, which was statistically similar with Improved Tori-7 (101.3) and SAU SR-03 (77.93) and the lowest number of siliquae per plant (49.50) was obtained from BARI Sarisha-15, which was statistically similar with BARI Sarisha-13 (62.63). At 75 DAS, the highest number of siliquae plant^{-1} (118.2) was obtained from BARI Sarisha-16, which was statistically similar with Improved Tori-7 (107.2) and SAU SR-03 (108.3) and the lowest number of siliquae plant^{-1} (71.50) was obtained from BARI Sarisha-15, which was statistically similar with BARI Sarisha-13 (72.80).

At harvest the highest number of siliquae plant^{-1} (143.7) was obtained from BARI Sarisha-16, which was statistically similar with SAU SR-03(134.1) and Improved Tori-7(116.9) and the lowest number of siliquae plant^{-1} (83.95) was obtained from BARI Sarisha-15, which was statistically similar with BARI Sarisha-13 (90.43).

Akhter (2005), Roy (2008) and Mamun *et al.* (2014) were agreed with the result of this finding that the number of siliquae plant^{-1} of rapeseed mustard was significantly affected by the varieties. Shamsuddin and Rahman (1977) reported that the number of siliquae plant^{-1} was significantly varied for rapeseed and mustard varieties and the highest number of siliquae was found from mustard varieties. Mondal *et al.* (1992) found the maximum number of siliquae plant^{-1} (136) 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. Similar result was also found by Hossain *et al.* (1996).

Table 10. Effect of varieties on number of siliqua plant^{-1} at different growth duration of rapeseed-mustard

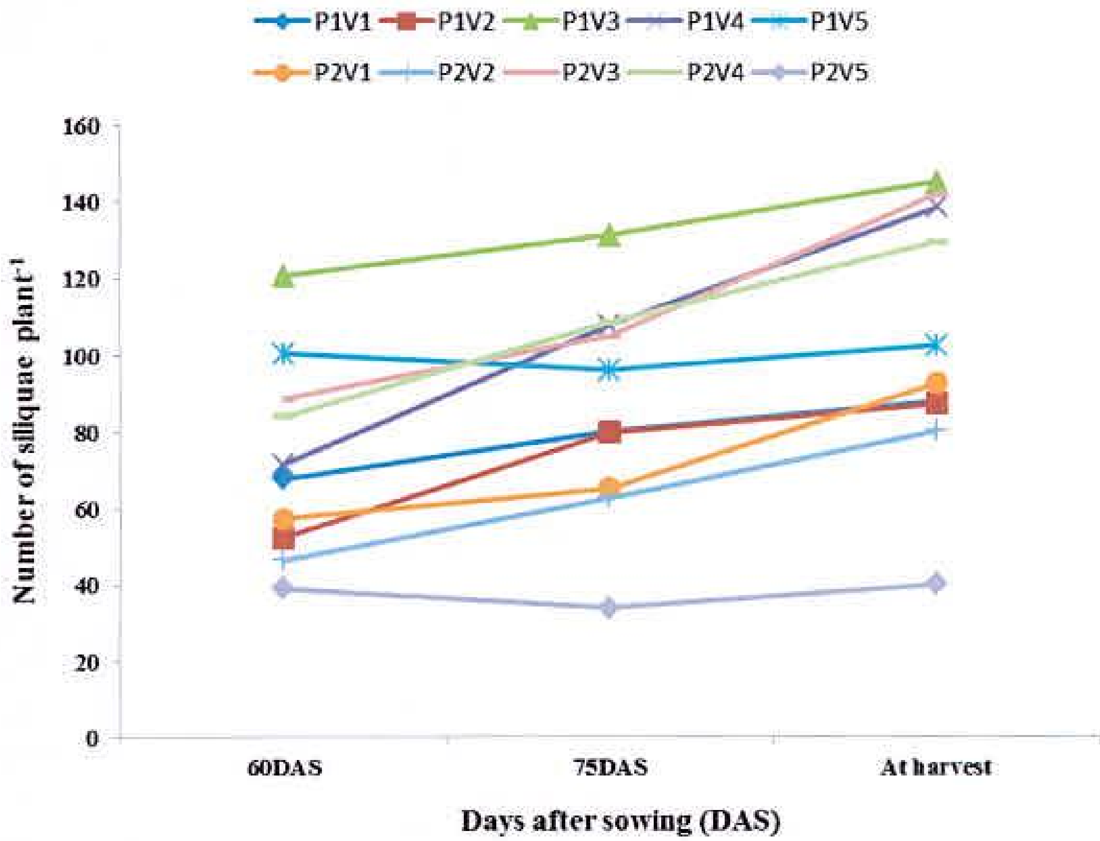
Treatments	Number of siliquae plant^{-1} at different DAS		
	60	75	At harvest
V_1	101.3 a	107.2 a	116.9 ab
V_2	62.63 bc	72.80 b	90.43 bc
V_3	49.50 c	71.50 b	83.95 c
V_4	104.7 a	118.2 a	143.7 a
V_5	77.93 ab	108.3 a	134.1 a
$LSD_{(0.05)}$	27.69	24.09	28.43
CV (%)	28.56%	20.59%	20.41%

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

4.5.3 Interaction effect of planting techniques and varieties

There was a significant variation in number of siliquae plant^{-1} observed due to the interaction among planting techniques and varieties at different growth duration (Appendix VII and Figure 5).

At 60 DAS, the highest number of siliquae plant^{-1} (120.7) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with Improved Tori-7 (102.1) and the lowest number of siliquae plant^{-1} (46.53) was obtained from puddle soil with BARI Sarisha-15 which was statistically similar with the interaction of conventional sowing with BARI Sarisha-15 (52.47) and puddle soil sowing with BARI Sarisha-13 (57.38). At 75 DAS, the highest number of siliquae plant^{-1} (131.3) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with Improved Tori-7 (118.3) and the lowest number of siliquae plant^{-1} (62.93) was obtained from puddle soil sowing with BARI Sarisha-15 which was statistically similar with the interaction of conventional sowing with BARI Sarisha-15 (80.07) and puddle soil sowing with BARI Sarisha-13 (65.47).



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 5. Interaction effect of planting techniques and varieties on number of siliquae plant^{-1} at different growth duration of rapeseed-mustard ($LSD_{0.05}$ = 39.16, 34.07 and 40.21 at 30, 45 and 60 DAS respectively)

At harvest, the highest number of siliquae plant^{-1} (145.2) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-16 (142.1) and the lowest number of siliquae plant^{-1} (80.43) was obtained from puddle soil sowing with BARI Sarisha-15 which was statistically similar with the interaction of conventional sowing with BARI Sarisha-15 (87.47) and puddle soil sowing with BARI Sarisha-13 (92.87).

4.6 Length of siliqua

4.6.1 Effect of planting techniques

Planting techniques of rapeseed-mustard was affected significantly on the length of siliqua (Appendix VIII and Table 11). The maximum length of siliqua (5.51 cm) was observed in the conventional planting technique and the lowest length of siliqua (5.14 cm) was obtained from the puddle soil sowing. Hossain *et al.* (2013) disagreed with this finding. They pointed out that Siliqua length was not significantly influenced by sowing method.

4.6.2 Effect of varieties

Variety affected significantly on the length of siliqua (Appendix VIII and Table 12). The highest length of siliqua (7.19cm) was obtained from BARI Sarisha-13 and the lowest length of siliqua (4.42 cm) was obtained from BARI Sarisha-16, which was statistically similar with Improved Tori-7 (4.93 cm) and SAU SR-03 (4.83 cm).

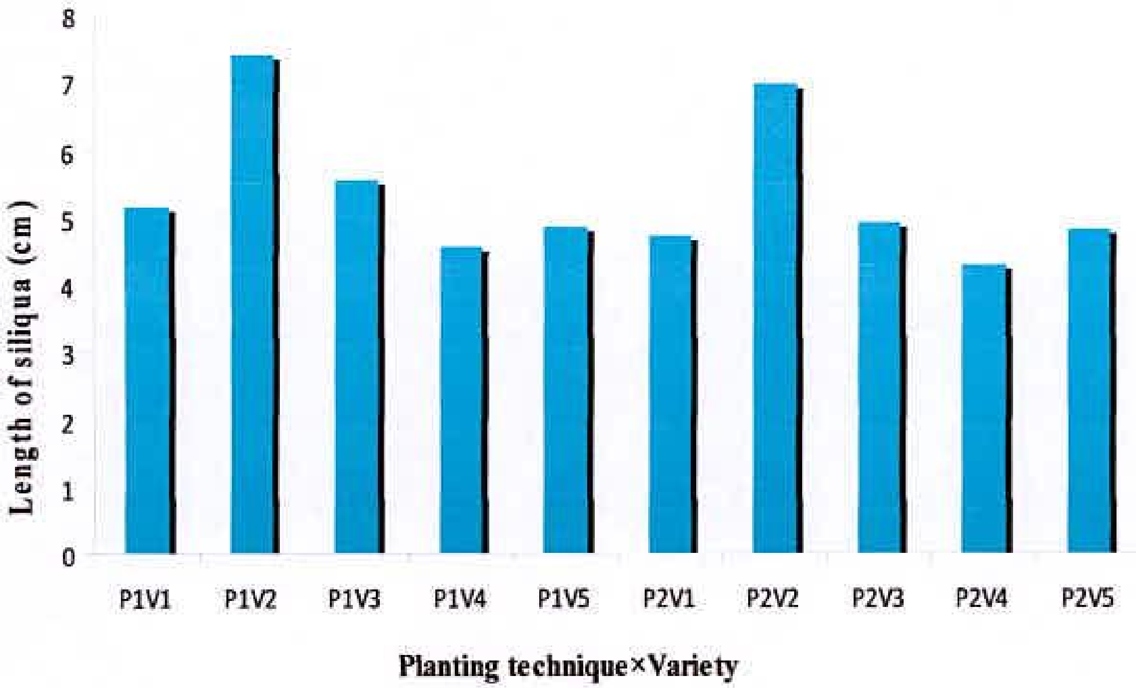
This result was in conformity to the finding of Akhter (2005) who pointed out that variations in siliqua length (cm) among the varieties were statistically significant. Hossain *et al.* (1996) also reported that the varieties differed significantly in respect of siliqua length. It has been also reported that the *napus* group showed higher siliqua length than that of *juncea* group (BARI, 2001).

But the result was in contradiction with Yeasmin (2013) who observed that varietal effect was insignificant on length of siliqua. The finding was in conformity with those of Jahan and Zakaria (1997), Gangasaran *et al.* (1981)

and Hossain *et al.* (1996) who observed a significant variation in siliqua length among the different varieties of mustard.

4.6.3 Interaction effect of planting techniques and varieties

Siliqua length was significantly influenced by interaction among planting techniques and varieties (Appendix VIII and Figure 6).



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2= BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 6. Interaction effect of techniques and varieties on length of siliqua plant^{-1} at harvesting of rapeseed-mustard ($LSD_{0.05}$ = 0.748)

The highest Siliqua length (7.41 cm) was obtained from conventional sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-13 (6.97 cm) and the lowest number of siliqua length (4.29 cm) was produced by the interaction of puddle soil sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with BARI Sarisha-16 (4.55 cm), SAU SR-03 (4.85 cm) and also with interaction of puddle soil sowing with BARI Sarisha-15 (4.91 cm) and SAU SR-03 (4.82 cm).

4.7 Number of seeds siliqua^{-1}

Number of seeds siliqua^{-1} is also an important factor which contributes towards seed yield.

4.7.1 Effect of planting techniques

Table 11. Yield attributes and shelling percentage of rapeseed-mustard as affected by planting techniques

Treatments	Seeds siliqua^{-1} (No.)	Length of siliqua (cm)	1000 seed weight (g)	Shelling percentage (%)
P_1	17.99	5.51 a	3.79	26.88
P_2	18.34	5.14 b	3.45	37.77
$LSD_{(0.05)}$	NS	0.142	NS	NS
CV (%)	9.56	1.70	8.15	43.76

P_1= Conventional method, P_2 = Puddle soil, NS = Not Significant

No significant variation of number of seed siliqua^{-1}was found due to planting techniques of mustard (Appendix VIII and Table 11). Numerically higher number of seeds siliqua^{-1} (18.34) was observed from puddle soil sowing and the lower number of seeds siliqua^{-1} (17.99) was obtained from the conventional sowing.

Sarkees (2013) found conformity with this finding who reported that no significant variation was found due to sowing method for number of seeds siliqua^{-1}. But the result was in contradiction with the findings of Hossain *et al.* (2013) who reported that changes of planting technique significantly influenced the number of seeds siliqua^{-1}. The result was also in contradiction with the findings of Khan *et al.* (2000) who reported that changes of planting technique significantly influenced the number of seeds siliqua^{-1}.

4.7.2 Effect of varieties

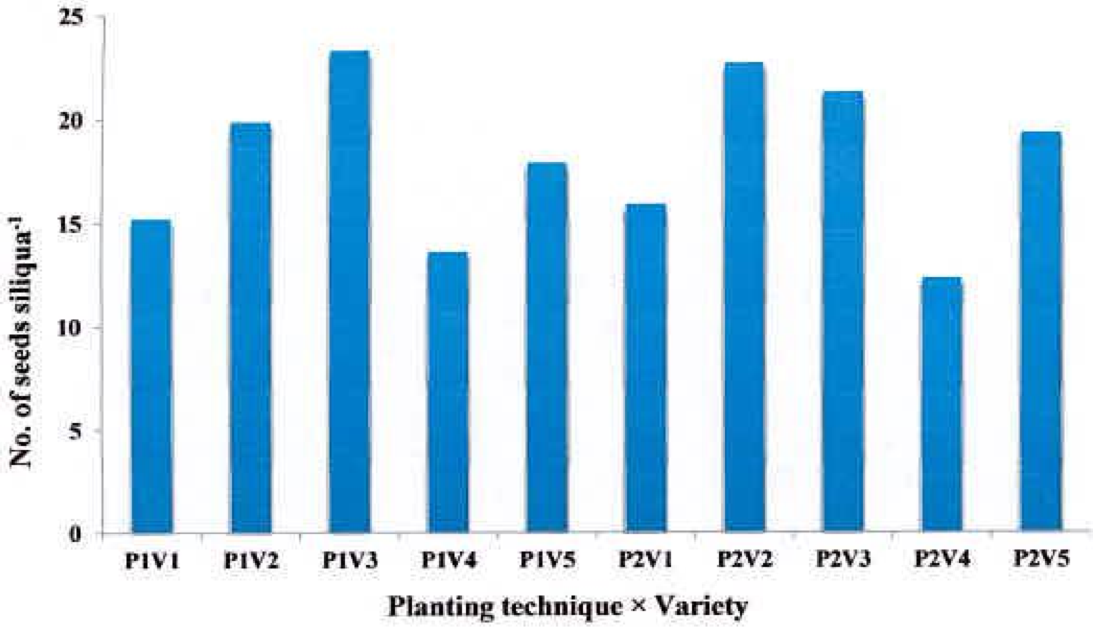
The number of seeds siliqua^{-1} was significantly influenced by the variety (Appendix VIII and Table 12). The highest number of seeds siliqua^{-1} (22.34) was produced by the variety BARI Sarisha-15 that similar with the variety BARI Sarisha-13 (21.32). The lowest number of seeds siliqua^{-1} (12.95) was observed in the variety BARI Sarisha-16, which was statistically similar with Improved Tori-7 (15.55).

Variation in seeds siliqua^{-1} among the varieties was in conformity with Mamun *et al.* (2014), who found the highest seeds siliqua^{-1} in BARI Sarisha-13 and the lowest seeds siliqua^{-1} in BARI Sarisha-16 and this result supports the findings of Jahan and Zakaria (1997) and Gurjar and Chauhan (1997). Variation in seeds siliqua^{-1} among the varieties was also in conformity with Islam *et al.* (1994) who found a significant variation in number of seeds siliqua^{-1} among different varieties of mustard and rapeseed.

But the result was in contradiction with Roy (2007) who found the highest seeds siliqua^{-1} in Improved Tori-7 and lowest number of seeds siliqua^{-1} in SAU Sarisha-1.

4.7.3 Interaction effect of planting techniques and varieties

There was a significant variation in number of seeds siliqua^{-1} observed due to interaction among planting techniques and varieties (Appendix VIII and Figure 7).



P_1= Conventional method, P_2= Puddle soil, V_1= Improved tori-7, V_2= BARI Sarisha-13, V_3= BARI Sarisha-15, V_4= BARI Sarisha-16 and V_5 = SAU SR-03

Figure 7. Interaction effect of planting techniques and varieties on number of seeds siliqua^{-1}at harvesting of rapeseed-mustard ($LSD_{0.05}$= 4.233)

The highest number of seeds siliqua^{-1} (23.32) was obtained from conventional sowing with BARI Sarisha-15, which was statistically similar with the interaction of conventional sowing with BARI Sarisha-13 (19.88) and with the interaction of puddle soil sowing with BARI Sarisha-13 (22.75), BARI Sarisha-15 (21.37) and SAU SR-03 (19.40) and the lowest number of seeds siliqua^{-1} (12.30) was found in the interaction of puddle soil sowing with BARI Sarisha-16, which was statistically similar with the interaction of conventional sowing with BARI Sarisha-15 (13.60) and also with the interaction of puddle soil sowing with Improved Tori-7 (15.91).

4.8 1000-seed weight

The weight of seed is related with the magnitude of seed development as an important yield determinant and plays a decisive role on expression of yield potential of a variety (Sana *et al.*, 2003).

The weight of the seed expresses the magnitude of seed development which is an important yield determinant and plays a decisive role in showing off the yield potential of a crop (Mamun *et al.*, 2014).

4.8.1 Effect of planting techniques

No significant variation on to the weight of thousand seeds was found due to planting techniques of mustard (Appendix VIII and Table 11). Numerically the conventional planting technique produced the higher weight of thousand seeds (3.79 g) and the lower number (3.45 g) of weight of seeds obtained from the puddle soil sowing.

This result is in conformity with the findings of Hossain *et al.* (2013). They also reported that 1000 seed weight did not show any significant variation due to sowing method. The result was also in contradiction with the findings of Khan *et al.* (2000) who reported that changes of planting technique significantly influenced the 1000 seed weight of canola.

4.8.2 Effect of varieties

Variety significantly affected by the 1000-seed weight (Appendix VIII and Table 12). BARI Sarisha-13 produced the highest 1000-seed weight (4.07 g) which was statistically similar with BARI Sarisha-16 (4.07 g) and the lowest 1000-seed weight was produced by Improved Tori-7 (3.07 g) and BARI Sarisha-15 (3.21 g).

The result of this finding was in conformity with Mamun *et al.* (2014). They also observed that BARI Sarisha-13 had the highest 1000 seed weight (4.00 g) whereas the lowest (2.82 g) was found in SAU Sarisha-3.

The 1000-seed weight is the stable part of yield and it varies from variety to variety which was supported by Mondal and Wahab (2001). Researcher suggested that weight of 1000 seeds varies from variety to variety and from species to species (Roy, 2007; Mondal and Wahhab, 2001; Karim *et al.*, 2000 and Hossain *et al.*, 1998)

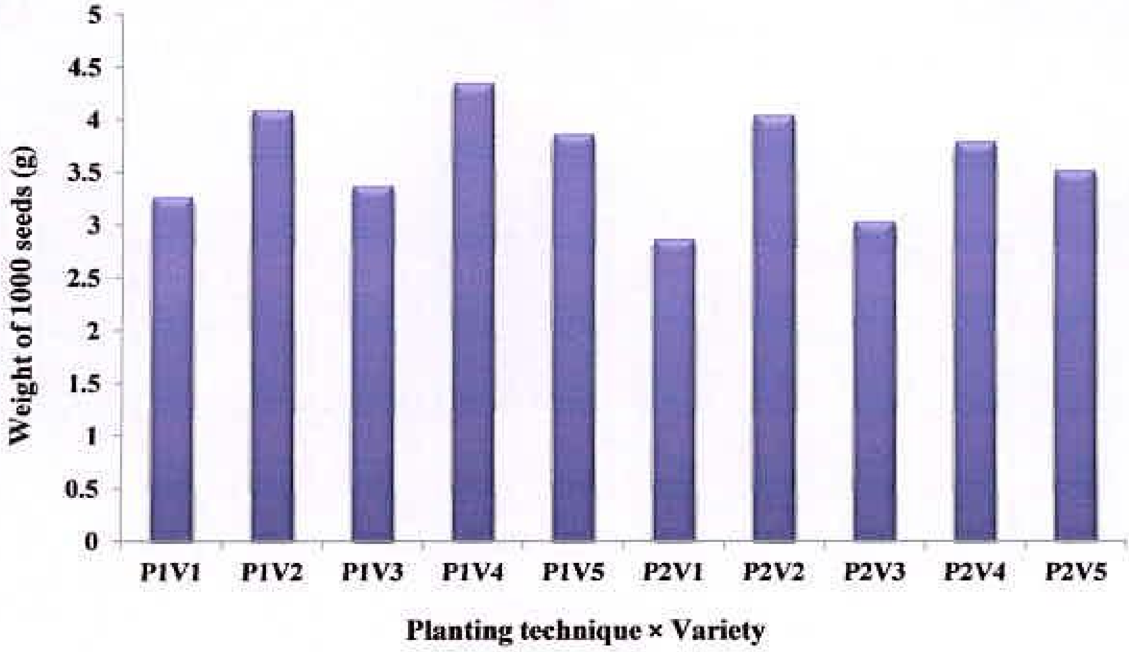
Table 12. Yield attributes and shelling percentage of rapeseed-mustard as affected by different varieties

Treatments	Seeds siliqua^{-1} (No	Length of siliqua (cm)	1000 seed weight (g)	Shelling percentage (%)
V_1	15.55 c	4.94 bc	3.07 c	54.79 a
V_2	21.32 ab	7.19 a	4.07 a	44.04 ab
V_3	22.34 a	5.24 b	3.21 c	30.22 bc
V_4	12.95 c	4.42 c	4.07 a	17.15 c
V_5	18.67 b	4.83 bc	3.69 b	15.41 c
$LSD_{(0.05)}$	2.993	0.529	0.297	15.1
CV (%)	13.46	8.12	6.70	38.16

V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

4.8.3 Interaction effect of planting techniques and varieties

1000-seed weight was significantly influenced by interaction among planting techniques and varieties (Appendix VIII and Figure 8). The highest 1000-seed weight (4.35g) was obtained from conventional sowing with BARI Sarisha-16, which was statistically similar with the interaction of conventional sowing with BARI Sarisha-13 (4.09 g) and puddle soil sowing with BARI Sarisha-13 (4.05 g). The lowest number of 1000-seed weight (2.87 g) was produced by the interaction of puddle soil sowing with Improved Tori-7 which was statistically similar with the interaction of conventional sowing with improved Tori-7 (3.27 g).



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 8. Interaction effect of planting techniques and varieties on weight of 1000 seeds per at harvesting of rapeseed-mustard ($LSD_{0.05}$=0.066)

4.9 Shelling percentage

4.9.1 Effect of planting techniques

No significant variation to the shelling percentage was found due to planting techniques of rapeseed and mustard (Appendix VIII and Table 11). Numerically the puddle soil sowing produced the higher shelling percentage (37.77) and the lower shelling percentage (26.88) was observed in conventional sowing.

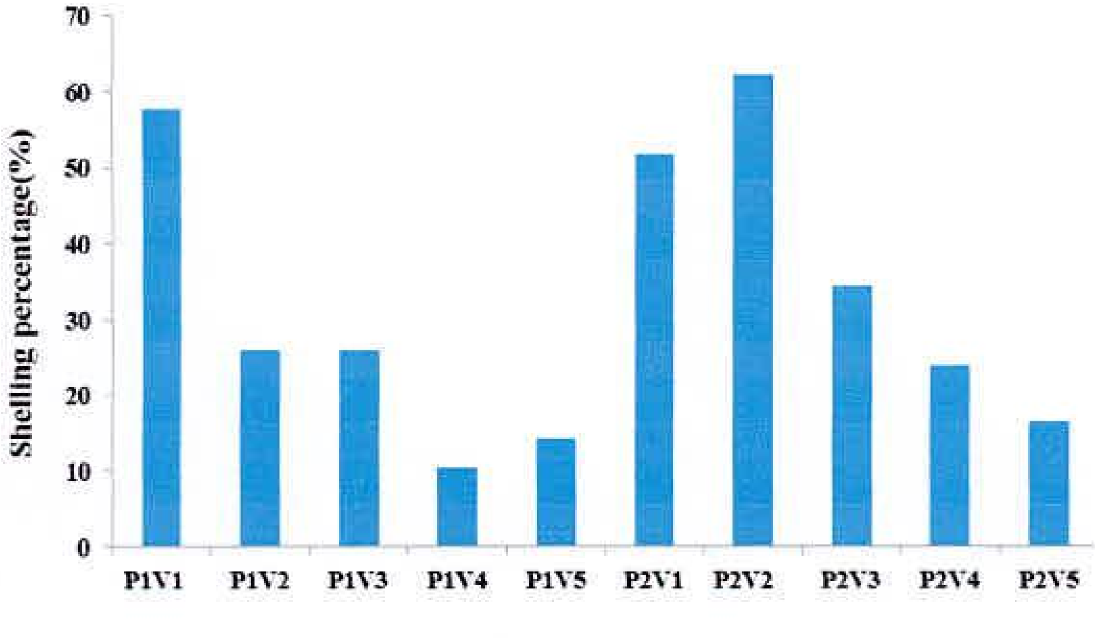
4.9.2 Effect of varieties

Variety significantly affected the shelling percentage of mustard (Appendix VIII and Table 12). Improved Tori-7 produced the highest shelling percentage (54.79) which was statistically similar with BARI Sarisha-13 (44.04).

The lowest shelling percentage was produced by SAU SR-03 (15.41), which was statistically similar with BARI Sarisha-16 (17.15).

The result was in conformity with Akhter (2005) who observed significant variations for shelling percentage for different varieties. But the result was in contradiction with Roy (2007) who pointed out that there was no significant variation observed due to variety on shelling percentage.

4.9.3 Interaction effect of planting techniques and varieties



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 9. Interaction effect of planting techniques and varieties on shelling percentage of rapeseed-mustard ($LSD_{0.05}$ = 30.05)

Shelling percentage was significantly influenced by interaction among planting techniques and varieties (Appendix VIII and Figure 9). The highest Shelling percentage (62.21) was obtained from puddle soil sowing with BARI Sarisha-13, which was statistically similar with the interaction of conventional sowing with Improved Tori-7 (57.81), and puddle soil sowing with Improved Tori-7 (51.77). The lowest shelling percentage (10.28) was produced by the interaction of puddle soil sowing with BARI Sarisha-16 which was statistically similar with the interaction of conventional sowing with SAU SR-03 (14.38) and puddle soil sowing with SAU SR-03 (16.43).

4.10 Seed yield

4.10.1 Effect of planting techniques

Seed yield of rapeseed and mustard was not significantly influenced by the planting techniques (Appendix VIII and Table 13). Numerically the maximum seed yield (1.90 t ha^{-1}) was obtained from conventional technique of planting and the lower yield (1.56 t ha^{-1}) was given by the puddle soil technique.

Table 13. Yield and harvest index of rapeseed-mustard as affected by planting techniques

Treatments	Grain Yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
P_1	1.90	4.81	3.59	30.62
P_2	1.56	3.41	4.97	33.80
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	13.88	46.56	28.07	36.98

P_1= Conventional method, P_2 = Puddle soil, NS = Not Significant

This result was in no conformity with the findings of Sarkees (2013) who did not show any variation due to planting techniques. Khan *et al.* (2000) and Hossain *et al.* (2013) also disagreed with the result of this finding. They found significant variation due to sowing method.

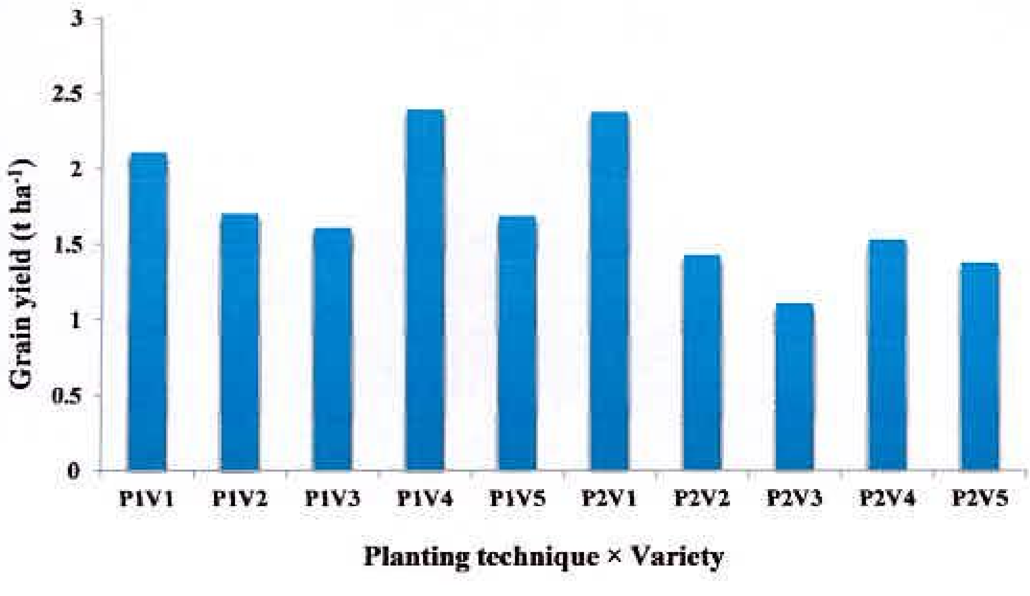
4.10.2 Effect of varieties

Varietal differences significantly affected on the seed yield (Appendix VIII and Table 14). Improved Tori-7 produced the highest seed yield (2.24 t ha^{-1}) and the lowest seed yield was produced by BARI Sarisha-15 (1.36 t ha^{-1}) which was statistically similar with SAU SR-03 (1.53 t ha^{-1}). The result agreed with Rahman (2002), BARI (2001), Mondal *et al.* (1995), Zaman *et al.* (1991) and Mendham *et al.* (1981) who reported that seed yield of rape and mustard were varied with different varieties. Yeasmin (2013) also found significant varietal effect on seed yield. This finding was in conformity with the findings of Zaman *et al.* (1991), Chakrabarty *et al.* (1991) and Uddin *et al.* (1987) who reported that yields were different among the varieties.

But the result was in contradiction with Roy (2007) who reported that seed yield of rapeseed was not significantly influenced by the variety. This result was also in agreement with Monir and McNeilly (1987) who reported that there was no significant yield differences observed between cultivars of *B. napus*.

4.10.3 Interaction effect of planting techniques and varieties

Seed yield was significantly influenced by interaction among planting techniques and varieties (Appendix VIII and Figure 10). The highest seed yield (2.39 t ha^{-1}) was obtained from conventional sowing with BARI Sarisha-16 which was statistically similar with puddle soil sowing of Improved Tori-7 (2.38 t ha^{-1}) and conventional sowing with Improved Tori-7 (2.11 t ha^{-1}) and the lowest seed yield (1.11 t ha^{-1}) was produced by the interaction of puddle soil with BARI Sarisha-15 which was statistically similar with the interaction of puddle soil with SAU SR-03 (1.38 t ha^{-1}).



P_1= Conventional method, P_2= Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 10. Interaction effect of planting techniques and varieties on grain yield of rapeseed-mustard ($LSD_{0.05}$ = 0.284)

4.11 Stover yield

4.11.1 Effect of planting techniques

Stover yield of rapeseed was not significantly influenced by the planting techniques (Appendix VIII and Table 13). Numerically the maximum stover yield (4.81 t ha^{-1}) was obtained from conventional technique of planting and the lower yield (3.41 t ha^{-1}) was obtained from puddle soil sowing. The result is in contradiction with the findings of Khan *et al.* (2000) who reported that changes of planting technique did not significantly influence the stover yield. Hossain *et al.* (2013) and Sarkees (2013) also disagreed with this finding.

Table 14. Yield and harvest index of rapeseed-mustard as affected by different varieties

Treatments	Grain Yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
V_1	2.24 a	2.99 c	5.25 bc	43.75 a
V_2	1.57 c	2.96 c	4.53 c	35.99 ab
V_3	1.36 d	3.31 c	4.67 c	31.15 bc
V_4	1.96 b	6.50 a	8.46 a	24.67 c
V_5	1.53 cd	4.76 b	6.30 b	25.51 c
$LSD_{(0.05)}$	0.201	1.35	1.408	8.095
CV (%)	9.50	26.85	19.69	20.53

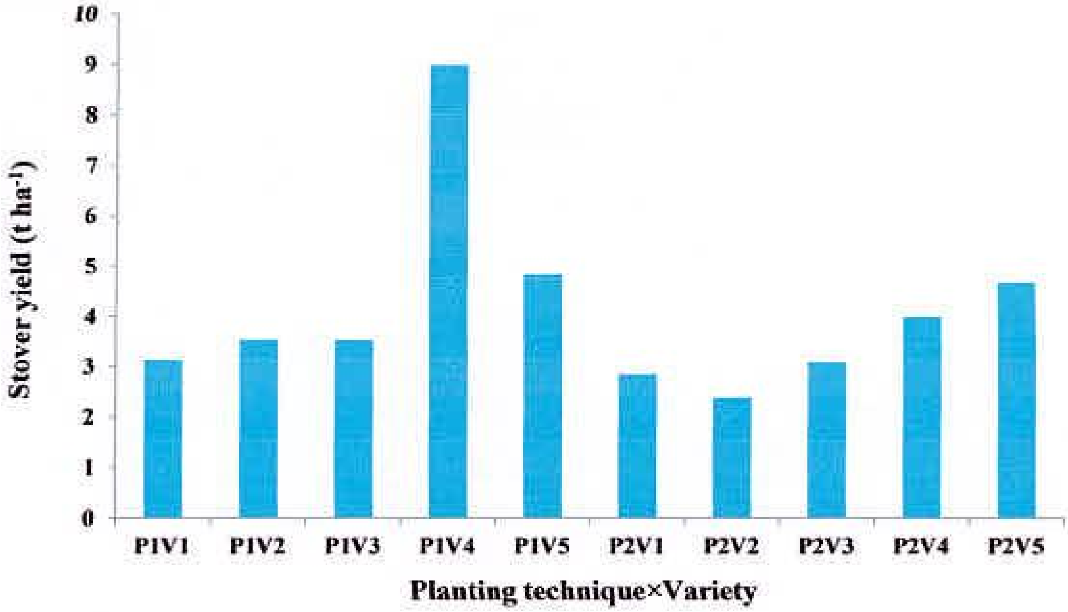
V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

4.11.2 Effect of varieties

Stover yield was significantly influenced by the varieties (Appendix VIII and Table 14). BARI Sarisha-16 gave the highest stover yield (6.50 t ha^{-1}) and the lowest stover yield (2.96 t ha^{-1}) was observed in BARI Sarisha-13, which was statistically similar with Improved Tori-7 (2.99 t ha^{-1}), BARI Sarisha-15 (3.13 t ha^{-1}). It has been reported that the highest stover yield (6400 kg ha^{-1}) was obtained from the variety Rai-5 and lowest stover yield (4413.3 kg ha^{-1}) was obtained from Tori-7 (BARI, 2000). It has been reported that stover yields of rape and mustard are different in different varieties (BARI, 2000).

This finding agreed with Akhter (2005) who found that variety affect significantly on stover yield. The result was not in conformity with the findings of Yeasmin (2013). She observed insignificant varietal effect on Stover yield.

4.11.3 Interaction effect of planting techniques and varieties



P_1= Conventional method, P_2= Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 11. Interaction effect of planting techniques and varieties on stover yield of rapeseed-mustard ($LSD_{0.05}$=1.909)

Stover yield was significantly influenced by interaction among planting techniques and varieties (Appendix VIII and Figure 11). The highest stover yield (9.0 t ha^{-1}) was produced by the interaction of conventional sowing with BARI Sarisha-16 and the lowest stover yield (2.39 t ha^{-1}) was observed in the interaction of puddle soil sowing with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil sowing with BARI Sarisha-16 (3.99 t ha^{-1}) and BARI Sarisha-15 (3.10 t ha^{-1}) and also statistically similar with the interaction effect of conventional sowing with Improved Tori-7 (3.14 t ha^{-1}), BARI Sarisha-13 (3.53 t ha^{-1}) and BARI Sarisha-15 (3.52 t ha^{-1}).

4.12 Harvest index

Harvest index is a measure of physiological productivity potential of a crop variety. It is the ability of a crop plant to convert the dry matter into economic yield.

4.12.1 Effect of planting techniques

No significant difference was found due to the effect of planting techniques in rapeseed-mustard (Appendix VIII and Table 13). Numerically the higher harvest index (33.80%) was found in puddle soil sowing and the lower (30.62%) was obtained from the conventional technique of planting. This result was in agreement with the findings of Sarkees (2013) who showed that harvest index was not significantly affected by sowing method.

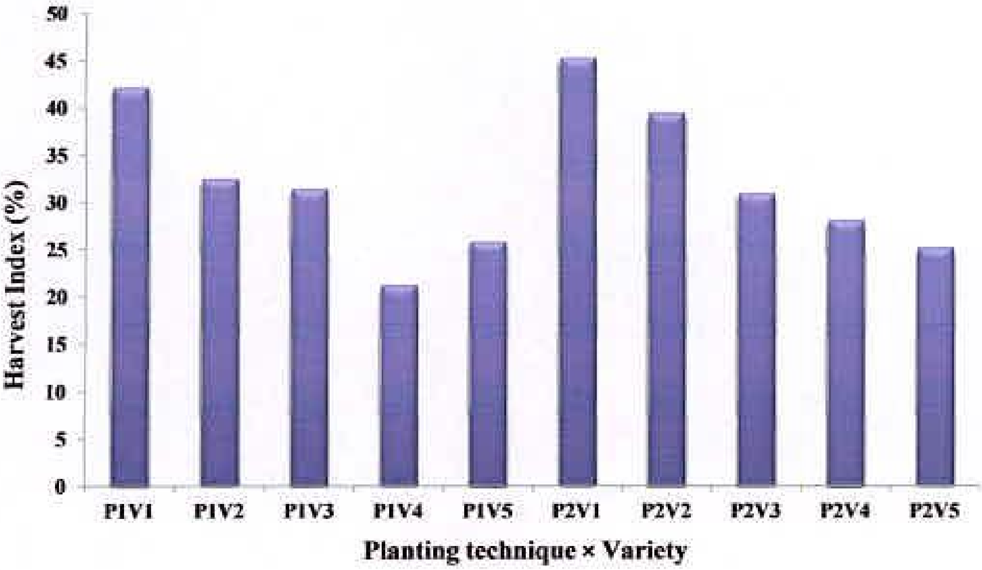
But the result was in contradiction with the findings of Khan *et al.* (2000) and Hossain *et al.* (2013). They found no significant variation due to sowing method.

4.12.2 Effect of varieties

Variety affected significantly on the harvest index (Appendix VIII and Table 14). Improved Tori-7 produced the highest harvest index (43.75%) which was statistically similar with BARI sarisha-13 (35.99%). The lowest harvest index (24.67%) was observed in BARI Sarisha-16 which was statistically similar with SAU SR-03 (25.51%). Roy (2007) also found the highest harvest index in Improved Tori-7.

Similar result was also observed by Islam *et al.* (1994). Mendham *et al.* (1981) stated that a low harvest index of rapeseed might be due to excessive pod and seed losses during flowering. Thurling (1974) reported that the value of harvest index ranged from 10 to 23 percent in both the species of *B. campestries* and *B. napus*. Yeasmin (2013) found insignificant varietal effect on harvest index.

4.12.3 Interaction effect of planting techniques and varieties



P_1= Conventional method, P_2= Puddle soil, V_1 = Improved tori-7, V_2= BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4= BARI Sarisha-16 and V_5 = SAU SR-03

Figure 12. Interaction effect of planting techniques and varieties on harvest index of rapeseed-mustard ($LSD_{0.05}$= 11.45)

Harvest index was significantly influenced by the interaction among planting techniques and varieties (Appendix VIII and Figure 12). The highest harvest index (45.33%) was produced by the interaction of puddle soil sowing with Improved Tori-7 which was statistically similar with the combination of puddle soil with BARI Sarisha-13 (39.48%) and also with the combination of conventional sowing with Improved Tori-7 (42.17%). The lowest harvest index (21.24%) was produced by the interaction of conventional sowing with BARI Sarisha-16 which was statistically similar with the interaction of puddle soil sowing with SAU SR-03 (25.20%) and BARI Sarisha-16 (28.10%) and also statistically similar with the interaction of conventional sowing of BARI Sarisha-13 (32.49%), BARI Sarisha-15 (31.39%) and SAU SR-03 (25.83%).

4.13 Biological yield

4.13.1 Effect of planting techniques

Biological yield of rapeseed was not significantly influenced by the planting techniques (Appendix VIII and Table 13). Numerically the maximum biological yield (4.97 t ha^{-1}) was obtained from puddle soil sowing and the lower yield (3.59 t ha^{-1}) was recorded from the conventional technique of planting.

The result was in contradiction with the findings of Khan *et al.* (2000) who found significant difference between the sowing methods in case of biological yield.

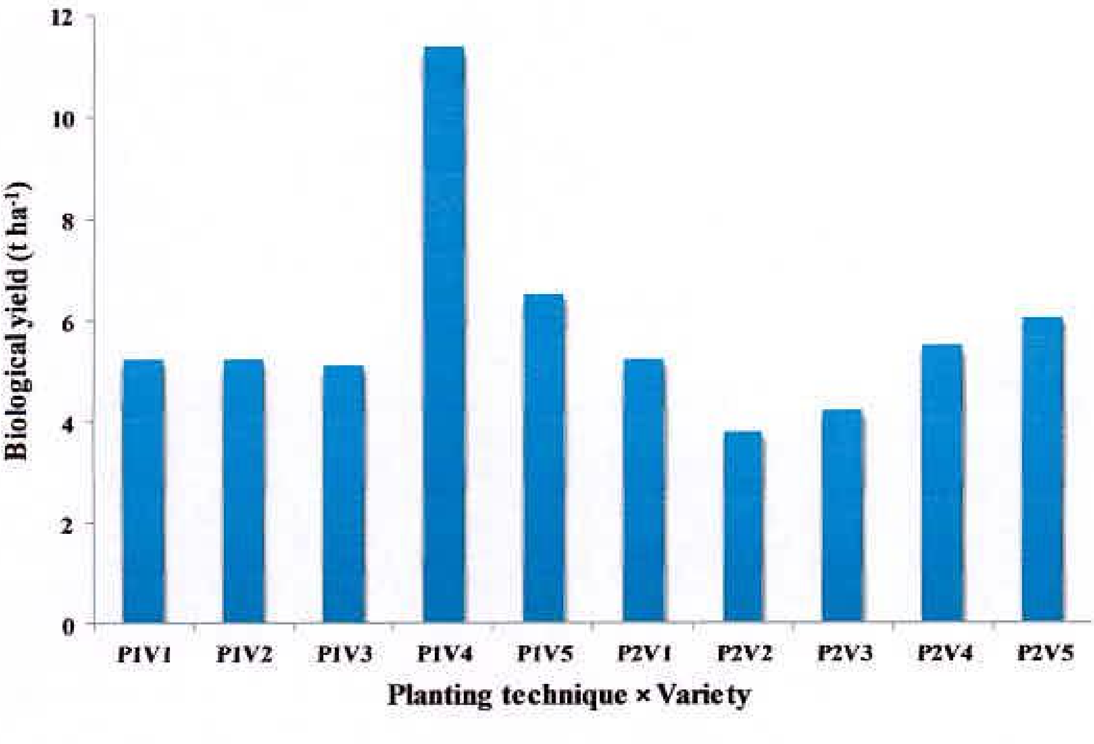
4.13.2 Effect of varieties

Biological yield was significantly influenced by the varieties (Appendix VIII and Table 14). BARI sarisha-16 gave the highest biological yield (8.46 t ha^{-1}) and the lowest biological yield (4.53 t ha^{-1}) was observed in BARI Sarisha-13, which was statistically similar with BARI Sarisha-15 (4.67 t ha^{-1}) and Improved Tori-7 (5.25 t ha^{-1}).

Mamun *et al.* (2014) found similar result on biological yield due to varieties. But this result was in contradiction with the findings of Yeasmin (2013) who found insignificant varietal effect on biological yield.

4.13.3 Interaction effect of planting techniques and varieties

Biological yield was significantly influenced by the interaction among planting techniques and varieties (Appendix VIII and Figure 13). The highest biological yield (11.40 t ha^{-1}) was produced by the interaction of conventional sowing with BARI Sarisha-16 and the lowest biological yield (3.82 t ha^{-1}) was observed in the interaction of puddle soil technique with BARI Sarisha-13, which was statistically similar with the interaction of puddle soil with BARI Sarisha-15 (4.21 t ha^{-1}), BARI Sarisha-16 (5.53 t ha^{-1}) and Improved Tori-7 (5.24 t ha¯1) and also statistically similar with the interaction of conventional sowing with Improved Tori-7 (5.23 t ha^{-1}), BARI Sarisha-13 (5.24 t ha^{-1}) and BARI Sarisha-15 (5.13 t ha^{-1}).



P_1= Conventional method, P_2 = Puddle soil, V_1 = Improved tori-7, V_2 = BARI Sarisha-13, V_3 = BARI Sarisha-15, V_4 = BARI Sarisha-16 and V_5 = SAU SR-03

Figure 13. Interaction effect of planting techniques and varieties on biological yield of rapeseed-mustard ($LSD_{0.05}$ = 1.991)

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Agronomy field of Sher-e- Bangla Agricultural University (SAU), Dhaka in the Rabi season (November-February) of 2013-2014 to study performance of rapeseed and mustard varieties under two planting techniques. The experiment was comprised of two sets of treatments viz. A. Planting techniques and B. Variety. The planting techniques were conventional sowing and sowing in puddle soil. Different varieties were Improved Tori-7, BARI Sarisha-13, BARI Sarisha-15, BARI Sarisha-16 and SAU SR-03. The experiment was laid out in split-plot design with three replications having planting techniques in the main plots and variety in the sub plots. The data on crop growth characters like plant height, plant dry weight were recorded at different days after sowing in the field and yield as well as yield contributing characters like number of branches plant^{-1}, siliquae plant^{-1}, number of seeds siliqua^{-1}, length of siliqua, 1000 seed weight, grain and stover yield were recorded after harvest and analysis was done using the MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5 % level of significance.

Planting techniques showed no significant variation more or less all agronomic parameters except siliqua length. Results of the experiment showed that the plant height was not significantly influenced by planting techniques. Number of leaves plant^{-1} was also not affected significantly due to planting techniques at 30 DAS and 60 DAS except 45 DAS. Dry weight of plant affected significantly at 30 DAS, where conventional technique showed the higher plant dry weight but at 45 and 60 DAS plant dry weight did not show any significant variation. Number of branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1} were not affected significantly by planting techniques. But siliqua length showed significant variation between planting techniques. Conventional method of sowing showed the higher siliqua length (5.51 cm).

No significant variation was found due to planting techniques for 1000-seed weight, shelling percentage, grain yield, biological yield and harvest index.

Variety had significant influence on the growth and yield attributes. Results of the experiment showed that the plant height was significantly influenced by variety at 30, 45, 60 and 75 DAS and at harvest. However, the tallest plant (24.25, 109.4, 139.2, 147.7 and 150.4 cm at 30, 45, 60 and 75 DAS and at harvest, respectively) was recorded from the variety BARI Sarisha-16. At 45 and 60 DAS variety affected leaf numbers significantly except 30 DAS. At 45 DAS, the highest number of leaves plant^{-1} (32.97) was recorded from BARI Sarisha-15 and at 60 DAS, the highest number of leaves plant^{-1} (32.27) was obtained from SAU SR-03. The highest plant dry weight was observed in the variety BARI Sarisha-16 (4.86, 27.09 and 58.05 g at 30, 45 and 60 DAS respectively). The number of branches plant^{-1} was significantly influenced by different variety at 45, 60, 75 DAS and at harvest. The highest number of branches plant^{-1} was recorded in the variety BARI Sarisha-15 (6.40, 4.73 and 5.63 at 45, 60 and 75 DAS respectively). But at harvest highest number of branches plant^{-1} was recorded in SAU SR-03 (5.20). The number of siliquae plant^{-1} was significantly influenced by different variety at 30, 45, 60 DAS and at harvest. The highest number of siliquae plant^{-1} was obtained from the variety BARI Sarisha-16 (104.7, 118.2 and 143.7 at 60, 75 and at harvest respectively) which was statistically similar with the variety Improved Tori-7. Variety affected significantly on the length of siliqua, seeds siliqua^{-1}, 1000-seed weight, shelling percentage, grain yield, stover yield, biological yield and harvest index. The maximum length of siliqua (7.19 cm) was obtained from BARI Sarisha-13. The highest number of seeds siliqua^{-1} (22.34) was produced by the variety BARI Sarisha-15. BARI sarisha-13 and BARI Sarisha-16 produced the highest 1000-seed weight (4.07 g). Improved Tori-7 produced the highest shelling percentage (54.79). Improved Tori-7 produced the highest seed yield (2.24 t ha^{-1}). The variety BARI Sarisha-16 gave the highest stover yield and biological yield (6.50 t ha^{-1} and 8.46 t ha^{-1} respectively). Improved Tori-7 produced the highest harvest index (43.75%).

Interaction effect of planting techniques and varieties also significantly influenced all the growth as well as yield and other crop characters. The interaction effect of conventional planting technique with BARI Sarisha-16 (P_1V_4) give the highest plant height (26.67, 113.2, 140.9, 151.4 and 153.2 cm at 30, 45, 60, 75 DAS and at harvest respectively). The same variety with puddle soil sowing (P_2V_4) give the highest plant height during 45, 60, 75 DAS and at harvest except 30 DAS. At 30 DAS, the highest number of leaves $plant^{-1}$ (7.67) was obtained from P_1V_1 while at 45 DAS, the highest number of leaves $plant^{-1}$ (37.20) was obtained from P_1V_3 and at 60 DAS it was recorded on P_1V_4. However, the highest plant dry weight was recorded from the interaction effect of conventional sowing with the variety BARI Sarisha-16 (5.50, 27.92 and 71.19 g at 30, 45 and 60 DAS respectively) while the statistically same result was given by the same variety in puddle soil sowing except at 30 DAS. At 45 DAS, the highest number of branches $plant^{-1}$ (7.80) was obtained from P_1V_3, at 60 DAS, the highest number of branches $plant^{-1}$ (5.40) was obtained from P_1V_4 and at 75 DAS the highest number of branches $plant^{-1}$ (6.07) was obtained from P_1V_3. Although at harvest, the highest number of branches $plant^{-1}$ (5.33) was obtained from P_1V_5. The highest number of siliquae $plant^{-1}$ was recorded from the combination P_1V_4 during 60, 75 DAS and at harvest i.e. 120.7, 131.3 and 145.2 respectively. The highest Siliqua length (7.41 cm) was observed from the treatment combination P_1V_2. The highest number of seeds $siliqua^{-1}$ (23.32) was obtained from P_1V_3. The highest number of 1000-seed weight (4.35 g) was obtained from P_1V_4. The highest Shelling percentage (62.21) was obtained from P_2V_2. The highest seed yield (2.39 t ha^{-1}) was obtained from P_1V_4 which was statistically similar with P_2V_1 (2.38 t ha^{-1}) and P_2V_1 (2.11 t ha^{-1}). The highest stover yield, harvest index and biological yield was recorded in the treatment combination P_1V_4 9.0 t ha^{-1}, 45.33% and 11.40 t ha^{-1} respectively.

By summarizing the above discussion, conclusion may be drawn as the seed yield of mustard varied with varietal difference but not with different planting techniques. The growth behavior of the five studied varieties was different. The variety Improved Tori-7 and BARI Sarisha-16 showed the better performance on growth and yield contributing characters of rapeseed-mustard. But as BARI Sarisha-16 is a long duration variety and if farmers grow this variety then it will hamper the next crop in the cropping pattern. In case of interaction effect, conventional sowing with BARI Sarisha-16 showed the highest yield that statistically similar with puddled soil sowing of Improved Tori 7 as well as conventional sowing of the same variety.

Recommendations

Considering the above observation of the present experiment, further studies in the following areas may be suggested-

- Farmers can cultivate rapeseed-mustard as if rain occurred during the sowing time.
- The variety Improved Tori-7 showed its maximum yield response. As the duration of this variety is short and it also shows better yield performance with puddle soil condition, so it can be well suited in the T. Aman-Mustard-Boro cropping pattern.
- However it is not wise to recommend with a single experimental findings and in a single location study and hence the same experiment should be conducted in different regions of the country for sustainable recommendation.

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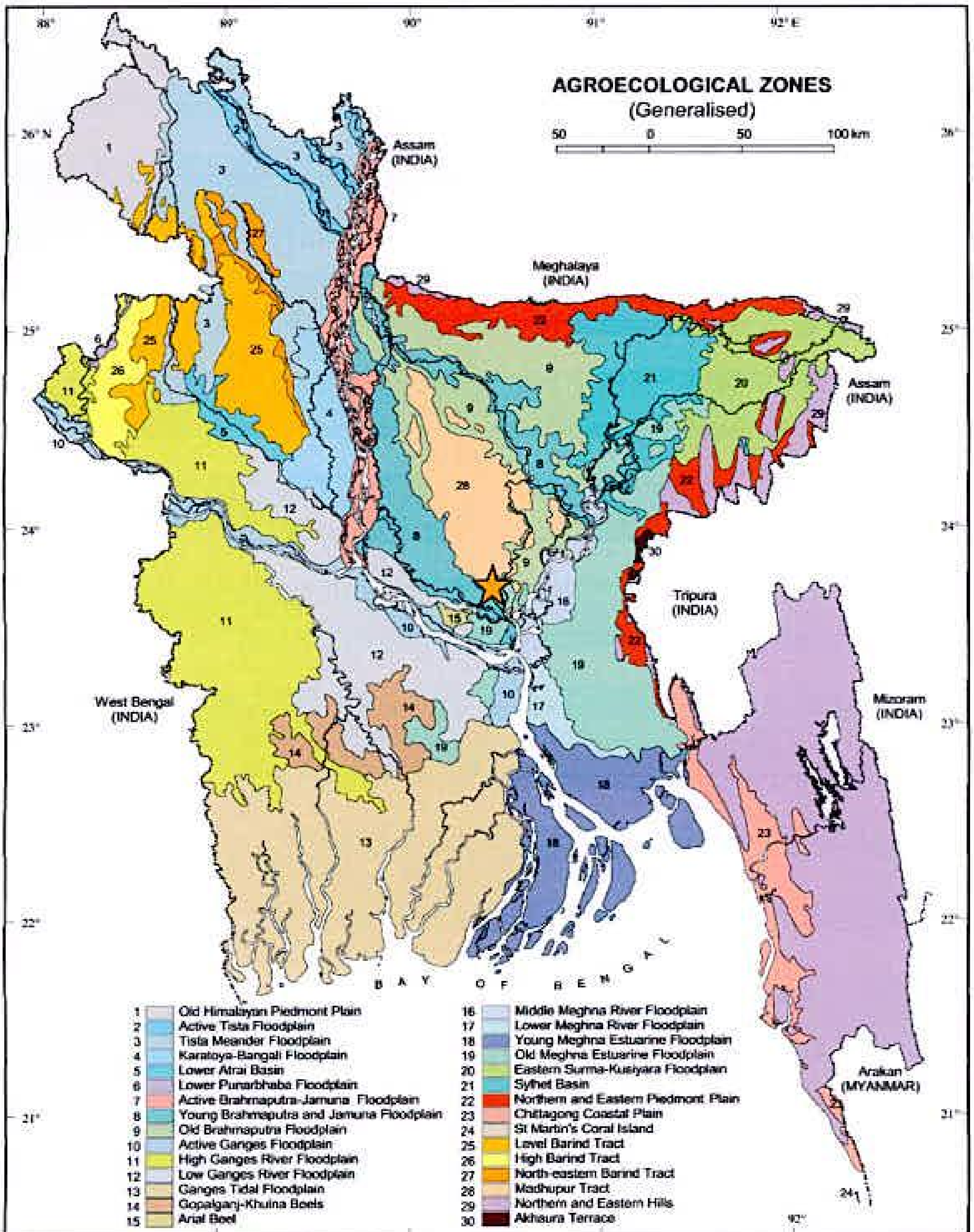
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



★ **The experimental site under study**

Appendix II. Weather data Monthly record of average air temperature, relative humidity and total rainfall of the experimental site during the period from November 2013 to March 2014

Month	Average Relative Humidity (RH)	Average Temperature (^0C)		Total Rainfall (mm)
		Minimum	Maximum	
November	58.18	6.88	28.10	1.56
December	54.30	5.21	25.36	0.63
January	64.02	15.46	21.17	0.00
February	53.07	19.12	24.30	2.34
March	48.66	22.37	29.78	0.12

Source: Weather station, Sher-e-Bangla Agricultural University, Dhaka-1207.

Appendix III. Mean square values for plant height at different days after sowing of rapeseed-mustard

Sources of variation	Degrees of freedom	Means square values				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	0.336	87.835	27.605	73.622	155.654
Planting Technique	1	206.247	496.459	73.008	337.077	405.169
Error (a)	2	32.117	202.834	75.736	13.465	21.621
Variety	4	32.117*	1492.608*	3108.291*	3696.968*	3827.664*
Planting Technique x Variety	4	2.720 *	25.788*	30.563*	65.989*	61.3868
Error (b)	16	4.572	22.138	28.410	25.665	58.450

- Significant at 5% level

Appendix IV. Mean square values for number of leaves plant^{-1} at different days after sowing of rapeseed-mustard

Sources of variation	Degrees of freedom	Mean square values		
		30 DAS	45 DAS	60 DAS
Replication	2	0.400	20.356	26.929
Planting Technique	1	4.720	106.785*	58.241
Error (a)	2	0.312	5.001	13.0089
Variety	4	0.862	277.977*	193.882*
Planting Technique x Variety	4	0.599*	7.102*	65.325*
Error (b)	16	0.716	23.580	8.214

*Significant at 5% level

Appendix V. Mean square values for plant dry weight at different days after sowing of rapeseed-mustard

Sources of variation	Degrees of freedom	Mean square values		
		30 DAS	**45 DAS**	**60 DAS**
Replication	2	0.313	1.820	150.677
Planting Technique	1	13.534*	110.247	734.679
Error (a)	2	1.893	51.126	248.580
Variety	4	2.151*	181.375*	607.540*
Planting Technique x Variety	4	2.151*	10.625*	183.519*
Error (b)	16	0.770	15.565	135.695

* Significant at 5% level

Appendix VI. Mean square values for number of branches plant^{-1} at different days after sowing of rapeseed-mustard

Sources of variation	Degrees of freedom	Mean square values			
		45 DAS	60 DAS	75 DAS	At harvest
Replication	2	0.129	4.037	0.520	0.616
Planting Technique	1	6.721	0.533	0.456	0.000
Error (a)	2	1.169	1.733	0.800	0.660
Variety	4	9.005*	1.667*	2.511*	4.544*
Planting Technique x Variety	4	1.725*	1.227*	0.798*	0.837*
Error (b)	16	0.803	1.044	0.419	0.708

* Significant at 5% level

Appendix VII. Mean square values for number of siliquae plant^{-1} at different days after sowing of rapeseed-mustard

Sources of variation	Degrees of freedom	Mean square values		
		30 DAS	45 DAS	60 DAS
Replication	2	3543.313	441.084	705.417
Planting Technique	1	418.133	1883.376	551.437
Error (a)	2	1964.642	640.464	560.589
Variety	4	3445.332*	2864.452*	4129.457*
Planting Technique x Variety	4	391.583*	159.506*	230.470*
Error (b)	16	511.744	387.548	539.635

* Significant at 5% level

Appendix VIII. Summary of analysis of variance for yield and yield contributing characters, harvest index and shelling percentage of rapeseed-mustard varieties at harvest

Sources of Variation	Degrees of freedom	Mean square values							
		Seeds siliqua^{-1} (No)	Length of siliqua (cm)	1000 seed weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Shelling percentage (%)
Replication	2	2.354	0.036	0.011	0.039	2.953	2.790	187.742	397.520
Planting technique	1	0.954	0.986*	0.840	0.850	14.714	22.620	75.907	889.223
Error (a)	2	3.015	0.008	0.087	0.070	3.655	2.687	141.945	200.058
Variety	4	92.474*	7.049*	1.330*	0.782*	13.975*	15.783*	15.783*	1744.021*
Planting technique × Variety	4	5.894*	0.80*	0.051*	0.253*	6.316*	8.420*	20.951*	385.195*
Error (b)	16	5.980	5.980	0.059	0.027	1.216	1.323	43.740	152.135

* Significant at 5% level

Plate 1: Photograph showing land preparation of the experimental plots

Plate 2: Photograph showing a plot of puddle soil condition after germination

Plate 3: Photograph showing a plot of conventional sowing after germination and thinning

Plate 4: Photograph showing the variety Improved Tori-7 with conventional method of sowing

Plate 5: Photograph showing the variety BARI Sarisha-13 with conventional method of sowing

Plate 6: Photograph showing the variety BARI Sarisha-15 with conventional method of sowing

Plate 7: Photograph showing the variety BARI Sarisha-16 with conventional method of sowing

Plate 8: Photograph showing the variety SAU SR-03 with conventional method of sowing

Plate 9: Photograph showing the variety Improved Tori-7 with puddle soil condition

Plate 10: Photograph showing the variety BARI Sarisha-13 with puddle soil condition

Plate 11: Photograph showing the variety BARI Sarisha-15 with puddle soil condition

Plate 12: Photograph showing the variety BARI Sarisha-16 with puddle soil condition

Plate 13: Photograph showing the variety SAU SR-03 with puddle soil condition

Plate 14. Photograph showing variation among different plots of the experiment

Plate 15. Photograph showing overall field view of the experiment