EFFECT OF SOWING DATE ON YIELD AND YIELD COMPONENTS OF RAPESEED VARIETIES

BY

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A Thesis

**Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of**

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JULY-DECEMBER, 2005

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CERTIFICATE

This is to certify that the thesis entitled, "Effect of sowing date on yield and yield components of rapeseed varieties" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY embodies the result of a piece of *bona fide* research work carried out by Md. Afzal Hossen Registration No. 23885/00239 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 been duly acknowledged by him.

Dated: 27-12-2005
Place: Dhaka, Bangladesh

(Prof. Md. Sadrul Anam Sardar)
Supervisor

DEDICATED TO MY

Beloved Mother

LIST OF ABBREVIATIONS OF SYMBOLS AND TERMS

Full Word	Abbreviation
And others (at elli)	*et al.*
Bangladesh Agricultural Research Institute	BARI
Centimeter	cm
Coefficient of Variation	CV
Degree Celsius (Centigrade)	^{0}C
Etcetera	etc.
Example	e.g.
Gram	g
Harvest Index	HI
Hectare	ha
Hour	hr
Hydrogen ion conc.	P^{H}
Kilogram	kg
Leas significant difference	LSD
Meter	m
Micron	μ
Millieqivalent	meq
Muriate of potash	MP
Namely	viz.
Percent	%
Square meter	m^2
Ton	t
Triple Super Phosphate	TSP

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah Who enable me to complete this thesis.

I would like to express my heartfelt respect, deepest sense of gratitude, profound appreciation and ever indebtedness to my Supervisor Md. Sadrul Anam Sardar, professor, Department of Agronomy, Sher-e-Bangla Agricultural University, (SAU), Dhaka for his sincere guidance, scholastic supervision, constructive criticism, and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

I express my sincere respect to my Co-supervisor, Dr. A. K. M. Ruhul Amin, Associate professor, department of Agronomy, Sher-e-Bangla Agricultural University, (SAU), Dhaka for his utmost co-operation, constructive suggestion to conduct the research work as well as preparation of the manuscript of the thesis.

I would like to express my heartfelt indebtedness and profound appreciation to my respectable teacher Dr. Parimal Kanti Biswas., Associate professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his nice co-operation sincere guidance, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.

I thank all of my course mates specially Hasan, Jashim, Shawkat, Shabuj, Rokon, and Likhi to cooperate and help me during taking data from the field and to take care of my experimental plot time to time. Special thanks to my friends and roommates.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my parents for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate me to this level.

The Author

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ABSTRACT

The study was carried out at the Field Laboratory of Sher-e- Bangla Agricultural University farm, Dhaka during October 2004 to February 2005 to evaluate the effect of sowing date and variety on yield and yield components of rapeseed (*Brassica campestris* and *Brassica napus*). The treatments comprised of four sowing dates at 15-days interval on viz. October 20, November 4, November 19 and December 4 and three varieties viz. Improved Tori-7, BARI Sarisha-8 and BARI Sarisha-9. The experiment was laid out in a Randomized Complete Block Design.

The results showed that BARI Sarisha-8 performed best by producing 52.4 % and 132.9 % higher yield than BARI Sarisha-9 and Improved Tori-7, respectively. This variety (BARI Sarisha-8) also showed higher siliquae plant^{-1}, seeds siliqua^{-1}, siliqua length, 1000 seed weight, shelling percentage, stover yield, biological yield and harvest index. In case of sowing date, grain yield reduced gradually with the advancement of delay in sowing. October 20 sowing gave maximum grain yield (1422 kg ha^{-1}) and that of lowest (437.2 kg ha^{-1}) was observed in December 4. BARI Sarisha-8 on October 20 sowing produced the significantly highest grain yield (1865 kg ha^{-1}) and the lowest (130 kg ha^{-1}) was found in Improved Tori-7 on December 4 sowing. The variety BARI Sarisha-8 and October 20 sowing performed best in respect of grain yield as well as other studied parameters.

CHAPTER I

Introduction

CHAPTER I

INTRODUCTION

Mustard-rapeseed is one of the most important and widely grown oilseed crops of Bangladesh. Mustard-rapeseed belongs to genus *Brassica* under the family Cruciferae and has got several cultivated species, viz. *Brassica campestris* L., *Brassica juncea* L. Czern & Cross and *Brassica napus* L. etc. Out of total cropped area of 13.53 million hectare, oil crops occupy only 0.561 million hectare which is about 4.2 % of the total cropped area and contribute to about 1.6 % of total grain production of the country (BARI 2002). Rapeseed-mustard occupies only 0.336 million hectare, (60%) among oil cropped area (Wahhab *et al.*, 2002). Among mustard Tori-7 (*Brassica campestris*) is grown in 75 % of the area and Rai group (*Brassica juncea*) covers about 25 % of the area. Recently rapeseed (*Brassica napus*) is being introduced (Rahman, 2002). The analysis of productivity trend reveals that mustard yield in Bangladesh has increased from 672 kg ha^{-1} to 757 kg ha^{-1} with the annual growth rate of 1.26% (Rahman, 2002) which is alarmingly poor compared to that of advanced countries like Algeria, Germany, France, UK and Poland producing 6667 kg ha^{-1}, 3507 kg ha^{-1}, 3264 kg ha^{-1}, 3076 kg ha^{-1} and 2076 kg ha^{-1} respectively (FAO, 2001). The major reasons for low yield of rapeseed-mustard in our country are due to lack of high yielding variety, inappropriate sowing time and proper management etc.

Domestic production of edible oil comes from rapeseed-mustard, groundnut and sesame. Edible oils play a very vital role in human nutrition. As a high energy component of food, edible oil is important for meeting the caloric requirement. Each gram oil/fat supplies 9 kilocalorie energy while each gram of carbohydrate/ protein furnishes 4 kilocalorie energy (Stryer, 1980). It is not only a high energy food but also a carrier of fat soluble vitamins (A, D, E and K) in the body. On the nutritional point of view at least 15-20 % calorie should come from the fats and oils. Mustard oil is our principal edible oil. Mustard seeds contain 40-45 % oil and 20-25 % protein. It is also important for improving the taste of a number of food items. It also serves as an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc.

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, 2001). Major rape and mustard growing area in Bangladesh are shown in Appendix A.

The best growth of mustard occurs above 12 ^{0}C and below 25 ^{0}C (Wahhab *et al.*, 2002). Bangladesh weather allows very short sowing period for rapeseed-mustard. The winter in Bangladesh is not very long, temperature starts rising from the month of February. So mustard harvesting should be completed by middle of February, otherwise the crop faces high temperature and yield becomes low. So, sowing at proper time allows sufficient growth and development of a crop to obtain satisfactory yield. Different sowing dates provide variable environmental conditions within the same location for the growth and development of crop yield stability (Pandey, 1981).

Planting time has significant effect on the yield and yield components of mustard (Saran and Giri, 1987). The seeding date has a considerable influence on growth and development of plants as well as on seed yield of rapeseed and mustard (Rahman *et al.*, 1988). Early sowing may result in vigorous growth and less resistance to cold during winter while late seeding may result in stunted growth and crop may be attacked with disease and insect pests leading to reduction in seed yield (Kaul and Das, 1986). Seed yield of mustard declined gradually by 11.7, 21.5, 43.4 and 62.9 % respectively, for each week delay after November 1 sowing (Rahman *et al.*, 1993). Yield reduction due to late sowing is of common occurrence owing to low level of dry matter accumulation accompanied by pod abortion and poor seed set.

There are potential areas in Bangladesh where rapeseed and mustard can grow profitably. But due to ignorance of optimum sowing time farmers generally harvest a poor yield (Hossain *et al.*, 1996).

So an experiment on date of sowing with different varieties of rapeseed was carried out to determine the optimum time of sowing of the crop for its proper growth and development in relation to time and day length.

In view of the limited information on the problems mentioned above, a field study containing the different sowing dates were conducted with the following objectives:

i. To find out the appropriate sowing date of rapeseed in this Agro climatic zone.

ii. To evaluate the yield performance of different rapeseed varieties.

CHAPTER II

Review of Literatures

CHAPTER II

REVIEW OF LITERATURE

Time of sowing has profound effect on the growth, development and yield of rapeseed-mustard. This demands the correct identification of optimum period of sowing for its yield maximization. The work in this line in the country is few and sporadic. In this chapter the information and pertinent to the present study have been reviewed below.

2.1 Effect of variety on different crop characters

Varietal performance of a crop depends on its genetic makeup. There are four species of *Oleiferous Brassica* viz. *B. campestris, B. juncea, B. napus* and *B. carinata*, everyone of which differs from one another with respect to yield, yield components and oil contents.

2.1.1 Days to maturity

Jahan and Zakaria (1997) reported that the exotic varieties required lowest time to mature compared to the local varieties. AGA- 95-21 took the highest time (188 days) to mature which was followed by the varieties Hyola–10 (114 days) and BLU–900 (111 days). The shortest duration variety was Tori-7 (77 days).

Hossain *et al.* (1996) found that the maximum days to maturity variety was semu DNK-89/218 (118 days) and the lowest days to maturity variety was Tori-7 (79 days).

Mondal *et al.* (1992) stated that Tori-7 took 72 days to mature, the variety SS-75 matured 98 days of emergence and J-5004 required a period almost similar to that of SS-75.

2.1.2 Branches plant^{-1}

BARI (2000) found that under poor management number of branch plant^{-1} was higher in the variety SS-75; lower in the variety BARI Sarisha-8. Under medium management, best performance was in Dhali and worst performance was in BARI Sarisha-8. Under higher management, highest in Dhali and lowest in Nap-248.

Jahan and Zakaria (1997) found that the local varieties Tori-7 and Sampad produced the highest number of primary branches plant^{-1} (4.07) which was at per with BLN-900. The minimum number of primary branches plant^{-1} of 2-90 was found in Jatarai which was identical to those found in Hhole-401 and BARI Sarisha-8 varieties. Hossain *et al.* (1996) stated that the varieties were statistically different with respect to number of primary branches.

2.1.3 Plant height

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

Ali *et al.* (1998) observed significant variation on plant height of different varieties of rapes and mustard.

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

Hossain *et al*. (1996) observed that the highest plant was in Narenda (175 cm) which was identical with AGA-95-21 (166 cm) and Hyola-51 (165 cm). The shortest variety was Tori-7.

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

2.1.4 Number of siliquae plant^{-1}

Jahan *et al.* (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}.

Hossain *et al.* (1996) showed that there was marked statistical variation in number of siliquae plant^{-1}.

Mondal *et al.* (1992) found that the maximum number of siliquae plant^{-1} (136) was found 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.

2.1.5 Number of seeds siliqua^{-1}

Jahan and Zakaria (1997) found highest number of seeds siliqua^{-1} (26.13) in Dhali, which was at par with Sonali Sarisha (23.5) and Jatorai (22.8). The lowest number (18.0) of seeds siliqua^{-1} was found in tori-7, which was at par with that in Sampad (20.0), BARI Sarisha-7 (20.5) and BARI Sarisha-8 (21.6).

2.1.6 Siliqua length

BARI (1999) observed significant variations in pod length in different varieties of rapeseed. Highest pod length was found in Daulat and lowest in Dhali.

Hossain *et al.* (1996) stated that the varieties of rapeseed differed significantly in respect of siliqua length. The longer siliqua length was found in hybrid BGN-900 (7.75 cm) that was similar to Hyole-101, Sampad, Dhali and Hyola-51. The shortest siliqua length was found in hybrid Semu-249/84 (4.62 cm) which was identical to those of Semu-DNK-89/218, AGH 95-7 and Tori-7. The longest siliqua (8.07cm) was found in BLN –900, which was superior to all other varieties. The shortest siliqua length (4.83cm) was obtained in Hyola-401 (Jahan and Zakaria 1997).

2.1.7 Weight of thousand seed

Mondal and Wahhab (2001) found that weight of 1000 seeds varies from variety to variety and from species to species. They found the thousand seed weight of 2.50-2.65 g in case of improved Tori-7 (*B. campestries*) and 1.50 - 2.80 g in Rai-5 (*B. napus*).

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-3023 (3.43 g), J-3018 (3.42 g) and J-4008 (3.50 g).

Hossain *et al.* (1998) observed significant variation in 1000 seed weight as influenced by different varieties. They found Hyda-401 had the highest thousand seeds weight (3.43g) and the lowest thousand seed weight was recorded in Tori-7 (2.1 g).

BARI (2001) concluded that there was significant variation in thousand seed weight of different mustard varieties and highest weight was in Jamalpur-1 variety and lowest in BARI Sarisha-10.

2.1.8 Grain yield

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 was in variety Torio-7 (0.95-1.10 t ha^{-1}).

BARI (2001) observed that seed yield and other yield contributing characters significantly varied among the varieties.

Mondal *et al.* (1995) reported that after continuous efforts plant breeders of Oilseed Research Centre, BARI have developed several short duration genotypes of *B. napus* with high yield potential. The genotype, Nap-3 is one of these genotypes (Biswas and Zaman, 1990) which is under active consideration for recommendation as a variety. It is likely to be a good variety for Bangladesh, but it has a problem of high shattering habit.

Zaman *et al.* (1991) reported that seed yields of rape and mustard are different in different varieties. Chakrabarty *et al.* (1991) stated that seed yields varied from species to species.

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

Malik (1989) observed that *B. carinata* produced 49 % higher yield than each of *B. juncea* and *B. campestries*.

Uddin *et al.* (1987) reported that there was a significant yield difference among the varieties of rapes and mustard with the same species. Shamsuddin and Rahman (1977) found that yields were different among the varieties within the same species.

Monir and McNeilly (1987) reported that there was no significant yield difference between cultivars of *B. napus.*

2.1.9 Stover yield

BARI (2000) reported that in case of poor management Isd-local gave the highest stover yield (3779 kg ha^{-1}) and lowest yield (1295 kg ha^{-1}) was found in Nap-248. In case of medium management highest weight (6223.3 kg ha^{-1}) was in the same variety and lowest (3702.3 kg ha^{-1}) from PT-303 under high management conditions. 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.

2.1.10 Biological yield

The biological yield of plant is measured in terms of total dry weight of the plant at final harvest, is easily correlated to seed yield and depends on the growth of the plant during its various development stages. In *B. campestris*, the total antithesis phase of growth has a greater significance for the determination of seed yield than the vegetative phase (Thurling, 1974 b).

Mendham *et al.* (1990) showed that vernalization and photoperiod appear to affect the rate of development to flowering in a quantitative and additive fashion in all cultivers, which helped to biological yield.

2.1.11 Harvest index

Robertson *et al.* (2004) stated that Indian mustard had a lower harvest index.

Islam *et al.* (1994) showed that varieties had significant harvest index (%) of mustard.

Mendham *et al.* (1981) stated that a low harvest index of rapeseed might be due to excessive pod and seed losses during flowering. In *Brassica* species harvest index is strongly influenced by environment (Thurling 1974b).

2.2 Effect of sowing date on different crop characters

Due to sowing dates crop experiences different environmental conditions during growth and development period within the same area. This in turn affect and the different crop characters.

2.2.1 Days to flowering

Flowering is a varietal character of any plant. But it can be affected by various environmental factors and some agronomic management practices. Among the agronomic managements, date of sowing influences a lot on the flowering and yield of rapeseed. A number of scientists worked on this aspect at home and abroad. Few findings of them are reviewed below.

Robertson *et al.* (2004) conducted experiment with three cultivers viz. an early and late flowering canola and an advanced breeding line of Indian mustard. They found that a delay in sowing shortened the time to 50% flowering for all the genotypes. At Tamworth sowing beyond May 15, 1 day delay in sowing delayed flowering by 0.42, 0.42 and 0.37 days in Indian mustard, Monty and Oscar, respectively.

Mondal *et al.* (1999) stated that, seeding date significantly influenced days to flowering. Delayed sowing reduced days to flowering.

Mondal and Islam (1993) found that maximum days to flowering (38 days) were required by the October 15 sown plant which was followed by November 1, November 15, and December 1 sowing. Delay in sowing reduced the number of days to flowering. In case of early sowing plant experienced little warm temperature during vegetative stage as a result the growth became slow that is why maturity periods were longer, and later sowing plants completed vegetative growth earlier than the plant of early sowing.

Hang and Gilliland (1984) reported that, days to flowering varied from year to year depending upon temperature.

2.2.2 Days to maturity

Islam *et al.* (1994) stated that delayed sowing curtailed the period of crop duration in all varieties. In all sowings, varieties Tori-7 and TS-72 matured much earlier (75-78 days) than the other (90-107days). It appears that rise of temperature from January onwards might have greatly influenced the post flowering developments, particularly for late sown crops resulting in the shorter maturity periods.

Mondal and Islam (1993) found that maximum days to maturity of mustard (115 days) were required by the October 15 sown plant which was followed by November 1, November 15, and December 1 sowing. Delay in seeding reduced the number of days to maturity. In case of early sowing plant faced little warm temperature during vegetative stage and the growth was slow that is why maturity periods were longer and later sowing plants completed vegetative growth earlier than the plant of early sowing. Hang and Gilliland (1984) reported that days to maturity varied from year to year depending upon temperature.

Mondal *et al.* (1992) observed that there was a trend of reduction in days to maturity with delayed plantings. In the first planting it took 89 days to mature and in the last planting, this was 83 days.

2.2.3 Number of branches plant^{-1}

The number of primary branches plant^{-1} has a very low direct effect on seed yield but it has an indirect positive effect via pods plant^{-1} (Rahman *et al.* 1993).

Islam *et al.* (1994) found that early sown crop produced more primary branches than late planted crop on end October and mid November and he also observed that delayed sowing significantly reduced branches plant^{-1} except that the difference was similar between sowing of November 4 and November 18 over the varieties. The maximum (4.55) number of branches plant^{-1} produced on October 20 and minimum (3.31) on December 2.

Late sowing in oilseed rape suppresses the number of branches plant^{-1} (Ali *et al.* 1985).

Majumder and Sandhu (1964) found that the number of primary branches plant^{-1} had a significant positive correlation with number of pods plant^{-1} and seed yield. Number of primary branches plant^{-1} was influenced by different sowing dates (Mondal *et al.*, 1992; Uddin *et al.* 1987; Chatterjee *et al.*, 1985)

Maini *et al.* (1964) found that the number of primary branches was reduced with each delay in sowing from mid September to late October.

2.2.4 Plant height

Plant height is a varietal character of rapeseed but environmental conditions and cultural operations may affect it.

Angrej *et. al.* (2002) found that, early sowing was recorded higher value for the different plant height.

Mondal and Islam (1993) found that the longest plants were found in the plots of November 1 sowing which was followed by November 15, and October 15 sowing. The shortest plant height was found in the plots of December 1 sowing. In case of late sowing in December 1 plants faced higher temperature during later stages of growth, so the plants were shorter than the other sowing dates.

Date of planting has direct effect on plant height. Sran and Giri (1987) reported that plant height decreased gradually (51-140) with delaying the sowing by one month (October 15 - November 15). Mohammed *et al.* (1984) observed similar results at Aligarh (India). A number of authors also reported that the seedling of mustard on October produced the highest plant height (Kandil 1983; Ansari *et al.*, 1990).

Mondal (1986) conducted an experiment on sowing date on seven sites of New York State with Canola varieties and found that early sowing (May 5) for both the varieties in each case produced tallest plants than in late sowing (April 20) which decreased plant height.

But Maini *et al.* (1964) found that too early (September 28) and too late (October 29) planting reduced the height of toria. Majumder and Sandhu (1964) reported that sowing in October was superior with respect to growth characteristics in sarson. BARI (1992) also reported that sowing date had no influence on plant height.

2.2.5 Number of siliquae plant^{-1}

Shivani *et al.* (2002) experimented sowing on September 25 and October 5 recorded significantly higher number of siliquae plant^{-1}. Number of siliquae plant^{-1} was significantly influenced by sowing date.

Buttar and Aulakh (1999) found pods plant^{-1} were higher in October 25 (1st date) sowing. This was due to the fact that under earlier sown crop, the temperature and other climatological parameters played a major role for growth and yield attributes.

Mondal *et al.* (1999) stated that the highest number of siliquae plant^{-1} was found in the plants of third planting (1 November). The number of siliquae was less in the last two plantings and first planting.

Brar *et al.* (1998) stated that early sown crop produced higher number of siliquae plant^{-1} compared to late sowing. Sowing at October 30 and November 15 were at par with each other but further delay in sowing caused significant reduction in number of siliquae plant^{-1}.

Shahidullah *et al.* (1997) reported that number of siliquae plant^{-1} was decreased with delay in sowing among the three sowing dates on October 27, November 6 and November 16.

Mondal and Islam (1993) found that the highest number of siliquae plant^{-1} was in the plants of November 1 sowing and the lowest number of siliquae plant^{-1} was in the plants of December 1 sowing.

Mondal *et al.* (1992) stated that number of siliquae plant^{-1} decreased in late planting.

According to Saran and Giri (1987) pods plant^{-1} decreased gradually from early (October 15) to later (October 25; November 5 and November 15) sowings. Ghosh and Chatterjee (1988) also reported that fifteen days to one month delay in sowing produced 24 to 57% reduced pods m^{-2}.

Uddin *et al.* (1986) reported that numbers of siliqua plant^{-1} were generally reduced with delay in sowing among the four sowing dates on October 25, November 4, November 14 and November 24.

The number of pods plant^{-1} is an important yield contributing character having the greatest effect on seed yield on rape and mustard (Mendham and Scott, 1975, Thurling, 1974a Rahman *et al.* 1988). Mendham *et al.* (1981) strongly pointed out that delayed sowing always reduced the number of pods plant^{-1}.

Scott *et al.* (1973) observed that late sowing produced minimum number of pods plant^{-1}. It occurred due to rapid inflorescence initiation, insect and disease pest infestation and frost damage. On the other hand, several scientists observed that early sowing produced too many pods plant^{-1} (Patel *et al.*, 1980; Mendham *et al.*, 1981, Chauhan and Bhargava, 1984; Uddin *et al.*, 1987 and Chay and Thurling, 1989).

2.2.6 Number of seeds siliqua^{-1}

Shivani *et al.* (2002) experimented sowing on September 25 and October 5 recorded significantly higher number of seeds siliquae^{-1} than that on October 15, October 25 and

November 4. Number of seeds siliqua^{-1} decreased progressively with delay in planting. Number of seeds siliqua^{-1} was significantly influenced by sowing date.

Angrej *et al.* (2002) observed that early sowing gives higher values of seeds per siliqua in mustard.

Mondal *et al.* (1999) stated that, the highest number of seeds siliqua^{-1} was found in the plants of third planting (November 1).

Shahidullah *et al.* (1997) reported that number of seeds siliqua^{-1} was decreased with delay in sowing among the three sowing dates on October 27, November 6 and November 16.

Seeds siliqua^{-1} in mustard is directly affected by sowing date (Beech and Norman, 1964; Ghosh and Chatterjee, 1988). Ghosh and Chatterjee (1988) stated that one-month delay in sowing decreased seeds pod^{-1} by 23 %. Saran and Giri (1987) also observed that delayed sowing decreased seeds pod^{-1} and 1000-seed weight in several other trials (Ansari *et al.*, 1990; Uddin *et al.*, 1987; Kalra *et al.*, 1985; Scott *et al.*, 1973; Beech and Norman, 1964).

2.2.7 Length of siliqua

Siliqua lengths of the varieties of rapeseed vary by the environmental effects. By making variation in sowing date we can find various length of siliqua in rapeseed.

Hossain *et al.* (1996) found significant variation in siliqua length due to planting time. In each case length decreased from first date to 4^{th} date of sowing. i.e. delayed sowing reduced the siliqua length.

BARI (1992) conducted an experiment during rabi season at Joydebpur, Jessore, Ishurdi and Rajshahi. Five dates of planting (October 1, October 16, November 1, November 16 and December 1) and two genotypes of rapeseed were used. Significant variations due to different dates of sowing were found in respect of siliqua length and other traits. Siliqua length showed decreasing tendency with delay in sowing. Highest length (6.8 cm) was found from October 15 sowing and lowest (5.8 cm) in December 1 sowing.

2.2.8 Thousand seed weight

Shivani *et al.* (2002) experimented that, 1000-seed weight was significantly influenced by sowing date. Sowing on September 25 and October 5 recorded significantly higher 1000-seed weight than that on October 15, October 25 and November 4. 1000-seed weight decreased progressively with delay in planting.

Mondal *et al.* (1999) stated that, 1000 seed weight reduced with the delayed planting time.

Ghosh and Chatterjee (1988) reported that one month later planting produced 32% reduction in seed weight. Saran and Giri (1987) observed that sowing in October 25 gave 11 % higher 1000-seed weight than that of November 15 sowing.

Delayed sowing in oilseed rape severely reduces 1000-seed weight (Mendham *et al.*, 1981; Scarisbrick *et al.*, 1981; Scott *et al.*, 1973).

Majumder and Sanddhu (1964) found highest 1000-seed weight in October 1sowing. Delayed sowing decreased the seed weight (Lutman and Dixon, 1987). Similar findings were reported by many scientists (Ansari *et al.*, 1990; Scot *et al.*, 1973; Uddin *et al.*, 1986; Kalra *et al.*, 1985; Beech and Norman, 1964).

2.2.9 Grain yield

Time of sowing is very much important for cultivation of rape and mustard in that it has a direct effect on seed yield. This view was supported by many researchers who had performed experiments all over the world. In general, early plantings of rapeseed give higher seed yield than late sowing. Individual genotypes also differ in seed yield from one planting date to another. The optimum sowing time of individual genotype differs from place to place depending on environment and edaphic conditions.

Patel *et al.* (2004) observed that Indian mustard seeds were sown on November 8, November 18 and November 28, and December 8 and December 18 in a field experiment conducted in India during winter of 1995-98. The yield of Indian mustard decreased with delay in sowing. The highest seed yield (1409 kg/ha) was recorded with November 8 sowing. The critical period of mustard exposure to aphids was during the flowering stage of the crop. The aphid population increased in December.

Panda *et al.* (2004), a field experiment was conducted during the winter season of 1997-98 on sandy-loam soil in New Delhi, India, to study the effect of dates of sowing

(October 16, October 31 and November 15) on Indian mustard (*B. juncea*). The crop sown on October 16 recorded a higher seed yield (1945 kg ha^{-1}) than the crops sown on October 31 (1556 kg ha^{-1}) and November 15 (872 kg ha^{-1}). Delayed sowing beyond October 16 significantly reduced yields.

Sihag *et al.* (2003) found that among the sowing dates October 15, October 30, November 14 and November 29 the highest dry matter accumulation at 90 days of crop growth (31.07 g $plant^{-1}$) and at harvest (42.40 g $plant^{-1}$) was obtained in October15 sown crops. The highest seed (21.50 q ha^{-1}) was obtained in October 15 sown crops.

Razzaque *et al.* (2002) mentioned that, the crop sown on November 15 recorded the highest seed yield (1164.4 kg ha^{-1}) but it did not differ significantly from that of November 23 sowing (1001.9 kg ha^{-1}). Inferior yield was obtained from December 7 (612 kg ha^{-1}) sowing which was identical to that from November 30 (700.6 kg ha^{-1}) due to the high temperature at reproductive stage.

Angrej *et al.* (2002) found that, the highest yield was obtained when the crop was sown between October 10 and October 30. Yield reductions of 26.4 and 40.2 % were obtained when sowing was delayed to November 20 and December 10, respectively.

BARI (2001) reported that at Joydebpur location seed yield and other yield contributing characters were significantly varied among the dates of plantings.

Panwar *et al.* (2000) reported that yield of *Brassica* spp. decreased when sown on November 5 (mean 1.17 t ha^{-1}) compared with October 5 or October 20 (1.70 and 1.77 t ha^{-1}

respectively). Brar *et al.* (1998) reported that seed yield was influenced by sowing date. The highest yield was given by sowing on August 13 or September 5.

Buttar and Aulakh (1999) observed that the seed yield of Indian mustard obtained was significantly higher when the crop was sown on October 25 than sown on November 15 and September 5. Shastry and Kumar (1981) and Narang and Singh (1987) also made similar observations.

Mondal *et al.* (1999) showed that, the highest seed yield ha^{-1} (1.39 t) was from third planting (November 1) compared with the first and last four planting dates.

BARI (1999) stated that different sowing time significantly influenced the yield of mustard. Significantly highest yield grain yield was obtained from November 19 sowing. Yield reduction was (31 to 72%) when mustard was sown in December and 28 % in October 29 sowing.

Brar *et al.* (1998) stated that crops sown on October 30 recorded highest seed yield (16.5 q ha^{-1} than November 30 and December 15 sowings. Chakraborty *et al.* (1991) reported that early sowing (October 16) produced 24 % higher seed yield than that of later sowing (November 2). Ghosh and Chatterjee (1988) stated similar results in their experiment with sowing date.

Nair (1998) stated that mean grain yield in both the years among the varieties decreased with later sowing.

Yadav *et al.* (1996) observed that a 2-year field experiment was conducted during the winter seasons of 1988-89 and 1989-90 at Morena, Madhya Pradesh, to investigate the effects of sowing date (October 17 or October 27, November 6 or November 16) on the seed yield of *Brassica juncea* cv. Pusa Bold. Early sowing (October) resulted in significantly higher seed compared with later sowing.

Mondal and Islam (1993) found that the highest seed yield plant^{-1} and seed yield ha^{-1} were obtained from the October 15 sowing which were similar to November 1. Seed yield decreased with delayed sowing.

Mondal *et al.* (1992) reported that the highest seed yield ha^{-1} (1.45 t) was from second planting (October 16) and was significantly different from last planting (November 16).

Zaman *et al.* (1991) suggested that October 18 and October 28 were better over November 7 for higher yield, and higher yield was attributed by pods plant^{-1} and seed pod^{-1}. They observed that the seed yield decreased generally with the delay in sowing in all varieties. This view was strengthened by the finding of Uddin *et al.* (1987).

Joshi *et al.* (1989) reported that sowing too early and too late resulted in seed reduction due to natural hazards like insect pest and disease infestation. Early sowing reduced seed yield than in late sowing (mid July-mid August) since the former had a risk of rotting.

An investigation was carried out during two rabi seasons (1989/90 and 1990/01) in Patna, Bihar, India, to study the effect of sowing date (October 20-25, November 5-15 and November 20-25) on seed yield of Indian mustard (*B. juncea*) cv. Varuna. There was a significant decrease in seed yield with the advancement of sowing date. The maximum seed yield was obtained from October 20-25 sown crop (1735 kg ha^{-1}) Kumar *et al.* (2003).

In India, several studies on date of planting on mustard and rapeseed indicate that a suitable sowing time for higher seed yield is specified for a particular area. Best time in Punjab is the last week of September (Maini *et al.*, 1964); In West Bengal and in Haryana, it was last week of October (Ghosh and Chatterjee, 1988; Bishnoi and Singh, 1979; Sen and Sur, 1964; Vacchani, 1952).

Singh (1988) and Saran and Giri (1987) reported that delay in sowing by two and four weeks produced respectively 27 % and 57 % lower yields compared to normal planting time.

2.2.10 Stover yield

BARI (2001) reported that sowing date have effect on stover yield. In sowing time November 16 stover yield (3991 kg/ha^{-1}) was higher than December sowing 3 (2417.56 kg/ha^{-1}).

Brar *et al.* (1998) stated that straw yield of mustard decreased significantly with the each delay in sowing.

Islam *et al.* (1994) stated that stover yield was significantly influenced by sowing time. Higher stover yield was observed in October 20 sowing that gradually decreased in December 02 sowing.

Chakraborty *et al.* (1991) stated that delayed sowing significantly reduced stover yield. October sown crops produced higher dry matter than in November sown ones.

Ghosh and Chatterjee (1988) obtained higher dry matter accumulation from an October sown mustard compared to a crop sown in November.

Sowing time directly influenced plant dry weight (stover yield). Lutman and Dixon (1987) pointed out that sowing in oil seed rape beyond mid September produced significantly less vigorous plant and ultimately produced lower crop dry weight compared to early sown crops.

2.2.11 Biological yield

Sihag *et al.* (2003) a field experiment was conducted in Bikaner, Rajasthan, India, during the 1998/99 rabi season to determine the effect of sowing date (October 15, October 30, November 14 and November 29) of Indian mustard. The highest biological yield (65.23 q ha^{-1}) was obtained in October 15 sown crops.

Islam and Razzaque (1999) stated that biological yield reduced in general with delaying the day of sowing. Highest biological yield was obtained mainly between the first and second date of sowing. The last date of sowing (December 1) reduced biological yield.

The dry weight of rape plants in the autumn and winter was severely reduced by delay in drilling (Lutman and Dixon, 1987). Thurlilg (1974 a) reported significant correlation between yield and total dry weight of total plant in both *B. campestries* and *B. napus*. High temperature at vegetative stage was conducive to high dry matter production (Degenhardt and Kondra, 1981). Dry matter accumulation/ plant in the late sown crop was less at all stages of crop growth as reported by Saran and Giri (1987).

Majumder and Sandhu (1964) reported that the highest dry matter production was obtained from October 1 sowing compared to each October 16 and November 4 plantings. In their another study, higher dry matter production was obtained from planting on September 29 than from planting on September 4 and October 24 (Maini *et al.*, 1964) and it helped to produce higher biological yield. Ghosh and Chatterjee (1988) made similar observations.

2.2.12 Harvest index

Gfadakar *et al.* (1988) stated that seed yield and dry matter accumulation was positively correlated with heat unit accumulation. The accumulation of heat unit varied with growth stage, variety and sowing time. The temperature fluctuation caused the variation in the accumulation of thermal units in plants and it affected harvest index.

CHAPTER III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site and soil

The experiment was conducted at the Agronomy Field Laboratory of Sher-e-Bangla Agricultural University, Dhaka in the Rabi season during the period from October 2004 to February 2005. The soils of the experimental plots belong to the agro-ecological zone of the Madhupur soil tract (AEZ-28) of Nodda soil series, silty loam in texture with 29.97 % sand, 54.86 % loam and 15.28 % clay particles.

The mechanical and chemical composition of the soil as obtained from soil analysis is shown in Appendix B.

3.2 Climate

The experimental site lies in the sub-tropics where rainfall is minimum and temperature is moderately low during the rabi season (April to September). The monthly total rainfall, average sunshine hours, temperature and relative humidity during the study period have been shown in Appendix C.

3.3 Plant materials

Seeds of three rapeseed varieties namely improved Tori-7, BARI Sarisha-8 and BARI Sarisha-9 were collected from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Gazipur. 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.

3.4 Treatments

The experimental treatments are as follows:

A. Variety: 3

Improved Tori-7 (V_1)

BARI Sarisha-8 (V_2)

BARI Sarisha-9 (V_3)

B. Date of sowing: 4

October 20 (S_1)

November 04 (S_2)

November 19 (S_3)

December 04 (S_4)

3.5 Experimental design and lay out

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Factorial arrangements of treatments within the plot were made at random. Size of unit plot was 3m x 2m and the total number of plots were 36 (12 x 3). The spacing between the block and plots were 1m x 0.5 m respectively.

3.6 Land preparation

The land was first opened with a tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing and harrowing with country plough and ladder. The stubble and weeds were removed. The first ploughing and the final land preparation were done on October 10 and October 15, 2004 respectively.

3.7 Fertilizer application

The experimental plots were fertilized with the recommended fertilizer dose as given below:

i. Urea : 250 kg/ha

ii. TSP :180 kg/ha

iii. MP :100 kg/ha

iv. ZnO2 :5 kg/ha

v. Gypsum :150 kg/ha

vi. Boric Acid :10 kg/ha

Half of the urea and full amount of other fertilizers were broadcasted during final land preparation. Rest half of urea was top-dressed before flowering of each sowing.

3.8 Germination test

Germination test was performed before sowing the seeds in the field. For laboratory test, petridishes were used. Filter paper were placed on petridishes and the papers were soft with water. Seeds were distributed at random in petridish. Data on emergence were collected on percentage basis by using the following formula:

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

3.9 Sowing of seeds

Seeds were sown in lines continuously and line to line distance maintained was 30 cm. Seeds were placed 2 cm depth and then rows were covered with loose soil properly. The seed rates were used as 9 kg ha^{-1} for BARI Sarisha-8 and 7 kg ha^{-1} for BARI Sarisha-9 and Improved Tori-7. Seeds were sown on different dates according to treatment specification.

3.10 Weeding and Thinning

The crop field was weeded twice, first weeding followed by thinning was done after 12 days of emergence and 20 days after emergence. Thinning was done once in all the unit plots with care so as to maintain a uniform plant population in each plot.

3.11 Irrigation

Pre sowing irrigation was done for all the sowings to maintain equal germination. One irrigation was given at 25 days of sowing i.e. before flowering for all the treatments.

3.12 Application of pesticides

Late planted crops were attacked by aphids (*Lipaphis erysimi*. K) especially Improved Tori-7 and BARI Sarisha-9 at the time of flowering. 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.

3.13 Harvesting and threshing

The crop maturity varied with varieties and date of sowing. When 70-75 % siliquae of rapeseed became straw in colour the plants were harvested. Harvesting started on January 05 and completed on February 28, 2005. One squire meter area was harvested and yield recorded, was multiplied by six to get unit plot yield. The harvested plants were tied into bundles and carried to the threshing floor. The crops were sun dried by spreading on the threshing floor. The seeds were separated from the siliqua by beating with bamboo sticks and later were cleaned, dried and weighed. The weights of the dry straw were also taken.

3.14 Sampling and data collection

Ten sample plants were selected at random from each plot. The selected plants of each plot were uprooted carefully by a khurpi and washed in running tape water to remove the soil. The heights of plants were measured with a graduated scale placed on the ground level to top of the leaves. Number of branches, number of siliquae, siliqua length, number of grain *siliqua*$^{-1}$, weight of thousand seeds and shelling percentage were recorded separately. From each plot the weight of the straw were taken. Biological yield and the harvest index were also calculated from this data.

The parameters studied in the experiment were as follows:

i) Days to first flowering

ii) Days to 50% flowering

iii) Days to final flowering

iv) Days to maturity

v) Number of branches plant^{-1}

vi) Plant height (cm)

vii) Number of siliquae plant^{-1}

viii) Number of seeds siliqua^{-1}

ix) Length of siliqua (cm)

x) Weight of 1000 seed (g)

xi) Shelling percentage

xii) Grain yield (kg ha^{-1})

xiii) Stover yield (kg ha^{-1})

xiv) Biological yield (kg ha^{-1})

xv) Harvest index (%)

3.15 Procedure for data collection at and after harvest

Days to flowering

The dates of first flowering, 50 % flowering and 100 % flowering were recorded from the experimental field.

Days to maturity

When 70-75% plants were straw colour, plants were harvested and counted the days from emergence to maturity.

Number of branches plant^{-1}

The number of branches plant^{-1} was counted from preselected ten plants and mean values were taken.

Plant height (cm)

The heights of ten plants from each treatment were measured with a meter scale from the ground level to the top of the plants and mean height was expressed in cm.

Number of siliquae plant^{-1}

Number of total siliquae of pre selected ten plants from each unit plot was noted and the mean number was recorded. The number of siliquae of each plant was counted and the mean was recorded.

Number of seeds siliqua^{-1}

The number of seeds were counted randomly taking 10 siliquae per treatment.

Length of siliqua (cm)

The length of the siliqua was measured from the base of the pod to the tip of the pod.

Weight of 1000 seeds (g)

The weight of thousand seeds were measured by taking seeds randomly from each plot and finally expressed in dry weight basis.

Shelling percentage

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

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

Grain yield (kg ha^{-1})

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

Stover yield (kg ha^{-1})

The weight of the plants containing grain was taken. By subtracting the grain weight from the total weight. The stover weights were calculated after threshing and separation of grain from the sample area and then expressed in kg ha^{-1} in dry weight basis.

Biological yield (kg ha^{-1})

The summation of grain yields and stover yields were considered as biological yields. Biological yield was calculated by using the following formula,

Biological yield = Grain yield + stover yield, (dry weight basis).

Harvest index (%)

The harvest index was calculated on the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100.$$

3.16 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT computer package program. The mean differences among the treatments were compared by Least Significant Difference Test.

CHAPTER IV

Results and Discussion

CHAPTER IV

RESULTS AND DSCUSSION

This chapter comprises with presentation and discussion of the results obtained from the study to observe the effects of date of sowing and variety on seed yield and yield attributes of rape seeds. Treatment effects on yield and yield attributes are presented in Table1-4 and Figure 1-15. Summary of analysis of variance of different parameters and correlation matrix are also given in appendices D-E.

4.1 Flowering date

Days to first flowering and that of final flowering of rapeseed varieties differed significantly for all the sowing dates. (Appendix D.01-03)

The variety Improved Tori-7 as revealed from Table 1 took the shortest period in both starting and ending of flowering. The starting and ending of flowering periods of Improved Tori-7 were 20.08 and 36.50 days respectively followed by 25.75 and 37.42 days of BARI Sharisha-9 and 29.08 and 41.92 days of BARISharisha-8. Improved Tori-7 is known as an early variety and as such it showed early flowering habit as supported by Khaleque (1985) who reported that Tori-7 is an early grown variety. BARI Sharisha-9 flowered later than Improved Tori-7 but earlier than BARI Sharisha-8.

Days to first flowering showed a pronounced effect on sowing date (Table 2). Period taken in first flowering or starting of flowering varied significantly from one sowing date to another. First sowing date (October 20) required highest period (28.67 days) for starting of flowing and this was statistically higher than 24.89 days of November 4 sowing (2nd sowing date) and again the period taken in November 4 sowing was statistically higher than that of November 19 sowing (3rd sowing) but the period (23 days) taken in December 4 sowing (last sowing) was similar to that of 3rd sowing date (November 19). In case of 50 % and final flowering there was a bit variation in the period taken/required for flowering. In both the cases November 4 (2nd sowing) took the shortest period 28.56 days and 35.0 days respectively for 50 % and ending of flowering. But in the 3rd (November 19) and 4th sowing (December 4) there was a gradual rise of the period in 50 % and ending of flowering. So November 19 sowing took respectively 33.78 and 39.33 days for 50 % and final flowering, which are statistically also superior to 31.22 and 37.56 days required for December 4 sowing date.

From the Table 2 it reveals that delay in sowing reduces the days to flowering. In October 20 sowing took 28.67 days for flowering while 23 days were required for the same in December 4 sowing. Similarly 36.11 and 42.56 days were required for 50 % and final flowering in October 20 sowing while 31.22 and 37.56 were days required for the same in December 4 sowing. There is a regular downward trend in the days to first flowering in each successive sowing date but in case of 50 % and final flowering the trend is not regular in successive sowing date.

4.2 Days to maturity

The analysis of variance presented in appendix D.02 indicated that days to maturity was significantly influenced by sowing date, variety and interaction of sowing date and variety.

Result shows that maturity period was significantly different from variety to variety. Improved Tori-7 was the shortest in maturity period (70.50 days) and BARI Sharisha-8 was the longest (82.75 days) while BARI Sharisha-9 was in the middle position (71.75), statistically being different from that of Improved Tori-7 (Table 1). These findings are in agreement with Khaleque (1985) who stated that Tori-7 was early grown variety.

Early sowing took long duration and late sown crops matured earlier. The October 20 sown rapeseed required 78.33 days to attain maturity which was statistically higher from those of other sowing dates (Table 2). These findings were in agreement with the observation of Mondal *et al.* (1993) who reported that the maturity period become gradually shorter with the delayed sowing as late sowing plants had to face little warm temperature during vegetative stage. Thus the growth become slow resulting longer maturity period. He also reported that delay sowing plants completed vegetative growth earlier than the plant of early sowing. Depauw (1976) and Bajpai *et al.* (1981) also reported that late sowings enhanced early maturity.

The variety and sowing date interaction effect showed significant variation in maturity period (ANOVA Table appendix D.02). The longer maturity period (84 days) was found in BARI Sharisha-8 with October 20 sowing and the shortest (66 days) was found in

Improved Tori-7 with December 4 sowing (Figure 1). The maturity period, 82 days obtained in BARI Sarisha-8 on last sowing date (December 4) was higher than each of maturity periods obtained in BARI Sarisha-9 and Improved Tori-7. From the Figure 1 it is evident that delayed sowing resulted in the declination of maturity in three varieties. The effect was distinct in Improved Tori-7, the maturity period being 75 days in 1st sowing date (October 20) came down to 66 days at last sowing date (December 4). In BARI Sarisha-8 there was only 2 days delay in maturity period from 1st sowing date to last sowing date i.e. from 84 days to 82 days. Maturity period was also shortened in BARI Sarisha-9 due to late sowing and it came down from 76 days (1st sowing date) to 69 days (last sowing date).

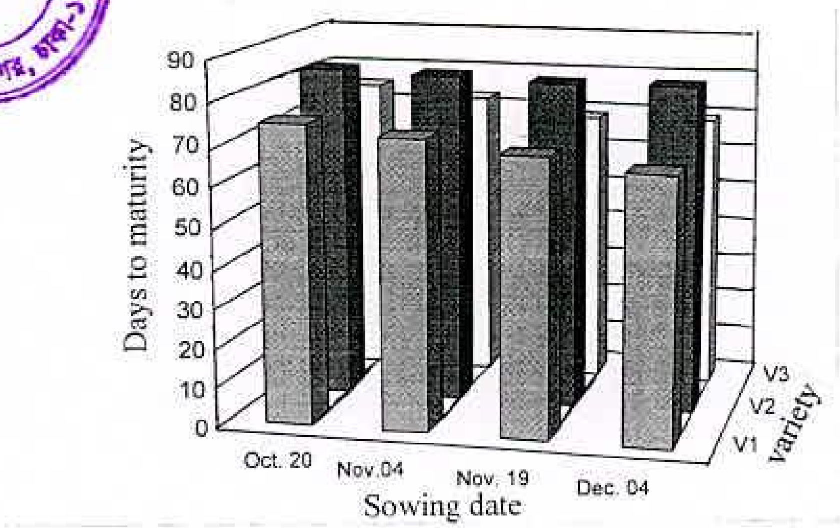

Figure 1. Interaction effect of variety and sowing date on maturity of rapeseed

4.3 Number of branches plant^{-1}

The analysis of variance table (Appendix D.05) revealed that the difference of average number of primary branches plant^{-1} was significant at 1 % level of probability for sowing date, for variety and for interaction of sowing date with variety.

BARI Sarisha-8 and BARI Sarisha-9 were found to produce the same number of branches plant^{-1} (3.592) which was significantly higher than that obtained from Improved Tori-7 (3.025) (Table 1).

In respect of formation of primary branches on different sowing dates as revealed from Table 2, November 4 sowing showed the highest number of branches (4.233), which was statistically higher than those, obtained on October 20 (3.867), November 19 (3.022) and December 4 (2.489) sowing. The results are in agreement with those of Thurling (1974a) who observed a marked effect on branches by variation in sowing dates. Islam *et al.* (1994) also reported that delay in sowing suppressed the number of primary branches plant^{-1}.

The interaction effect of varieties and sowing dates on number of branches plant^{-1} as is observed in Figure 2, November 4 sowing with BARI Sarisha-9 showed the highest number of branches plant^{-1} (4.80). The lowest number of branches plant^{-1} (2.033) which was found to be produced by BARI Sarisha-9 on December 4 sowing was lower than those of BARI Sarisha-8 (2.767) and Improved Tori-7 (2.667) on the same sowing date (Figure 2).

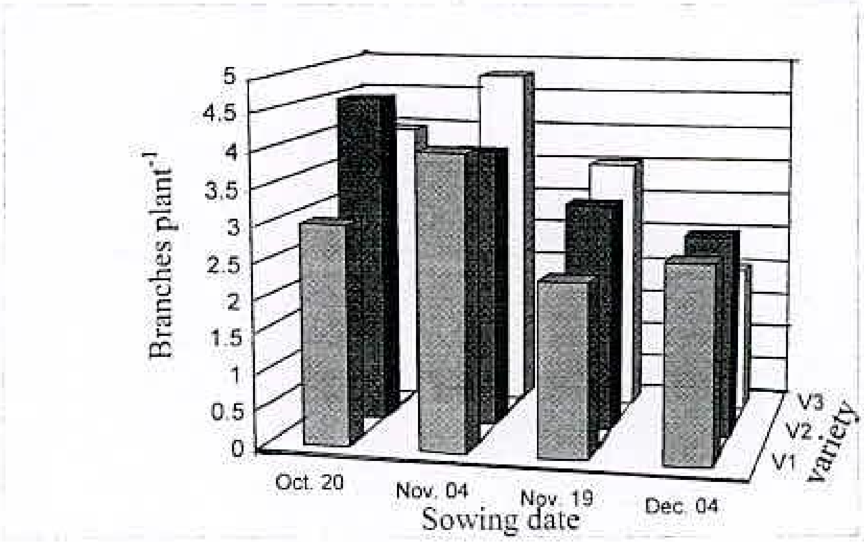

Figure 2. Interaction effect of variety and sowing date on number of branch plant $^{-1}$ of rapeseed

4.4 Plant height (cm)

The plant height was highly significant for all sowing dates and varieties as revealed from the analyses of variance Table D.06.

The higher plant stature (76.37 cm) produced by the variety BARI sarisha-8 as revealed from the Table 1 was highly significant and was different from those of BARI Sarisha-9 (72.18 cm) and Improved Tori-7 (59.91 cm). The plant height obtained in BARI Sarisha-9 (72.18 cm) was statistically different from that of Improved Tori-7 (59.92). The results are in agreement with Ali *et al.* (1985) who also reported that significant variation in plant height among the different varieties of mustard and rape. It is also similar to Islam *et al.* (1994) who stated that Tori-7 produced significantly shorter plants.

Plant height differed significantly on different sowing dates. Delayed sowing in general lowered plant height (Table 2). A significant lower plant height was observed on December 4 sowing (47.97 cm), which resulted in about 50 % shorter plants compared to that of October 20 sowing (82.78 cm). Plant height observed on November 4 sowing was 75.37 cm which was statistically higher than that of November 19 sowing (71.84 cm). The results are in agreement with those of Mondal (1986) and Ansari *et al.* (1990), who observed that delayed sowing produced significantly dwarf plants irrespective of varietal considerations.

On average October 20 sowing with the three-rapeseed varieties showed significantly higher plant heights than those of other sowing dates except BARI Sarisha-9 where higher plant height was obtained in November 4 (83.23 cm) which was similar with that of October 20 (82.97 cm) and the plant height obtained in BARI Sarisha-8 with November 4 sowing

(83.60 cm). There was observed a significant decreasing trend of plant height all over the sowing dates in the three varieties. The highest plant height (88.87 cm) obtained in BARI Sarisha-8 was statistically different from all the plant heights, 83.60 cm, 76.47 cm and 56.53 cm obtained respectively from November 4, November 19 and December 4 sowing in BARI Sarisha-8 as well as with plant heights obtained in BARI Sarisha-9 and Improved Tori-7 of all the sowing dates (Figure 3). Improved Tori-7 showed lowest plant heights all over the sowing dates (Figure 3). In Improved Tori-7 plant height due to interaction effect came down from 76.50 cm (October 20 sowing) to 40.57 cm (last sowing date). It is reveled from the Figure 3. that the interaction effect did not affect so much in reducing plant height in BARI Sarisha-8 and BARI Sarisha-9 up to November 19. The plant height came down from 88.87 cm to 76.47 cm in BARI Sarisha-8 and that of BARI Sarisha-9 from 83.23 cm to 75.73 cm. Worst reduction in plant height was caused on December 4 sowing. In December 4 sowing plant height reduced in BARI Sarisha-8 from 88.87 cm to 56.53 cm being less 32.34 cm. Similarly it was also in BARI Sarisha-9 where it was reduced from 82.97 cm to 46.80 cm i.e. 36.17 cm less. Similar results were observed by Uddin *et al.* (1986).

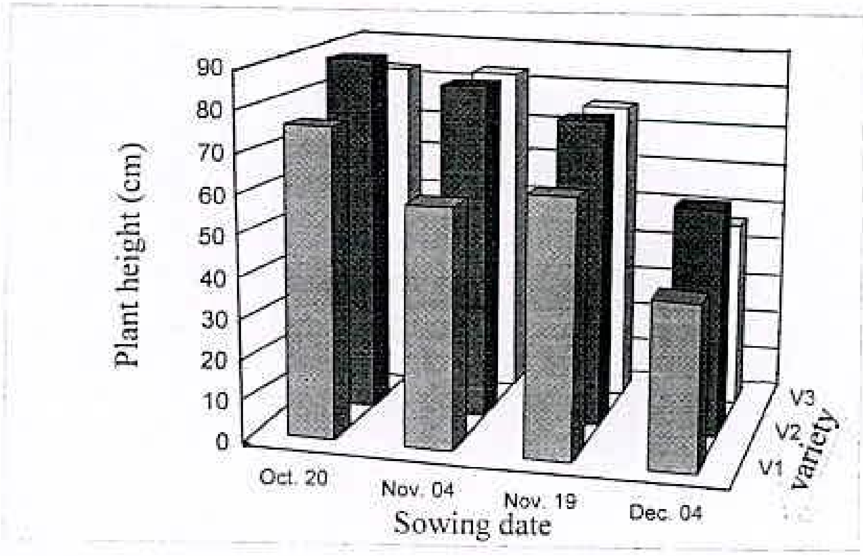

Figure 3. Interaction effect of variety and sowing date on plant height of rapeseed

Table 1. Effect of varieties on the growth pattern of rapeseed

	Growth Pattern					
Varieties	Flowering (days)			Maturity (days)	Branch plant^{-1}	Plant height (cm)
	First	50 %	Final			
Improved Tori-7	20.08	30.17	36.50	70.50	3.025	59.92
BARI Sarisha-8	29.08	34.67	41.92	82.75	3.592	76.37
BARI Sarisha-9	25.75	32.42	37.42	71.75	3.592	72.18
LSD	0.7750	0.7068	0.8261	0.2091	0.1284	2.367
CV (%)	3.67	2.58	7.99	0.33	4.43	4.02

Table 2. Effect of sowing date on the growth pattern of rape seed

	Growth Pattern					
Sowing date	Flowering (days)			Maturity (days)	Branch plant^{-1}	Plant height (cm)
	First	50 %	Final			
October 20	28.67	36.11	42.56	78.33	3.867	82.78
November 04	24.89	28.56	35.0	76.00	4.233	75.37
November 19	23.33	33.78	39.33	73.33	3.022	71.84
December 04	23.00	31.22	37.56	72.33	2.489	47.97
LSD	0.8949	0.8162	0.9539	0.2415	0.1483	2.734
CV (%)	3.67	2.58	7.99	0.33	4.43	4.02

4.5 Number of siliquae plant^{-1}

The number of siliquae plant^{-1} exhibited significant variation at 1 % level for variety sowing date and also for the interaction effect of sowing date and variety (Appendix D.07).

It reveals from the table 3 that BARI Sarisha-8 produced the highest no. of siliquae plant^{-1} (83.87) which was significantly different from 75.97 of Improved Tori-7 and 76.10 of BARI Sarisha-9 but the later two are identical to each other. Islam *et al.* (1994) reported that significant variation in siliquae plant^{-1} was found in different varieties of mustard.

It is observed from the Table 4 that there was a gradual reduction in number of siliquae plant^{-1} with delay in sowing. October 20 sowing produced the highest number of siliquae plant^{-1} (122.5) which was significantly higher than that of November 4 sowing (86.77). December 4 sowing being significantly the lowest (32.02). This finding is in conformity with the findings of Rahman *et al.* (1988); Mendham and Scott (1975); Thurling (1974a), who observed that delay in sowing reduced the number of siliquae plant^{-1}.

Interaction of variety and date of sowing reveals from the Figure 4 that like varietal effect on siliquae plant^{-1}, Improved Tori-7 of October 20 sowing produced highest number of siliquae plant^{-1} (132.90), which was statistically similar to that of BARI Sarisha-8 of October 20 sowing (129) but higher than those of later sowing as well as from that of BARI Sarisha-9 of the same sowing date (105.50). In respect of siliquae plant^{-1} the datum obtained on October 20 sowing in BARI Sarisha-9 though statistically lower than those of Improved Tori-7 and BARI Sarisha-8 of October 20 sowing but statistically higher than all the other data of siliquae plant^{-1} obtained in afterwards sowing of irrespective of varieties. There was also pronounced effect of delayed sowing date on the formation of siliquae plant^{-1}. A progressive reduction in siliquae plant^{-1} was observed in all the varieties (Figure 4). However the reduction trend was higher in Improved Tori-7 and BARI Sarisha-9 compared to that in BARI Sarisha-8. December 4 sowing produced the number of siliquae plant^{-1} in Improved Tori-7 as 15.63 which was statistically lower than that of BARI Sarisha-9 (20.87) of the same sowing date but statistically both are lower than that of BARI Sarisha-8 (59.57) of the same sowing date.

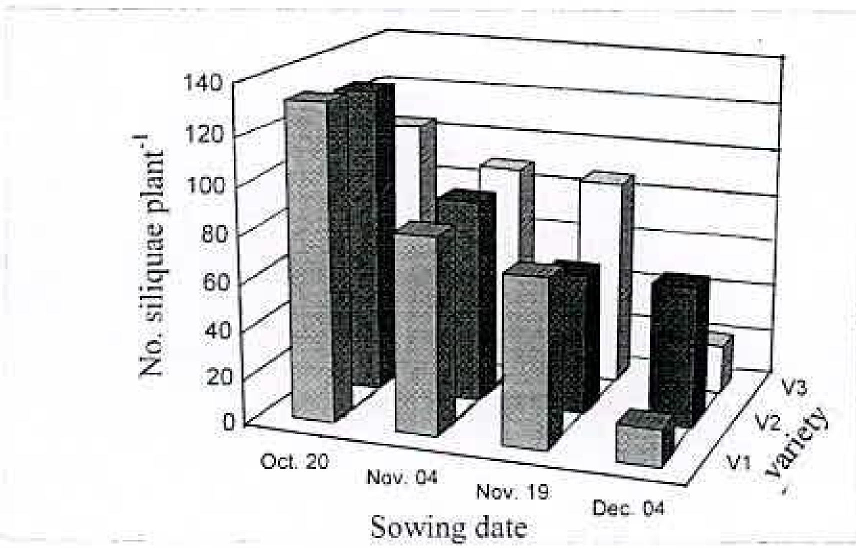

Figure 4. Interaction effect of variety and sowing date on sillique plant^{-1} of rapeseed

4.6 Number of seeds siliqua^{-1}

From the analysis of variance table (Appendix D.08), it revealed that number of seeds siliqua^{-1} significantly differed from variety to variety and from sowing date to sowing date and also from their interaction effect at 1 % level of probability.

Among the varieties BARI Sarisha-8 produced significantly higher number of seeds siliqua^{-1} (26.70) than that of BARI Sarisha-9 (13.62) and Improved Tori-7 (11.30) but BARI Sarisha-9 produce significantly higher number of seeds siliqua^{-1} than Improved Tor-7 as revealed from Table 3. Variation in seeds siliqua^{-1} among the varieties was 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.

October 20 sowing produced higher number of seeds siliqua^{-1} (Table 4). A significant lower seeds siliqua^{-1} was observed in December 4 sowing (8.778). Seed siliqua^{-1} observed in November 4 was 20.21 which was statistically higher than that of November 19 sowing (16.92). This result is in conformity with the findings of Mondal *et al.* (1992), who stated that November 1 sowing gave higher seed siliqua^{-1}. Gosh and Chatterjee (1988) also observed decreased seeds siliqua^{-1} in rapeseed due to late sowing.

Interaction effect of variety and sowing date on number of seeds siliqua^{-1} showed significant variation (Appendix D.08). BARI Sarisha-8 showed significantly superior results compared to other varieties on all sowing dates. BARI Sarisha-8 produced lowest no of seeds siliqua^{-1} (19.23) on December 4 but it was significantly superior to those of other varieties with all the sowing dates except October 20 sowing (19.73) of BARI Sarisha-9. However on

BARI Sarisha-8 the sowing date, October 20 was statistically superior to produce number of seeds siliqua^{-1} (32.27) which was followed by November 4 (28.93) and November 19 (26.37) where November 4 being statistically superior to November 19. Improved Tori-7 variety showed poorest results (no. of seeds siliqua^{-1}) all over the sowing periods having the lowest no of seeds siliqua^{-1} (3.267) on December 4 sowing (Figure 5).

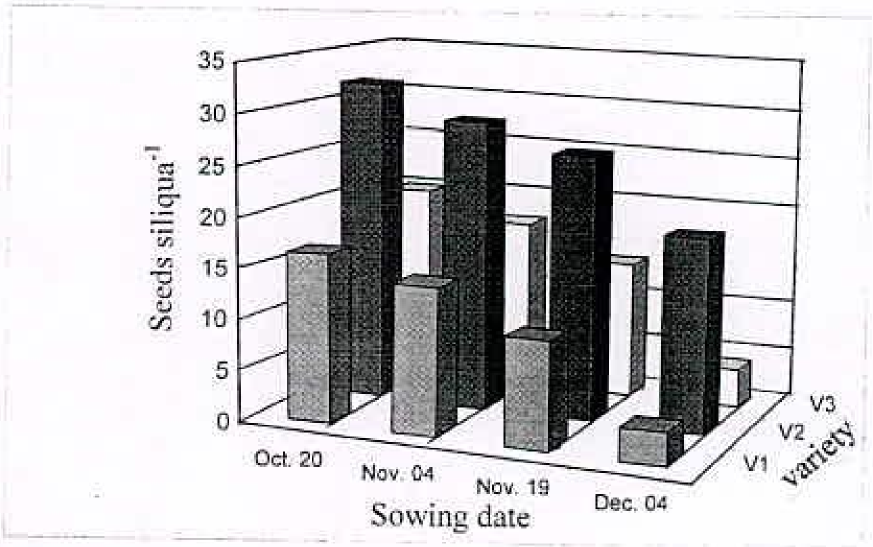

Figure 5. Interaction effect of variety and sowing date on number of seed silliqua^{-1} of rapeseed

4.7 Siliqua length (cm)

From the analysis of variance (Appendix D.09), it was found that siliqua length varied significantly from variety to variety and from date of sowing to date of sowing and also from the interaction of sowing date and variety at 1 % level.

Among the three-rapeseed varieties under study BARI Sarisha-8 was found to produce longer siliqua than those of Improved Tori-7 and BARI Sarisha-9 (Table 3). The siliqua length (6.522 cm) produced in BARI Sarisha-8 was statistically higher than 3.757 cm and 3.427 cm produced respectively in BARI Sarisha-9 and Improved Tori-7, the later being significantly lower than the former variety. Islam *et al.* (1994) observed a significant variation in siliqua length among the different varieties of mustard.

From the Table 4 it reveals that siliqua length differed significantly in each sowing date and it decreased in delay sowing. October 20 sowing date produced the significantly highest siliqua length (5.416 cm). November 4 sowing obtained the second highest siliqua length (4.679 cm), which was significantly superior to November 19 and December 4 sowing date. Similarly November 19 sowing date obtained significantly higher position in obtaining siliqua length (4.347 cm) then that of December 4 sowing date (3.842 cm). This finding is in conformity with Hossain *et al.* (1986) who reported that delayed sowing in December caused reduction in siliqua length.

The interaction between variety and date of sowing reveals from the Figure 6 that BARI Sarisha-8 produced the longest siliqua (7.867 cm) with 20 October sowing which was statistically superior to siliqua length 4.043 cm and 4.337 cm obtained respectably in Improved Tori-7 and BARI Sarisha-9 of October 20 sowing. Again 4.337 cm was statistically higher than 4.043 cm. It was further revealed from the Figure 6 that though there was a gradual reduction in siliqua length in each subsequent sowing of each variety, the siliqua length of BARI Sarisha-8 was always higher than that of other two varieties at each sowing date, even the siliqua length 5.063 cm obtained in BARI Sarisha-8 in the last sowing date (December 4) was higher than each of siliqua lengths obtained in BARI Sarisha-9 (4.337 cm) and Improved Tori-7 (4.043 cm) of the 1st sowing date. Further siliqua length of BARI Sarisha-9 at each sowing date was significantly different from those of Improved Tori-7.

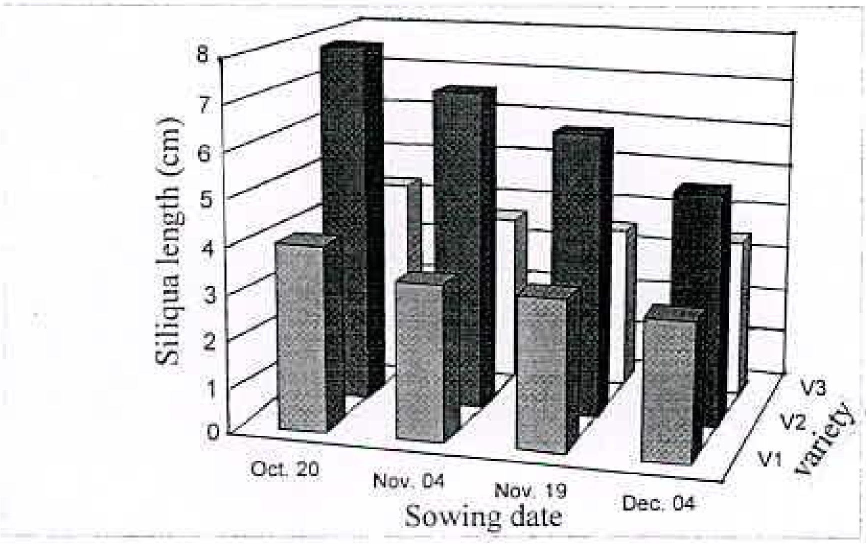

Figure 6. Interaction effect of variety and sowing date on silliqua length of rapeseed

4.8 1000 seeds weight (g)

The 1000 seeds weight as revealed from the analysis of variance (Appendix D.10) differed significantly at different dates of sowing and from variety to variety at 1 % level of probability.

From the Table 3 it is revealed that BARI Sarisha-8 had the highest 1000 seeds weight (3.342 g) which was statistically different from that of BARI Sarisha-9 (2.425 g) and Improved Tori-7 (2.446 g) while the later two were identical to each other. The presence of marked variations in seed size among different varieties has been endorsed by Ansari *et al.* (1990); Mondal and Wahab (2001) who described that weight of 1000 seeds vary from variety to variety and species to species. They found 2.40-2.52 g 1000 seeds weight in improved Tori-7 and 2.27 g in Tori-7.

The Table 4 shows that 1000 seeds weight on each sowing date was statistically different from one another. There was a gradual reduction in 1000 seeds weight in each subsequent delayed sowing date. The highest 1000 seeds weight (2.972 g) was found in October 20 sowing which was statistically higher than that obtained in November 4 sowing (2.778 g) and the later was statistically higher than that of November 19 sowing (2.628 g) and again November 19 sowing was statistically higher than that of December 4 sowing (2.572 g). This finding was in agreement with Saran and Giri (1987) who recorded 11 % higher 1000 seeds weight in October 20 sowing from 20 November sowing.

The interaction effect of BARI Sarisha-8 with different sowing dates on 1000 seeds weight performed better than those obtained from Improved Tori-7 and BARI Sarisha-9

(Figure 7). The interaction effect of BARI Sarisha-8 with October 20 sowing exhibited the highest 1000 seeds weight (3.517 g) which was identical to interaction effect of BARI Sarisha-8 with the sowing date of November 4 (3.450 g) but it was statistically higher than that of November 19 sowing of BARI Sarisha-8 (3.217 g) as well as from that of December 4 sowing (3.183 g). Of course, the interaction effect of BARI Sarisha-8 with December 4 sowing was higher than the interaction effects of Improved Tori-7 and BARI Sarisha-9 with all sowing dates. Initially the interaction effect of Improved Tori-7 on 1000 seeds weight was lower than the interaction effects of BARI Sarisha-9 but latter on the interaction effect on 1000 seeds weight of BARI Sarisha-9 dropped down sharply and it became 2.217 g which was statistically lower than that of Improved Tori-7 (2.317 g) at December 4 sowing (Figure 7).

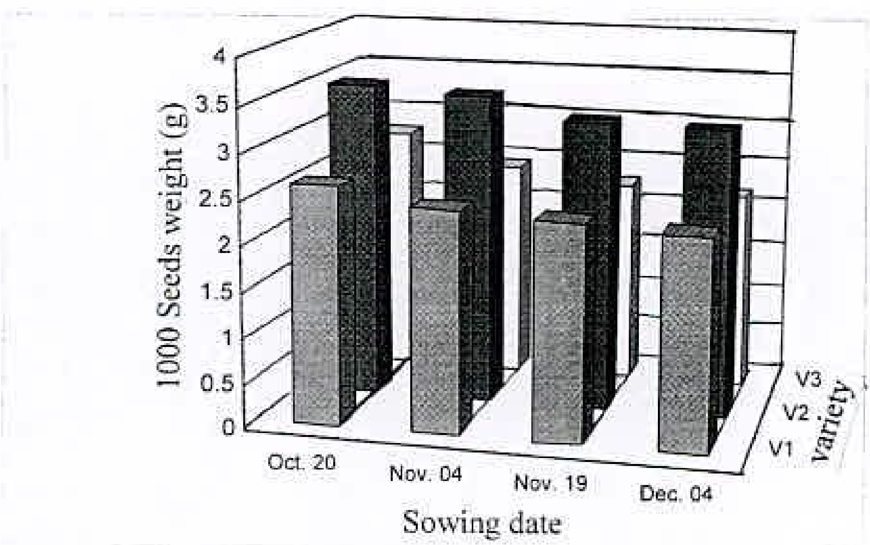

Figure 7. Interaction effect of variety and sowing date on 1000 seeds weight of rapeseed

4.9 Shelling Percentage

Shelling percent as revealed from the analysis of variance table (Appendix D.11) is highly significant at 1 % level of probability.

BARI Sarisha-8 showed significantly higher shelling percent (51.18) compared to BARI Sarisha-9 (44.69) and Improved Tori-7 (45.79) (Table 3). It was indicator of the higher oil content in BARI Sarisha-8 than BARI Sarisha-9 and Improved Tori-7, which is in agreement to the reality.

November 4 sowing showed the highest shelling percent (55.42) which was similar to October 20 sowing (54.53) but statistically higher than November 19 (53.08) and December 4 sowing (25.84), the last being the significantly lowest in shelling percent (Table 4). So it reveals from the table 4 that shelling % was reduced with delay in sowing which indicates the reduction in oil content at delayed sowing.

In interaction effect of variety with sowing date, the variety BARI Sarisha-9 on November 4 sowing showed the highest shelling % (56.82) which was identical with those of the variety Improved Tori-7 of October 20 (56.28), November 4 (56.11), November 19 (54.85) and BARI Sarisha-8 of October 20 (55.11) and November 4 (53.32) sowing. In all the varieties December 4 sowings drastically reduced the shelling percentage. In Improved Tori-7 the shelling percentage was 15.90 % on December 4 which was identical to 15.23, the shelling % of BARI Sarisha-9 of December 4 sowing (Figure 8).

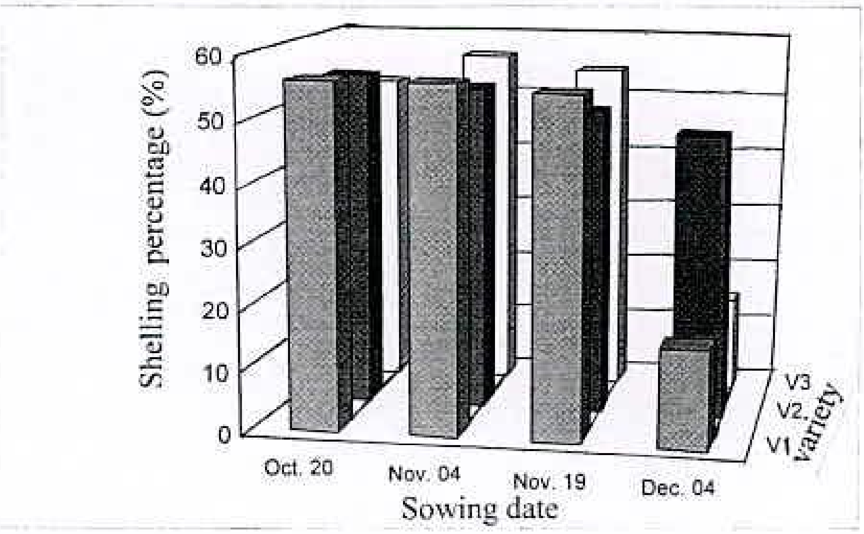

Figure 8. Interaction effect of variety and sowing date on shelling percentage of rapeseed

4.10 Grain yield (kg ha^{-1})

Analysis of variance table (Appendix D.12) reveals that mustard yield varied significantly from variety to variety and from sowing date to sowing date at 1 % level of probability. Interaction effect also showed variation at 1 % level of probability.

Grain yield of each rapeseed variety was significantly different from one another (Table 3). The variety BARI Sarisha-8 produced yield of (1339 kg ha^{-1}), which was significantly higher than those of BARI Sarisha-9 (878.8 kg ha^{-1}) and Improved Tori-7 (575 kg ha^{-1}). Again the yield of BARI Sarisha-9 (878.8 kg ha^{-1}) differed significantly from that of Improved Tori-7 (575 kg ha^{-1}). This finding is in support of the finding of Rahman (2002) who reported that BARI Sarisha-8 is one of the higher yielder of rapeseed varieties and Tori-7 is the low yielding variety. This result is in conformity with the findings of Islam *et al.* (1994) who also indicated the yield variation due to the varietal difference.

From the Table 4 it reveals that yield decreased gradually at every delayed sowing. The highest yield was obtained on October 20 sowing (1422 kg ha^{-1}) which differed significantly from the yields obtained on November 4 sowing (1113 kg ha^{-1}), November 19 sowing (752.1 kg ha^{-1}) and December 4 sowing (437.2 kg ha^{-1}). Grain yield between two consecutive sowing dates was found to vary from 309 kg to 361 kg. Yield reductions were 21.73 %, 47.1 % and 69.27 % respectively due to sowing on November 4, November 19 and December 4. Over October 20 sowing the trend in seed yield reduction over sowing dates as obtained in the present experiment has been found to be similar to the results of Uddin *et al.* (1987). Joshi *et al.* (1989) reported that late sowing resulted in seed yield reduction due to natural hazard like insect pest and disease yield reduction due to natural hazard like insect pest and disease infestation. The results are in agreement with findings of Gosh and Chattesjee ((1988); and Mondal *et al.* (1999).

Interaction effect of sowing date and variety on seed yield was significant (ANOVA Table D.12). BARI Sarisha-8 with October 20 sowing gave the highest yield (1865 kg ha^{-1}) which was significantly higher than yields of other combinations of varieties and sowing dates. BARI Sarisha-8 on the sowing date of November 4 sowing yielded 1439 kg ha^{-1} followed by BARI Sarisha-9 of October 20 sowing (1400 kg ha^{-1}) Improved Tori-7 (1000 kg ha^{-1}) with the first sowing (October 20) gave the lowest yield. Among the three varieties, initial yield was lower in Improved Tori-7 (Figure 9). Yield declination in successive delayed sowing was also highest in Improved Tori-7. Yield declination at December 4 sowing was 87 % for Improved Tori-7, 74 % for BARI Sarisha-9 and 55 % for BARI Sarisha-8. So it is reveled from the interaction effect that in each delayed sowing, climactic condition adversely affected Improved Tori-7. Hence Improved Tori-7 may not be suitable forsowing beyond November 19.

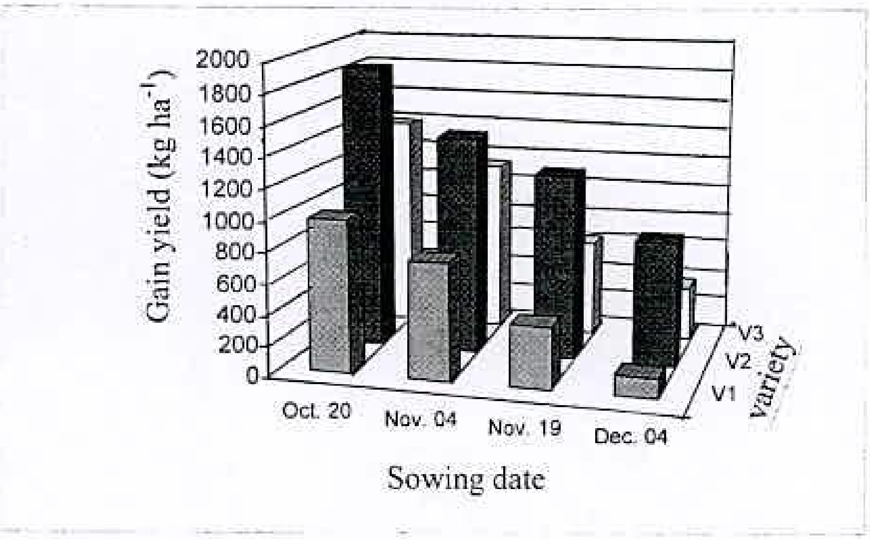

Figure 9. Interaction effect of variety and sowing date on grain yield of rapeseed

4.11 Stover yield (kg ha^{-1})

From the analysis of variance table as shown in appendix D.13, it was evident that stover yield for different variety, date of sowings and for interaction effect of variety and date of sowing differed significantly at 1 % level of probability.

Stover yield for different varieties of rapeseed under study differed significantly from one another (Table 3). Like grain yield, BARI Sarisha-8 produced the higher stover yield (3062 kg ha^{-1}), which was statistically superior to stover yield of BARI Sarisha-9 (2618 kg ha^{-1}) and the stover yield of Improved Tori-7 (1771 kg ha^{-1}). Again the stover yield of BARI Sarisha-9 (2618 kg ha^{-1}) was statistically higher than that of Improved Tori-7 (1771 kg ha^{-1}). Saran and Giri (1987) and Chakraborty *et al.* (1991) reported that the dry matter production in crops is importantly determined by varietal characteristics.

From the Table 4 it is revealed that stover yield of 3 rapeseed varieties at each consecutive sowing date differed significantly from one another. The highest stover yield, 3427 kg ha^{-1} obtained on October 20 sowing differed significantly from 2959 kg ha^{-1}, 2104 kg ha^{-1} and 1443 kg ha^{-1} obtained respectively on November 4, November 19 and December 4 sowings. Again the stover yield obtained on November 4 differed significantly from that of November 19 and from that of December 4. Mohammad *et al.* (1984) mentioned that dry matter accumulation in crops is a function equally controlled by sowing date.

The interaction effect of October 20 sowing on BARI Sarisha-8 and BARI Sarisha-9 was much favorable and produced higher stover yields of 3832 kg ha^{-1} and 3712 kg ha^{-1} respectively (Figure 10). These two stover yields are identical to each other but each is statistically significant from that of Improved Tori-7 of October 20 sowing and also from each of the stover yields obtained in three rapeseed varieties on three consecutive sowing dates. The interaction effect of sowing dates on varieties showed a decreasing trend in stover yield in successive delay in sowing (Figure 10). The decreasing trend is highest in Improved Tori-7 followed by BARI Sarisha-9 and BARI Sarisha-8. In BARI Sarisha-8 and BARI Sarisha-9 acceptable stover yield was obtained up to last sowing date (December 4) but in Improved Tori-7 up to 3rd sowing (November 19).

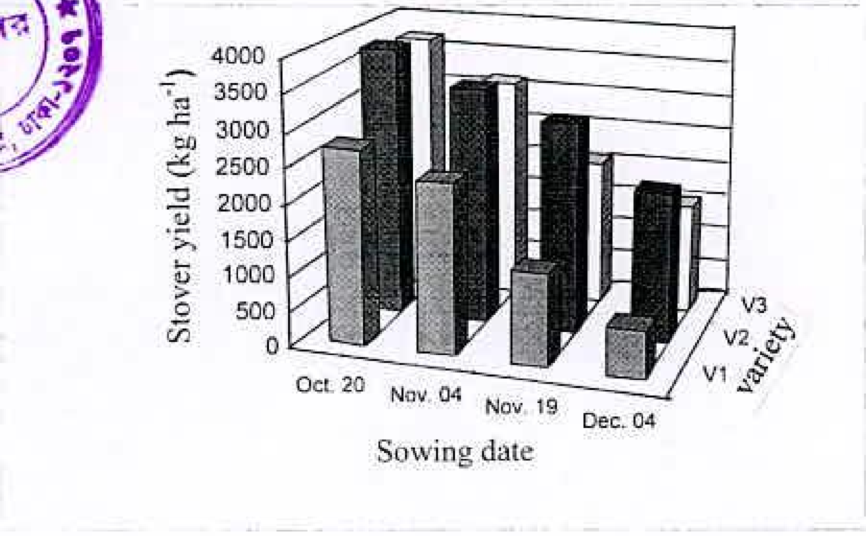

Figure 10. Interaction effect of variety and sowing date on stover yield of rapeseed

4.12 Biological yield (kg ha^{-1})

Biological yield is the summation of grain yield and stover yield. So the combined effect of grain yield and stover yield has been reflected on the biological yield for variety, sowing date and for interaction of them. From the analysis of variance table (Appendix D.14) the effect of it also reveals that biological yield for variety, sowing date and for interaction effect was significant at 1 % level of probability.

Like grain and stover yield variety BARI Sarisha-8 produced the highest biological yield (4400 kg ha^{-1}) which was significantly different from the yield of BARI Sarisha-9 (3496 kg ha^{-1}) and that of Improved Tori-7 (2346 kg ha^{-1}) (Table 3). Again the biological yield of BARI Sarisha-9 differed significantly from that of Improved Tori-7.

Sowing date also like that of grain yield and stover yield showed the similar effect on biological yield. October 20 sowing gave the highest biological yield (4849 kg ha^{-1}) which was followed by 4072 kg ha^{-1}, 2854 kg ha^{-1} and 1880 kg ha^{-1} obtained respectively on November 4, November 19 and December 4 sowing (Table 4). It is to be mentioned here that the biological yield obtained in each sowing date was statistically higher than that of the next sowing date.

In the interaction effect, Improved Tori-7 was found to be much affected at each sowing date (Figure 11). Biological yield (3737 kg ha^{-1}) obtained in Improved Tori-7 with the interaction effect of October 20 sowing date (1^{st} sowing date) was statistically lower than the biological yield of 4187 kg ha^{-1} obtained in BARI Sarisha-8 with the interaction of November 19 (3^{rd}) sowing date. Again 4280 kg ha^{-1}, the biological yield obtained by BARI

Sarisha-9 on November 4 (2nd) sowing was statistically higher than that of Improved Tori-7 of 1st (October 20) sowing. The interaction effect of last (December 4) sowing date had a very adverse effect on biological yield of Improved Tori-7 (803 kg ha^{-1}). Of course BARI Sarisha-9 also suffered a bit in biological yield (1903 kg ha^{-1}) due to the interaction effect of December 4 sowing (Figure 11).

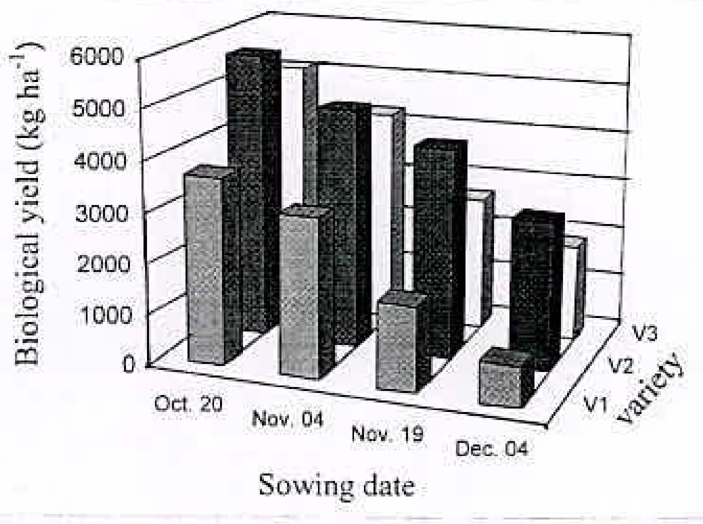

Figure 11. Interaction effect of variety and sowing date on biological yield of rapeseed

4.13 Harvest index (%)

The analysis of variance is presented in Appendix D.15 From the analysis of variance it reveals that sowing date, variety and interaction effect on harvest index were highly significant at 1 % level of probability.

BARI Sarisha-8 exhibited the highest value (30.06 %) of harvest index and Improved Tori-7 showed the lowest value (22.87 %). Of course the values of harvest index of the three varieties significantly differed from one other (Table 3). The results agree with those of Islam *et al.* (1999) who observed that the harvest index varied markedly among varieties of different plant types in mustard. Mendham *et al.* (1981) stated that a low harvest index of rapeseed might be due to excessive pod and seed losses during flowering.

Harvest indices obtained on different sowing dates differed significantly from one another (Table 4). Highest harvest index (28.96 %) was obtained on October 20 sowing which was followed by 26.96 % (November 4 sowing) 25.48 % (November 19 sowing), 21.12 % (December 4 sowing). It is fact that the subsequent sowing dates affected both grain and stover yield of rapeseeds but it affected more on grain yield than on stover yield which resulted a gradual reduction in harvest index in subsequent sowing.

Harvest indices as revealed from the interaction effect were significantly higher in BARI Sarisha-8 in all sowing dates than those of BARI Sarisha-9 and Improved Tori-7. Harvest index more or less of each variety in each sowing date differed significantly from that of subsequent time. In BARI Sarisha-8 they were respectively 32.73, 30.10, 29.37 and

28.06 in 4 consecutive sowing dates while those for BARI Sarisha-9 were 27.38, 26.48, 23.16 and 18.82 and for Improved Tori-7 were 26.77, 24.31, 23.91 and 16.49 (Figure 12).

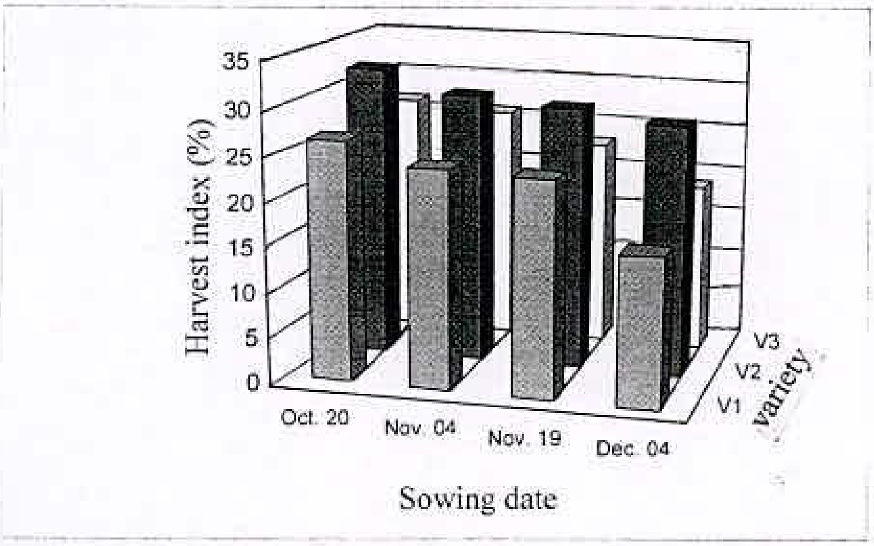

Figure 12. Interaction effect of variety and sowing date on harvest index (%) of rapeseed

Table 3. Varietal effect on yield and yield Components of rapeseed

	Yield and Yield Components								
Varieties	Silliqua plant^{-1}	Seed silliqua^{-1}	Silliqua length (cm)	1000 seed weight (g)	Shelling percentage (%)	Grain yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	H I (%)
Improved Tori-7	75.97	11.30	3.427	2.446	45.79	575.0	1771	2346	22.87
BARI Sarisha-8	83.87	26.70	6.522	3.342	51.18	1339	3062	4400	30.06
BARI Sarisha -9	76.10	13.62	3.757	2.425	44.69	878.8	2618	3496	23.96
LSD	2.483	0.4812	0.07573	0.03786	1.496	35.09	96.55	125.6	0.5692
CV (%)	3.73	3.3	1.92	1.43	3.74	4.45	4.59	4.35	2.62

Table 4. Effect of sowing date on yield and yield attributes of rapeseed

	Yield and Yield Components								
Sowing date	Silliqua plant^{-1}	Seeds silliqua^{-1}	Silliqua length (cm)	1000 seed weight (g)	Shelling percentage	Grain yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	H I (%)
October 20	122.5	22.91	5.416	2.972	54.53	1422	3427	4849	28.96
November 04	86.77	20.21	4.670	2.778	55.42	1113	2959	4072	26.96
November 19	73.32	16.92	4.347	2.628	53.08	752.1	2104	2854	25.48
December 04	32.02	8.778	3.842	2.572	25.84	437.2	1443	1880	21.12
LSD	2.867	0.5556	0.08744	0.04372	1.727	40.52	111.5	145.0	0.6573
CV (%)	3.73	3.30	1.92	1.43	3.74	4.45	4.59	4.35	2.62

4.14 Correlation and regression studies

It is important to study correlation between plant characters which has direct or indirect influence on the eventual yield of the crop. Statistical relationship between total number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000 seeds weight and seed yield of different sowing dates of the 3 rapeseed varieties under study have been presented in Figure (13 to 15).

4.14.1 Number of siliquae plant^{-1} and grain yield

The relationship between total number of siliquae plant^{-1} and grain yield has been found out and was positively correlated. The correlation coefficient ($r = 0.733$ **) was found significant at 1 % level of probability.

The line of regression of Y (yield) on X (siliquae plant^{-1}) having equation, $Y=10.285x + 122.13$ is shown in Figure 13. The positive slope indicates that total number of siliquae plant^{-1} and grain yield are directly related.

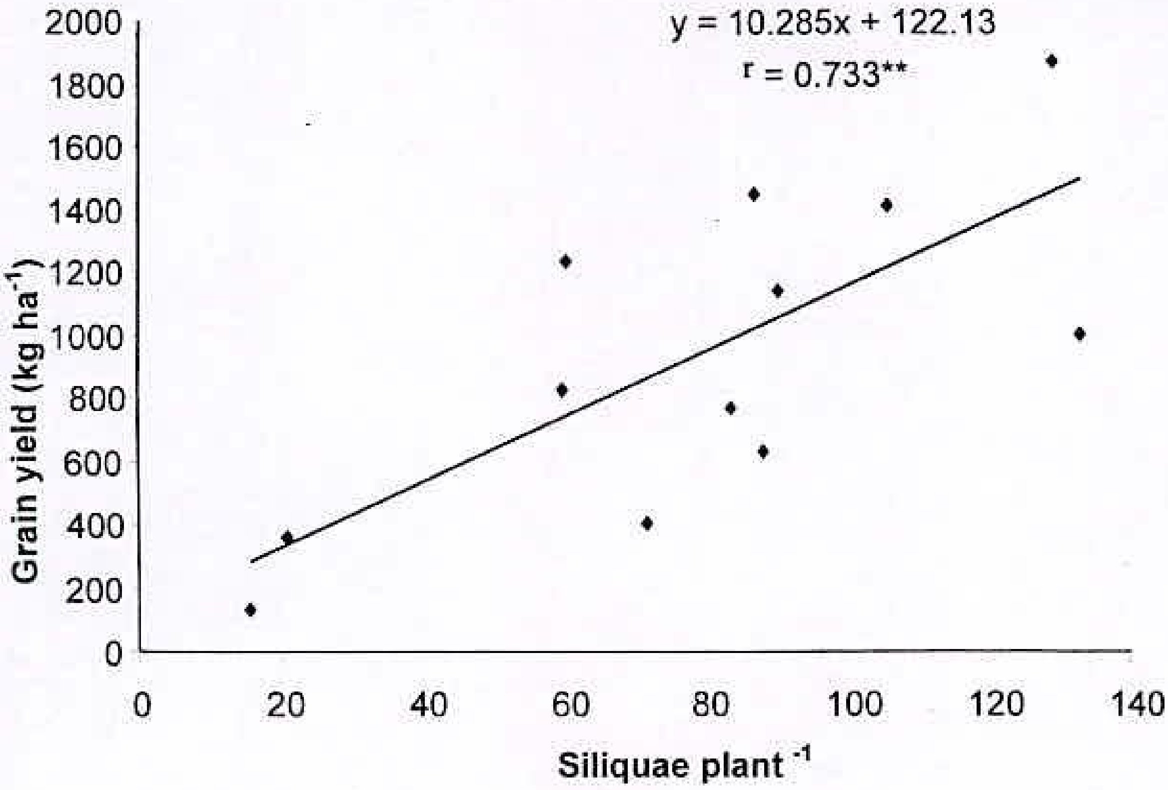

Figure 13 Relationship between siliquae plant^{-1} and grain yield ((kg ha^{-1}))

4.14.2 Number of seeds siliqua^{-1} and grain yield

The relationship between total number of seeds siliqua^{-1} and grain yield has been calculated and found positively correlated. The correlation coefficient (r = 0.937 **) was significant at 1 % level of probability.

The regression line of Y (yield) on X (seeds siliqua^{-1}) can be shown as, Y=53.072x + 17.915.

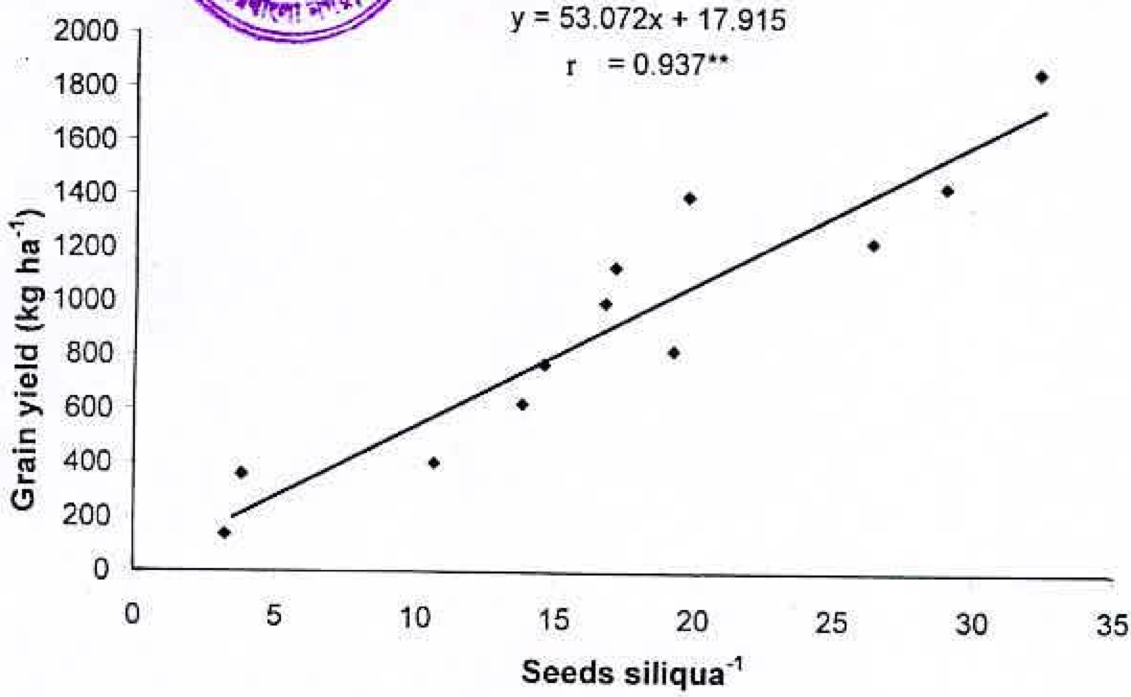

Figure 14 Relationship between seeds siliqua^{-1} and grain yield ((kg ha^{-1}))

4.14.3 Number of thousand seeds weight and grain yield

The correlation study between 1000 seeds weight and grain yield showed a positive relationship and was significant (r = 0.798 **) at 1 % level of probability. The regression line of Y (yield) on X (1000 seeds weight) can be shown as, Y=582.12x – 1398.2.

This result agrees with Khander and Bargava (1984) who reported that in *Brassica* spp. yield unit^{-1} area was determined largely by three major yield components namely (i) number of siliqua plant^{-1} (ii) seed number siliqua^{-1}and (iii) 1000 seeds weight and they are positively correlated.

From the earlier discussion it is evident that in variety BARI Sarisha-9 and particularly in Improved Tori-7 after November 4 sowing grain yield reduced due to reduction in siliquae plant^{-1}, seeds siliqua^{-1} and 1000 seeds weight.

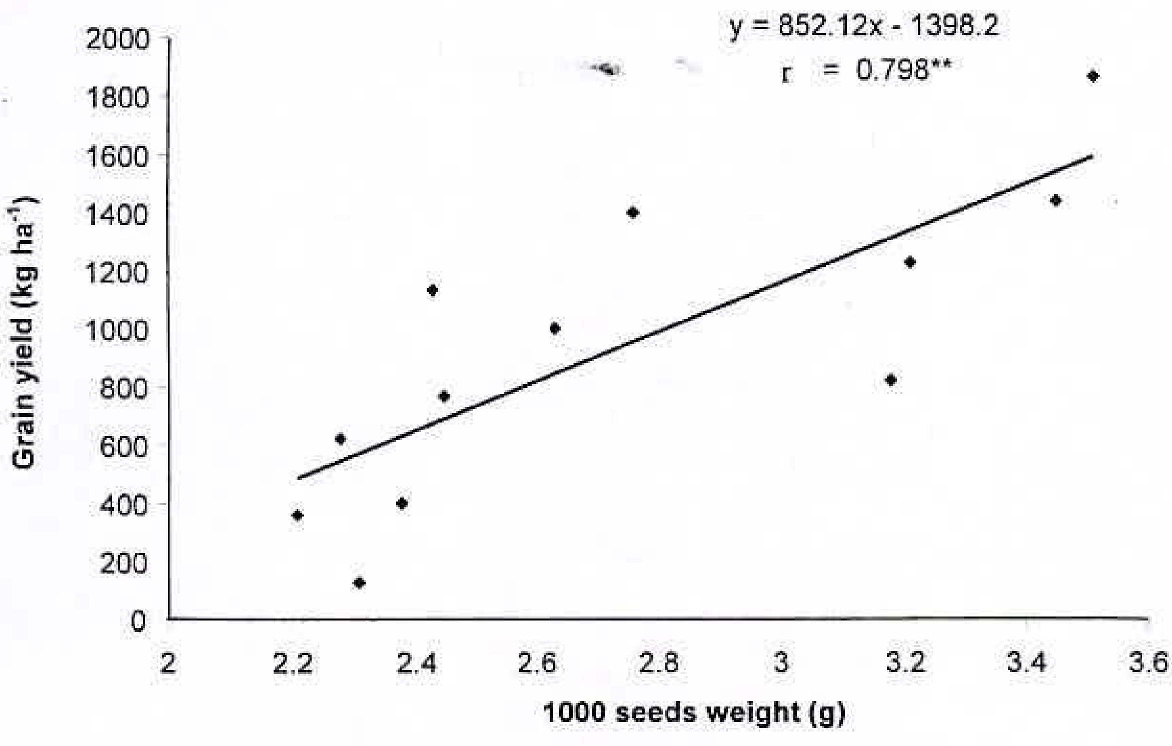

Figure 15 Relationship between 1000 seeds weight (g) and grain yield (kg ha^{-1})

Chapter V

Conclusion

CHAPTER V

CONCLUSION

The experiment was conducted at the field laboratory of the Sher-e-Bangla Agricultural University farm, Dhaka in Rabi season during October 2004 to February 2005 to find out the effect of different dates of sowing on the yield and yield components of three rapeseed varieties. The soils of the experimental plots belong to the Agro Ecological Zone of the Madhupur Soil Tract (AEZ-28). The topography of the land was high with texture loamy and reaction slightly acidic. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Factorial arrangements of treatments within the plots were made at random. The treatments were 3 rapeseed varieties viz., as Improved Tori-7 (V_1), BARI Sarisha-8 (V_2) and BARI Sarisha-9 (V_3) and 4 dates of sowing as October 20 (D_1), November 4 (D_2), November 19 (D_3), December 4 (D_4).

The crop maturity varied with variety and date of sowing. The variety, Improved Tori-7 took the shortest period of 20.08 and 36.50 days in starting and completion of flowering while BARI Sarisha-9 took 25.75 and 37.42 days and BARI Sarisha-8 29.08 and 41.92 days respectively. Both starting period of flowering and length of flowering were found to reduce with delay in sowing.

Improve Tori-7 was the shortest in obtaining maturity (70.50 days) and BARI Sarisha-8 was longest (82.75 days) while BARI Sarisha-9 took 71.75 days. Maturity delayed in early sowing and late sowing crop matured earlier. The highest maturity period (84 days) was found in BARI Sarisha-8 with October 20 sowing and the lowest (66 days) was found in Improved Tori-7 with December 4 sowing.

In respect of plant stature BARI Sarisha-8 was the tallest in height and Improved Tori-7 was the shortest. Delayed sowing in general shorten the plant height. Of course the effect of delayed sowing was not so much pronounced on BARI Sarisha-8 and BARI Sarisha-9 up to November 19 sowing. Plant height was reduced in BARI Sarisha-8 from 88.77cm. to 56.53 cm, in BARI Sarisha-9 from 82.97 cm to 46.80 cm and in Improved Tori-7 from 76.50cm to 40.37 cm in December 4 sowing.

BARI Sarisha-8 and BARI Sarisha-9 were found to produce the same number of branches plant^{-1} which was significantly superior than the branches produced in Improved Tori-7. November 4 sowing was found favorable to produce higher number of branches in all the varieties under study. November 4 sowing with BARI Sarisha-9 showed the highest number of branches plant^{-1} (4.8).

Silique plant^{-1}, the key component of rapeseed yield was found to be the highest (83.87) in BARI Sarisha-8 and was lowest (75.97) in Improved Tori-7. Silique number plant^{-1} decreased gradually in each successive sowing in all the varieties. Reduction trend was higher in Improved Tori-7 and lowest in BARI Sarisha-8. This phenomena resulted in obtaining higher yield in BARI Sarisha-8 in all the sowing dates than BARI Sarisha-9 and Improved Tori-7.

Siliqua length plays also significant role in determining yield of rapeseeds. Like Silique number plant^{-1}, BARI Sarisha-8 was also found to produce remarkably longest siliqua (6.52 cm) compared to BARI Sarisha-9 (3.757 cm) and Improved Tori-7 (3.427 cm). Sowing date also showed the similar influence on the siliqua length. There was also a gradual reduction in silluqua length in each variety in each successive sowing.

Seeds siliqua^{-1} is another prime determining factor of rapeseed yield. BARI Sarisha-8 showed dominancy in possessing higher number of seeds siliqua^{-1} compared to BARI Sarisha-9 and Improved Tori-7 throughout the sowing times. Improved Tori-7 was poor producer of seeds siliqua $^{-1}$ compared to BARI Sarisha-9. Delayed sowing reduced the seeds siliqua $^{-1}$ continuously in the 3 rapeseed varieties. But this reduction trend was remarkably higher in BARI Sarisha-9 and Improved Tori-7 which resulted in very poor yield on December 4 sowing in both the varieties.

Grain yield was highest in BARI Sarisha-8 on all sowing dates. The weighted average yield of BARI Sarisha-8 considering all sowing periods was 1339 kg ha^{-1}. It was 878.8 kg ha^{-1} for BARI Sarisha-9 and only 575 kg ha^{-1} for Improve Tori-7. Grain yield was reduced in successive delay in sowing. October 20 sowing gave the highest yield (1865 kg ha^{-1}) in BARI Sarisha-8 which was reduced to 823 kg ha^{-1} (55 %) in December 4 sowing. The appreciable yield of 1230 kg ha^{-1} was obtained from BARI Sarisha-8 up to November 19. The acceptable yield of BARI Sarisha-9 (1133 kg ha^{-1}) was obtained up to November 4, where as Improved Tori-7 lost its acceptable yield level from November 4 sowing (Figure 9).

Improved Tori-7 was observed as short statured, early flowering and short lived rapeseed crop of low yield potential. BARI Sarisha-8 was found comparatively as long statured, late flowering and long lived crop of high yield potential. BARI Sarisha-9 behaved as in middle position in respect of these traits. The highest accumulation of the yield components of rapeseeds such as number of seed siliqua^{-1}, siliqua length and 1000 seed weight, in BARI Sarisha-8 resulted its of higher yield than BARI Sarisha-9 and Improved Tori-7. The possession of these yield components in BARI Sarisha-8 were not affected much up to November 19 but Improved Tori-7 failed, November 4 sowing could not keep these traits unaffected. So it may be concluded here that

Improved Tori-7 seeds should be sown within the month of October, BARI Sarisha-8 may be sown up to the 20 November and BARI Sarisha-9 up to the 15th November.

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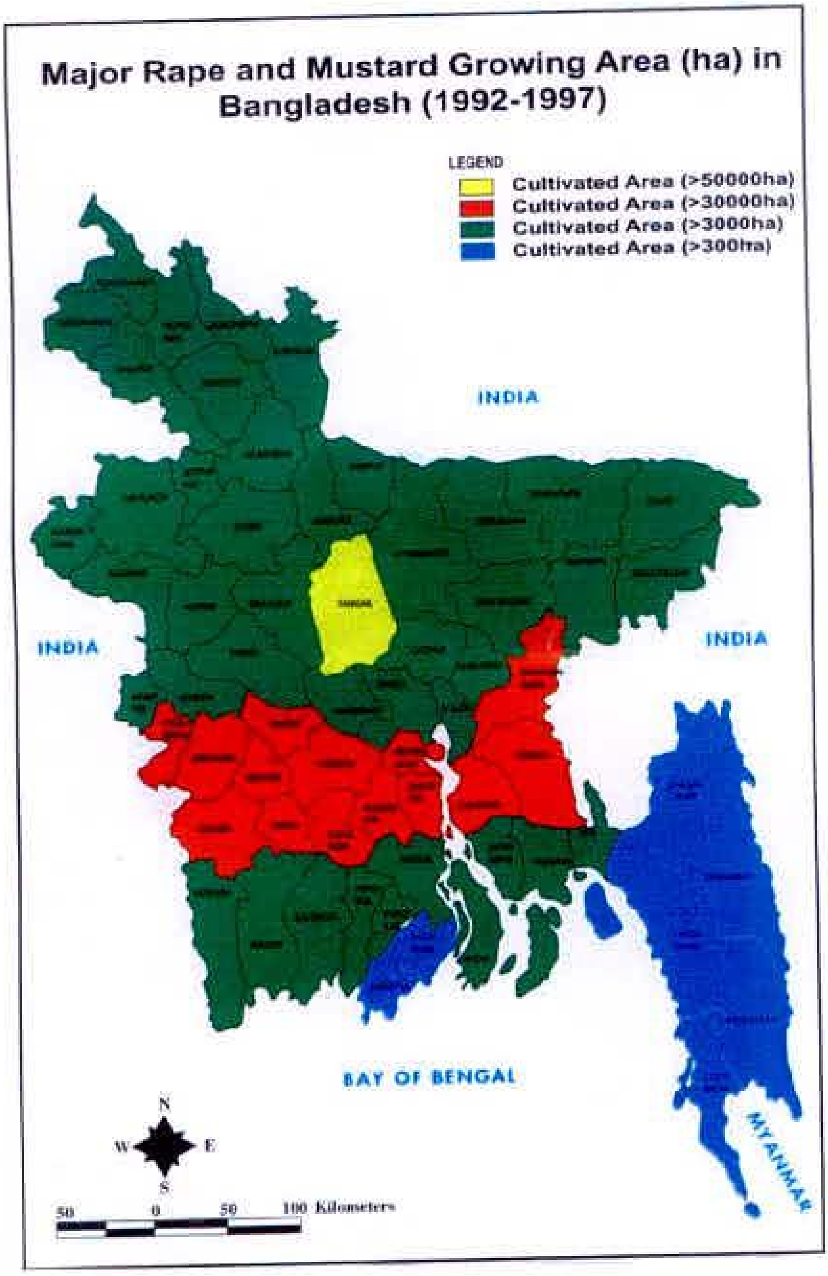
APPENDICES

Appendix A. Major Rape and Mustard Growing Area (ha) in Bangladesh (1992-97)



Source: Status of Oil crop Production in Bangladesh, Oilseed Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701.

Appendix B. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Locality : Agronomy Field Laboratory Sher-e-Bangla Agricultural University, Dhaka

Mechanical composition

Particle size constitution

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %

Texture : Loamy

Chemical composition

Constituents	:	0-15 cm depth
P^H	:	6.4
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	1.4

The soil sample was analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix C (a). Monthly Temperature, Rainfall, and Relative humidity of the experiment site during the period from October 2004 to February 2005

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2004	October	31.0	23.3	27.1	75.3	208
	November	29.5	18.6	24.0	69.5	0.0
	December	26.9	16.2	21.5	70.6	0.0
2005	January	24.5	13.9	19.2	68.5	4.0
	February	28.9	18.0	23.4	61.0	3.0

Appendix C (b). Monthly Soil Temperature and Sunshine of the experiment site during the period from November 2004 to February 2005

Year	Month	Soil Temperature (^{0}c)			Sunshine (hr)
		5 cm depth	10 cm depth	20cm depth	
2004	October	16.9	17.2	17.3	208.9
	November	13.8	14.4	14.8	233.2
	December	12.6	13.6	14.0	210.5
2005	January	11.3	12.4	13.0	194.1
	February	12.9	13.7	13.8	221.5

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212

Appendix D. Analysis of variance for yield and other yield attributes

01. Days to first flowering

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob.
1	Replication	2	0.222	0.111	0.1325	
2	Factor A	2	496.889	248.444	296.3373	0.0000
4	Factor B	3	182.083	60.694	72.3946	0.0000
6	AB	6	59.333	9.889	11.7952	0.0000
-7	Error	22	18.444	0.838		
	Total	35	756.972			

Coefficient of Variation: 3.67%

02. Days to 50% flowering

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	2.000	1.000	1.4348	0.2596
2	Factor A	2	121.500	60.750	87.1630	0.0000
4	Factor B	3	286.528	95.509	137.0350	0.0000
6	AB	6	171.389	28.565	40.9843	0.0000
-7	Error	22	15.333	0.697		
	Total	35	596.750			

Coefficient of Variation: 2.58%

03. Days to final flowering

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	1.056	0.528	0.5544	
2	Factor A	2	201.722	100.861	105.9443	0.0000
4	Factor B	3	272.111	90.704	95.2750	0.0000
6	AB	6	226.722	37.787	39.6914	0.0000
-7	Error	22	20.944	0.952		
	Total	35	722.556			

Coefficient of Variation: 2.53%

04. Days to maturity

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.000	0.000	0.0000	
2	Factor A	2	1115.167	557.583	9200.1250	0.0000
4	Factor B	3	198.000	66.000	1089.0000	0.0000
6	AB	6	43.500	7.250	119.6250	0.0000
-7	Error	22	1.333	0.061		
	Total	35	1358.000			

Coefficient of Variation: 0.33%

05. Number of branch plant^{-1}

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.027	0.014	0.5996	
2	Factor A	2	2.569	1.284	56.5784	0.0000
4	Factor B	3	16.965	5.655	249.1009	0.0000
6	AB	6	5.609	0.935	41.1776	0.0000
-7	Error	22	0.499	0.023		
	Total	35	25.670			

Coefficient of Variation: 4.43%

06. Plant height (cm)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	29.674	14.837	1.8975	0.1737
2	Factor A	2	1754.296	877.148	112.1763	0.0000
4	Factor B	3	6119.077	2039.692	260.8513	0.0000
6	AB	6	357.222	59.537	7.6140	0.0002
-7	Error	22	172.026	7.819		
	Total	35	8432.294			

Coefficient of Variation: 4.02%

07. Number of sillique plant^{-1}

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	15.182	7.591	0.8825	
2	Factor A	2	490.996	245.498	28.5416	0.0000
4	Factor B	3	37694.837	12564.946	1460.8008	0.0000
6	AB	6	5522.121	920.354	107.0003	0.0000
-7	Error	22	189.231	8.601		
	Total	35	43912.367			

Coefficient of Variation: 3.73%

08. Number of seeds silliqua^{-1}

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.001	0.000	0.0009	
2	Factor A	2	1654.802	827.401	2559.1729	0.0000
4	Factor B	3	1014.250	338.083	1045.7004	0.0000
6	AB	6	13.453	2.242	6.9352	0.0003
-7	Error	22	7.113	0.323		
	Total	35	2689.619			

Coefficient of Variation: 3.30%

09. Silliqua Length (cm)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.004	0.002	0.2769	
2	Factor A	2	69.316	34.658	4492.3757	0.0000
4	Factor B	3	11.740	3.913	507.2637	0.0000
6	AB	6	4.095	0.683	88.4741	0.0000
-7	Error	22	0.170	0.008		
	Total	35	85.326			

Coefficient of Variation: 1.92%

10. 1000 Seed Weight (g)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.003	0.001	0.9506	
2	Factor A	2	6.573	3.286	2142.2803	0.0000
4	Factor B	3	0.865	0.288	187.8749	0.0000
6	AB	6	0.093	0.015	10.0645	0.0000
-7	Error	22	0.034	0.002		
	Total	35	7.567			

Coefficient of Variation: 1.43%

11. Shelling percentage

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	12.287	6.144	1.9688	0.1635
2	Factor A	2	289.298	144.649	46.3543	0.0000
4	Factor B	3	5508.256	1836.085	588.3930	0.0000
6	AB	6	1704.438	284.073	91.0342	0.0000
-7	Error	22	68.651	3.121		
	Total	35	7582.930			

Coefficient of Variation: 3.74%

12. Grain yield (Kg ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	2925.056	1462.528	0.8513	
2	Factor A	2	3554426.056	1777213.028	1034.4951	0.0000
4	Factor B	3	4948240.972	1649413.657	960.1046	0.0000
6	AB	6	98681.944	16446.991	9.5736	0.0000
-7	Error	22	37794.944	1717.952		
	Total	35	8642068.972			

Coefficient of Variation: 4.45%

13. Stover yield (kg ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	22950.056	11475.028	0.8824	
2	Factor A	2	10331309.556	5165654.778	397.2054	0.0000
4	Factor B	3	21086396.667	7028798.889	540.4691	0.0000
6	AB	6	743784.667	123964.111	9.5320	0.0000
-7	Error	22	286109.944	13004.997		
	Total	35	32470550.889			

Coefficient of Variation: 4.59%

14. Biological Yield (Kg ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	43072.667	21536.333	0.9787	
2	Factor A	2	25439622.167	12719811.083	578.0331	0.0000
4	Factor B	3	46419219.639	15473073.213	703.1510	0.0000
6	AB	6	1107584.944	184597.491	8.3888	0.0001
-7	Error	22	484117.333	22005.333		
	Total	35	73493616.750			

Coefficient of Variation: 4.35%

15. Harvest Index (%)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.059	0.030	0.0655	
2	Factor A	2	360.820	180.410	398.9875	0.0000
4	Factor B	3	298.926	99.642	220.3643	0.0000
6	AB	6	48.432	8.072	17.8517	0.0000
-7	Error	22	9.948	0.452		
	Total	35	718.185			

Coefficient of Variation: 2.62 %

Appendix E. Correlation matrix of different yield contributing characters of rapeseed

Factor of correlation		Correlation coefficient r value
1.	Total number of siliquae $plant^{-1}$ and grain yield (kg ha^{-1}) at different sowing date	0.733**
2.	Total number of seeds $sliqua^{-1}$ and grain yield (kg ha^{-1}) at different sowing date	0.937**
3.	1000 seed weight (g) and grain yield (kg ha^{-1}) at different sowing date	0.798**

** = Significant at 1 % level of probability.

Appendix F. Photograph of the experiment

Picture 1: Improved Tori-7 (at flowering stage)

Picture 2: BARI Sarisha-8 (at flowering stage)

Picture 3: BARI Sarisha-9 (at flowering stage)

Picture 4: A view of rapeseed field in different sowing date