GROWTH AND YIELD OF TWO RAPESEED VARIETIES AS AFFECTED BY POPULATION DENSITY

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This is to certify that thesis entitled, "GROWTH AND YIELD OF TWO RAPESEED VARIETIES AS AFFECTED BY POPULATION DENSITY" 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**, embodies the result of a piece of bona fide research work carried out by **ABU SAYED MOHAMMAD AZMALUL MONIM,** Registration No. 27438/00648 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 30/12/2007
Dhaka, Bangladesh

(Professor. Md. Sadrul Anam Sardar)
Supervisor

Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was conducted at the field of Sher-e-Bangla Agricultural University farm, Dhaka in Rabi season during November 2006 to March 2007 to evaluate the growth and yield of two rapeseed varieties as affected by population density. The treatment of the experiment consisted of two varieties viz. BARI sarisha-13 and SAU sarisha-1 and six population density viz. 30, 40, 50, 60, 70 and 80 plants m^{-2}. The experiment was laid out in a randomized complete block design (factorial) with three replications. The higher seed yield was obtained from SAU sarisha-1 (1799.77 kg ha^{-1}) which was 8.17% higher than BARI sarisha-13. The higher seed yield of SAU sarisha-1 this was mainly attributed to number of branches plant $^{-1}$ and number of siliquae plant^{-1}. Among the population densities, the lowest population density of 30 plants m^{-2} had maximum number of branches plant $^{-1}$, number of siliquae plant $^{-1}$, length of siliqua, number of seeds per siliqua, 1000-seeds weight and seed yield plant $^{-1}$ except plant height. The seed yield hectare^{-1} was the highest with population density of 60 plants m^{-2} which was 28.07%, 19.97%, 17.74%, 10.25% and 6.47% higher than 30, 40, 50, 70 and 80 plants m^{-2} respectively. The interaction effect of variety and population density was also significant showing the highest seed yield plant $^{-1}$ from the combined effect of SAU sarisha-1 and population density of 30 plants m^{-2}. This was achieved due to maximum number of branches plant $^{-1}$ and number of siliquae plant $^{-1}$.The maximum seed yield per hectare was obtained by using SAU sarisha-1 and 60 plants m^{-2}.This was due to the fact that 60 plants m^{-2} was the optimum plant population m^{-2} which assested in obtaining higher yield than other plant densities. All of the yield attributes were highly significant. The relationship between the yields attributes and yield was highly significant.

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LIST OF ABBREVIATIONS

Abbreviation	Full word
AEZ	Agro Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
CV	Coefficient of variation
cv.	Cultivar
DAE	Days after emergence
DAS	Days after sowing
DM	Dry matter
E	East
et al.	et alibi (and others)
etc.	etcetera (and so on)
FAO	Food and Agriculture Organization
Fig.	Figure
HI	Harvest Index
HYV	High yielding variety
i.e.	Idlest (that is)
IW	Irrigation Water
LSD	Least significant difference
N	North
NNC	National Nutritional Council
NSB	National Seed Board
PD	Population Density
SAU	Sher-e-Bangla Agricultural University
TDM	Total Dry Matter
Viz.	Videlicet (namely)

Unit

%	Percentage
°C	Degree Celsius
cm	Centimeter
g	Gram
ha	Hectare
kcal	Kilocalorie
kg	Kilogram
m	Meter
q	Quintal
t	Ton

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Rapeseed and Mustard are commonly known as mustard in Bangladesh those belong to the family Cruciferae. Botanically it has three species, *Brassica campestris* L. *Brassica napus* L. *and Brassica juncea* L. These are cultivated for edible oil. Among the species *Brassica campestris* and *Brassica napus* are regarded as "rapeseed" while *Brassica juncea* is regarded as "mustard".

Rapeseed along with mustard is currently ranked as the world's third most important oil crop in terms of area and production (FAO, 1999) but it occupies the first position in respect of area and production among the oil crops grown in Bangladesh (BBS, 1999).

Oil seed crops play a vital role in human diet. Oils of plant origin are nutritionally superior to that of animal origin. (Singh, 2000). It is not only rich source of energy (about 9k cal/gm) but also rich in soluble vitamins A D E and K. According to the National Nutrition Council (NCC) of Bangladesh as per the recommended dietary allowance (RDA) basis, the edible oil need for 150 millions people are 0.39 million tons of oil equivalent to 0.82 million tons of oil seed (BBS, 2004).

In Bangladesh about 3 lakh hectare of land is under mustard cultivation which produces 2.2 lakh metric tons of seeds. The average per hectare yield of mustard in this country is 739 kg ha^{-1} which is alarmingly very poor compared to that of advanced countries like Germany, France, UK, Canada and Poland producing 6667 kg ha^{-1}, 507 kg ha^{-1}, 3264 kg ha^{-1}, 3076 kg ha^{-1}, respectively. The world average yield of mustard is 1575 kg ha^{-1} (FAO, 2003).The major reasons for low yield in our country are due to lacking in use of both high yielding variety and appropriate technologies. The internal production of edible oil can meet up only one-third of the annual requirement (Mondal and Wahhab, 2001). It needs to import oil and oilseeds to meet up the deficit every year spending huge foreign exchange.

Yield and its development process depend on genetic, environmental and agronomic factors as well as the interaction between them. Therefore, there is a scope to increase the yield level of mustard by using HYV seed and by adopting proper management practices such as spacing, population density, irrigation, fertilizer application and other cultural operations. Optimum population plays an important role in producing higher yield. Establishment of optimum population density per unit area is a prerequisite for having increased grain yield. Population density thus influences yield and yield contributing characters of rapeseed (Johnson *et al*., 2003).

Rapeseed yield can be affected by competitive stress among individual plants. Competition occurs when two or more plants need a particular factor necessary for growth, and when the immediate supply of this factor falls below the combined demands of the plants (Mondal *et al*., 1998). Establishment of an optimum population density is one of the important factors for securing good yield of a crop. It is well established that the crop environment with regard to light intensity and concentration of carbon dioxide can play a vital role in photosynthesis of the plant and thus increase dry matter accumulation and vegetative growth of the plant. Hence, plant density per unit area influences the crop yield considerably. Optimum population density ensures proper growth of both aerial and under ground parts of the plant through efficient utilization of solar radiation, nutrients and land as well as air spaces and water (Bhargava and Tomar, 1982).

Keeping in view the inter-plant competition for optimum plant nutrients, sun light, moisture and aeration, it may be required to find out a fair combination of population density to achieve maximum yield under certain agro-climatic conditions. Hence, the present study was undertaken with two important rapeseed varieties, BARI sarisha-13 and SAU sarisha-1 together with the following objectives:

i. To examine the effect of population density on the yield and yield contributing characters of rapeseed.

ii. To find out interactions between variety and population density on the yield and yield contributing characters of rapeseed.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Rapeseed is an important oil crop in Bangladesh which can contribute to large extent in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. Only some limited studies have so far been done in respect of agronomic management practices of the crop particularly the population density. However, a number of such studies have been carried out in other parts of the world. Some of the studies relevant to the present piece of work have been reviewed following the parameters of plant growth and yield.

2.1 Plant height

Plant height of rapeseed and mustard differs among the varieties depending on their genetic makeup. There are three species of cruciferous *Brassica* viz. *Brassica campestris, Brassica juncea* and *Brassica napus* from one another with respect to plant growth, development and yield (Alam, 2004).

The final plant height reflects the growth behavior of a crop. Besides genetic characteristics, environmental factors also play a vital role in determining the height of the plants (*Sana et al*., 2003).

Johnson and Hanson (2003) conducted a study to determine the interactions for commonly used spacing with canola (*Brassica napus*) performance using contemporary open-pollinated, hybrid and transgenic cultivars. They observed that population density and cultivar interaction were only significant for plant height. Shorter plants for the *Brassica rapa* cultivars was found when grown at the narrower row spacing, but *B. napus* cultivars had similar plant height at both population density and hybrid *B. napus* cultivar yielded greater than the open pollinated cultivars. Seed yield and oil content, the primary characters determining crop value were not affected by population density.

Meitei *et al.* (2001) conducted a two year experiment to determine the effect of (66.6 cm x 66.6 cm, 50 cm x 50 cm, 50 cm x 40 cm, 40 cm x 40 cm, 50 cm x 25 cm, 40 cm x 25 cm and 25 cm x 25 cm) spacing on the yield and yield components of *B. juncea* var. Rugosa cultivars (*Hanggam Amubi, Hanggam Angoubi and Hanggam Anganbi)*. They observed that *Hanggam Angoubi* gave the highest plant height (52.25 and 48.29 cm) and 66.6 cm population density resulted on the tallest plants (55.00 and 48.38 cm).

Ahmed *et al.* (1999) stated that the tallest plant (102.56cm) was recorded in the variety Daulat. No significant difference was observed in plant height of BARI sarisha-6 and Nap-8509.

Sharma and Thakur (1993) reported positive relationship between plant height and increasing row spacing of rapeseed. During 1988 -1989 among three row spacing of 30, 37.5 and 45 cm for the sowing of rapeseed, they found the tallest plant with 45 cm row spacing which was higher than 37.5 cm and 30 cm row spacing. But the effect was not statistically influenced.

Chauhan *et al.* (1993) reported no significant effect of row spacing on the plant height of toria. They evaluated three row spacing viz 20, 30, and 40 cm. The maximum plant height was found at 20 cm row spacing which was similar to the plant height found at 30 cm row spacing and lowest at 40 cm row spacing. It showed that plant height decreased with the increase of row spacing.

Uddin *et al.* (1992) observed that seed rate did not have any significant effect on the yield parameters but plant height decreased as the seed rate was increased or spacing decreases.

Mondal *et al.* (1992) found 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 significantly taller than JS-72 and Tori-7.

Miah *et al.* (1987) reported that when rapeseed was grown with 5kg ha^{-1} seed rate, it increased plant height.

Wankhede *et al.* (1970) reported that different levels of population density had no effect on the height of individual plant. Scarisbrick et al. (1982) stated that a negative relationship existed between plant height and higher plant density.

2.2 Number of Branches plant^{-1}

The yield contributing characters such as number of primary, secondary and tertiary branches are important determinant of the seed yield of rapeseed and mustard. Varieties among *Brassica* species show a marked variation in the arrangement of the branches plant^{-1}.

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

Shrief *et al.* (1990) maintained population density of 30, 60 and plants m^{-2} for raising rapeseed and claimed positive response of all yield contributing characters. They found that number of branches plant^{-1} was significantly superior in the plant density of 30 plants m^{-2} compared to those from 60 and 90 plants m^{-2}.

Chauhan *et al.* (1993) found significant differences among the row spacing (20, 30 and 40 cm) in relation to production of branches plant^{-1} of rapeseed. Among three row spacing, 40 cm row spacing gave highest number of branches plant^{-1} while 20 cm row spacing gave minimum number of branches.

Tomar and Namedo (1989) conducted a study on *Brassica campestris* var. Toria and found that when population density was maintained at 22.2 plants m^{-2} that increased the number of branches $plant^{-1}$ when seed rate of rapeseed was maintained 5 kg ha^{-1}.

Khaleque (1989) reported 3.9 and 3.1 primary branches $plant^{-1}$ produced in TS-72 and Sonali sarisha respectively. Rahman and Quddes (1978) noticed that most of the lower branches were unproductive in Sonali sarisha. Mondal *et al.* (1992) were identical due to varietals behavior.

Gupta (1988) conducted a field experiment to determine the effects of spacing on rapeseed on using (60 cm × 5 cm, 50 cm × 5 cm, 50 cm × 10 cm, 40 cm × 10 cm, 40 cm × 15 cm and 25 cm × 15 cm) the mean population density and he found that wider spacing increased the number of branches $plant^{-1}$.

Singh and Singh (1987) observed that higher seed yield was positively correlated with primary and secondary branches and siliquae $plant^{-1}$.

McGregore (1987) observed that when rapeseed was grown with 5 kg seeds ha^{-1}, the number of branches $plant^{-1}$ increased.

Gangwar and Kumar (1986) reported the increased number of plant at population density of 16.6 plants m^{-2} in *B.campestries* var. Toria. Tomar and Namedo (1989) on *B.campestris* var. Toria found that population density of 22.2 plants $m\text{-}^{2}$ increased the number of primary and secondary branches $plant^{-1}$.

Khader and Bhargava (1985) conducted a field experiment with two varieties of *B.juncea* and *B. campestris* and found maximum number of branches $plant^{-1}$ at the population density of 44 plants m^{-2}.

Kumar and Gangwar (1985) planted *B. campestris* var. Tori at 20, 30 and 40 cm apart rows and observed that number of primary and secondary branches plant^{-1} was decreased at 20 cm which gave over all poor growth of the plant.

Wankhede *et al.* (1970) investigated that different levels of population density did not have any significant effect on the number of branches plant^{-1}.

Singh *et al.* (1969) studied 30 cultivars of mustard and observed that seed yield was positively correlated with number if primary, secondary and tertiary branches.

2.3 Number of siliquae plant $^{-1}$

Jahan and Zakaria (1997) reported that the highest number of siliquae plant^{-1} was recorded in BLN-900(130.9) which was identical with that Observed in BARI sarisha-6 (126.3).Tori-7 had the lowest (46.3) number of siliquaeplant-1^{-1}.

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

McGregor (1987) observed that when rapeseed was grown with 5 kg seeds ha^{-1} number of siliquae plant^{-1} increased. On the other hand, he found the wider spacing increased the number of siliquae plant^{-1}.

Singh *et.al.* (1986) reported that wider inter and intra-row spacing improved the growth and yield attributes in mustard. Inter and intra-row spacing significantly influenced the number of siliquae plant^{-1}. However, the seed yield remained unaffected by spacing.

Mustapic *et al.* (1987) recommended that the optimum plant density of rape cultivar is 70-80 plants m^{-2} which corresponded to a sowing rate of 6 kg ha^{-1}. They also concluded that the crop responded to lower plant densities by producing a greater number of side shoots and hence a greater number of siliquae plant^{-1}.

Mudholkar and Ahlawat (1979) worked with 3 plant densities of mustard (33,166 and 111 thousand plants ha^{-1}) and found that the number of siliquae $plant^{-1}$ and seed yield $plant^{-1}$ tended to increase on linear fashion with decreasing plant densities. The situation may be attributed to reduce inter plant competition. The seed yield remains unaffected by different plant densities.

Allen and Morgan (1972) found that the seed yield of Brassica species were dependent upon siliquae m^{-2}. They also concluded that siliqua m^{-2} or siliqua $plant^{-1}$ at the same population density seemed to be the determinant factor of seed yield.

Wankhede *et al.* (1970) investigated the different levels of population and reported that variation in density did not have any significant effect on the siliquae plant-^{1} while a little but increases was noted with lower population. Mudholkar and Ahlawat (1981) reported that a density level with broadcastion was superior to seed sowing with 2kg ha^{-1} in 30cm apart in row in terms of number of siliquae $plant^{-1}$.

2.4 Length of siliqua

Hussain *et al.* (1996) stated that the varieties differed significantly in respect of siliqua length. The longer siliqua (7.75 cm) was found in the hybrid BLN-900 which was identical to Hyola-101. Sampad, BARI sarisha 6 and Hyloa -51. The shortest siliqua length (4.62 cm) was found in the hybrid Semu-249/84 which was identical to those of Semu-DNK-89/218, AGH-7 and Tori-7. The longest siliqua (8.07 cm) was found in BLN -900 and Hyola -401 (Jahan and Zakaria, 1997).

Regression analysis revealed that siliqua weight significantly influenced the seed yield whereas, siliqua length and siliqua diameter had a marginal effect (Gangasaran *et al.* 1981). They further noticed that siliqua length and number served as the most reliable index of selection for yield improvement in brown sarson (*B. campestris var.sarson*).

2.5 Number of seeds siliqua $^{-1}$

The number of seeds siliqua contributes materially towards the final grain yield in rapeseed. So, the number of seeds siliqua^{-1} is an important yield attributes of rapeseed and mustard and population density is a vital factor in producing optimum number of seeds siliqua^{-1}.

Row spacing had remarkable effect in producing more number of fertile siliqua plant^{-1}. Wider spacing facilitated favorable environment for producing more siliqua than closer spacing (Siddiqui, 1999).

Butter and Aulakh (1999) conducted a study on Indian mustard cv.RLM 619 and maintained 3 rows spacing (15, 22.5 and 30 cm). They observed that row spacing had significant effect on number of siliqua plant^{-1} and found increased number of siliqua plant^{-1} with wider row spacing (40 cm).

Jahan and Zakaria (1997) found that BARI Sarisha- 6 produced the highest number of seeds siliqua^{-1} (26.13) which was at par with Sonali (23.5) and
Jatarai (22.8). The lowest number of seeds siliqua-1 (18.0) was found in Tori-7 (205). AGA-95-21(20.7) and BARI sarisha-8 (21.6). Singh and Singh (1984) reported that lower density at 16.6 plants m^{-2} recorded higher seeds siliqua^{-1} than higher PD level of 33.3 plants m^{-2}. Tomar and Namedo (1989) concluded from a study on *B. campestris* var. Toria that when PD were maintained 22.2 plants m^{-2}, increased the number of seeds siliqua^{-1}. McGregor (1987) observed that when rapeseed was grown with 5 kg seeds ha^{-1}, seeds siliqua^{-1} increased.

Gurjar and Chauhan (1997) found maximum number of seed siliqua^{-1} (11.89) in Indian mustand with 30 cm row spacing. But it was less than the number of seed siliqua^{-1} (11.74) produced at 45 cm row spacing.

Thakuria and Gogoi (1996) conducted a field experiment to evaluate *Brassica juncea* cv. TM.2 TM 4 and Varuna at 2 row spacing (30 and 45 cm) The effects of cultivars and row spacing on seed yield and yield attributes was significant except siliquae plant^{-1} which increased under 45 cm row spacing.

Ali *et al.* (1996) found a significant difference in the number of seeds siliqua^{-1} with different population densities while working with rapeseed. They reported for the negative relation between the number of seeds siliqua^{-1} and population density. Rapeseed plant gave highest number of seeds siliqua^{-1} when population density was 100,000 plants ha^{-1} while lowest number of seeds siliqua^{-1} was found from the population density of 1,000,000 plants ha^{-1}.

Chauhan *et al.* (1993) reported that the number of siliquae plant^{-1} was significantly affected by population density. They found that number of siliqua increased with the increase of population density. The maximum number of siliquae plant^{-1} was found from 40 cm row spacing and 20 cm row spacing gave lowest number of siliqua number of siliquae were found 24% more m 40 cm row spacing than those of 20 cm.

Chauhan *et al.* (1993) reported a positive relation between row spacing and 1000-seeds weight .They found a significant effect of row spacing (20, 30 and 40 cm) on 1000-seeds weight of Toria. Among the row spacing 40 cm row spacing gave highest weight of 1000-seeds while 20 cm row spacing gave lowest weight.

Sharma (1992) found a significant increasing rate of 1000-seeds weight with the increase of row spacing in different mustard varieties. He conducted an experiment with four row spacing viz. 30.0, 33.5, 37.5 and 45.0 cm. Among all row spacing maximum seed weight was found from 45 cm row spacing which was significantly higher from others. Lowest seed weight was found from 33.5 cm row spacing.

Tomar and Namedo (1989) conducted a study on *B. campestris* var. Toria that when population density was maintained 22.2 plants m^{-2} there was increment in the number of primary and secondary branches and siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$ and 1000-seeds weight, which significantly increased seed yield and higher oil content of Toria.

Singh and Singh (1987) observed that higher seed yield was positively correlated with siliqua plant $^{-1}$. McGregor (1987) observed in rapeseed that the wider spacing increased the number of siliquae $plant^{-1}$.

Singh and Singh (1987) found no significant effect of row spacing on 1000-seeds weight of mustard .However, the weight increased with the increase of row spacing and the highest seed weight was found from 60 cm row spacing and 30 cm row spacing gave the lowest weight of 1000-seeds.

Gangwar and Kumar (1986) reported that lower population density in B.campestris var.Toria increased the number of siliquae $plant^{-1}$ but it did not differ significantly at different density levels.

Singh and Singh (1984) reported that the number of seeds $siliqua^{-1}$ increased as the population density decreased.

Patel *et al.*(1980) conducted an experiment during 1977-1978 with rapeseed and reported about the positive relation between row spacing population density and 1000-seeds of weight .They stated that among 30, 45 and 60 cm row spacing 60 cm row spacing gave highest 1000-seeds of weight than other row spacing, which indicated the lower 1000-seeds of weight with closer spacing.

2.6 1000-seeds weight

It is also an important character which reflects the seed size. It varies from genotype to genotype and is influenced by some production factors. A good number research works have been conducted on this character.

Mondal and Wahab (2001) described that weight of 1000-seeds varied from variety to variety and species. They found 1000-seeds weight 2.50-2.65 g in case of improved tori-7 *(B. campestris)* and 1.50.80 g in case of Rai-5 *(B. juncea)*.

BARI (2001) reported that there was significant variation in 1000-seeds weight of rapeseed and mustard in different variety and the highest weight of 1000-seeds was observed in variety Jamalpur 1 and the lowest in BARI sarishal-10.

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

Hussain *et al.* (1998) observed significant variation on 1000-seeds weight as influenced by different varieties. They found Hyola- 401 had the highest 1000-seeds weight (3.4 g) and the lowest 1000-seeds weight was recorded in Tori-7 (2.1g).

Jahan and Zakaria (1997) carried out an experiment to find out the performance of different varieties of rapeseed and mustard. They found variation in 1000-seeds weight and the highest weight in the variety BLN-900 (3.37g) and lowest in Tori-7 (2.27g).

2.7 Seed yield

It is an important polygenic character which is highly influenced by other characters and production factors. A good number of reports reveled that there were variabilities among different genotypes of rapeseed and mustard.

Angadi *et al*. (2003) reported that reducing plant population by half from 80 to 40 plants m^{-2} did not reduce seed yield but seed yield declined as population dropped below 40 plants m^{-2}.

Rahman (2002) observed higher seed yield in BARI sarisha-7, BARI Sharisha-8 and BARI sarisha- 11 (2.00-2.50 t ha^{-1}) and the lowest yield in variety Tori-7 (0.95-1.10 tha-1).

Behera *et al*. (2002) stated that field experiment were conducted during rabi season to study the effect of plant population consumptive use productivity and moisture of mustard (*Brassica juncea*) varieties viz "Sanjukta Asech" and Varuna underrainfed conditions. It was observed that interaction effect of variety and plant populations were found significant on pooled seed yield.

Behera *et al*. (2002) conducted a field experiment to study the effect of plant population and sulfur levels on yield of mustard (*B. juncea*) and found interaction effects of variety and plant population significant on pooled seed yield and recorded the maximum seed yield at the intermediate population level of 14.8 plants m^{-2}.

In Poland, Walkowshi (2001) conducted an experiment with different seed rates (80, 120, 160, and 200 siliquae m^{-2} and sowing date (early sowing and two weeks delayed) and the highest yields were obtained under the combination of 160-200 siliquae m^{-2} and early sowing time; and 120-160 siliquae m^{-2} and early sowing tome, respectively.

Surya *et al*. (1998) conducted a field experiment in the rabi (winter) season of 1996/97 in Hiser, where *Brassica juncea* cv. Varuna, RH-30 and Laxmi were sown 5 or at spacing of 30×15cm or 40×30cm. Yield and yield components were not affected by spacing, Laxmi gave the highest yield, followed by RH-30 then Veruna.

Khandey *et.al.* (1993) decreased *B. juncea* cv. kos land and found that densities of 333000,444000 or 666000 plantsha-1 produced seed yields of 0.31,0.87 and 0.82 t, respectively.

Rana *et al.* (1991) conducted a field experiment during the winter seasons in 1985-87 at Baraut, *B. juncea* cv. Pusa sown at densities of 66000, 100000 or 200000 plants ha-1, and given 0, 50, 100 or 150 kg N ha^{-1}. Seed oil content was unaffected by plant density, oil yield was higher at densities of 100000 or 200000 plants than 66600 plants. N content was unaffected by plant density but straw N content tended to increased with decrease in plant density. At densities of 100000 or 200000 plants N uptake in seeds and straw was similar and greater than in plants sown at 66600 plants ha^{-1}.

Chavan *et al.* (1989) investigated that when mustard was planted maintaining a spacing of 45cm ×15cm i.e. plants m^{-2} significantly increased seed yield over the population density of 30cm ×15cm and 22.5cm ×15cm i.e. 22 and 30 plants m^{-2} respectively.

Singh and Singh (1987) in an experiment with 3 row spacing (30, 45 and 60cm) in mustard found that number of siliqua and yields $plant^{-1}$ reduced markedly with closer row spacing of 30cm higher plant density as compared to 45 and 60 cm spacing. Length of siliqua and 1000 seed weight, however, remained unaffected by plant densities. They also concluded that seed yield reduction $plant^{-1}$ at closer spacing might be due to competition for growth resources like nutrients, space, light etc.

Hamid and Hussain (1987) obtained maximum seed yield of *Brassica campestris* when they maintained a plant density of 88 plants m^{-2}.

Bhati *et.al.* (1987) conducted a study on Indian mustard (*B. juncea*) and grew at a plant spacing of 10, 15, 20, and 25 cm with 30 and 45 cm apart rows. They found that among the spacing combination 30 cm ×15 cm gave the highest seed yield.

Singh *et al.* (1986) reported that wider inter and intra-raw spacing improved the growth and yield attributes in mustard. Inter and intra-row spacing significantly influenced the number of siliqua plant^{-1}. However, the seed yield remained unaffected by spacing.

Ogilvy (1986) sowed rapeseeds at different rates ranging from 3-12 kg ha^{-1} and found that maximum seed yield was obtained by the seed rates between 4-8 kg ha^{-1}. Plants from higher seed rates had lower percentage of establishment due to competition between them. From lower seed rates rape plants produced thicker stems, higher number of lateral branches and more siliquae plant^{-1} than those from higher seed rates.

Gangasaran and Giri (1986) stated that *juncea* seed yield and oil contents were increased by applying 1 irrigation and were similar at densities of 100000 and 170000 plants ha^{-1}.

Kumar and Gangwar (1985) observed that higher response of different growth parameters and maximum seed yield of rape seed at plant density levels of 166 and 222 thousand plants hectare^{-1}.

Hussain *et al.* (1985) conducted an experiment on mustard with seed rate ranging from 4-2.2 kg ha^{-1} and observed that the yield was increased with the increasing of seed rate. However, the farmers using seed rate higher than 20 kg ha^{-1} received fewer yields.

Singh and Singh (1984) reported that increasing plant densities adversely affected the various yield attributes except 1000 seeds weight. The number and weight of siliquae plant^{-1} increased markedly with decreasing plant densities. Length of siliqua and seeds siliqua increased significantly at lowest plant density as compared to highest. They also found that the grain and stalk yields were significantly higher at highest plant population.

Elias *et al.* (1982) found that in different places of Bangladesh farmers generally practiced broadcast method of seeding and used variable seed rate (5 kg to 20 kg ha^{-1}), irrespective of both traditional and improved varieties of rapeseed and mustard. In line sowing, only row to row distance are maintained without looking into the number of plants row. Over population within the row or plants unit area create heavy competition for nutrition causing either reduction in growth and yield or death of plant.

Shastry and Kumar (1981) observed that when mustard crop was grown at densities of 11.1, 14.18 and 22.2 plants m^{-2} gave yield in the range of 1.09 to 1.35, 1.39 to 1.41 and 1.34 to 1.35 ton ha^{-1}, respectively showing thereby the optimum population to be about 14.8 plants m^{-2}. They also noticed that higher population density enhanced maturity. At higher population density on an average, a crop took 5 to 10 days less time to reach 50 cent flowering, pos formation and completion of siliqua setting and 80 percent maturity.

Mudholkar and Ahlawat (1981) conducted an experiment at Haryana in India and concluded that a density of 16 thousand plants ha^{-1} was superior to drilling 2 kg seed in row 30 cm apart in terms of dry matter and number of siliquae $plant^{-1}$, but seed yield are similar. They also reported that plant height, dry matter yield and number of siliquae $plant^{-1}$, seed yield and 1000-seeds weight of rape increased with increasing nitrogen (0-80 kg ha^{-1}) and phosphorus (0-80 kg P_2O_5 ha^{-1}).

Rahman and Quddes (1978) reported that all the four varieties of mustard (BAU-M/12 cm, BAU-M/7, Tori-7 and Rai-5) responded favorably to increasing management levels. It was evident the plant height, number of branches $plant^{-1}$, number of siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and yield $siliqua^{-1}$ increased gradually with the increasing of management level at the sowing rate of 7.5 kg seed ha^{-1}.

Suraj *et al*. (1975) reported that when mustard was grown at variable population density, the higher density (20cm×10cm) i.e. 50cm plants m^{-2} produced higher seed yield ha^{-1}.

Bengtsson and Ohlssen (1973) conducted 41 experiments in Sweden on winter rape using the seed rates of 2, 4 and 6 kg ha^{-1} and found that the seed rate 6kg ha^{-1} gave the highest yield as compared with the rates of 2 or 4 kg ha^{-1}.

Downey (1971) reported that optimum spacing or population density unit area plays an important role in increasing yield. Grain yield can be increased by raising plant population, but this relationship is parabolic.

2.8 Stover yield

BARI (2001) reported that in case of poor management ISD local gave the highest stover yield (3779 kg ha^{-1}) and the lowest Stover yield (1295 kg ha^{-1}) was found from Nap-248. In case of medium management highest weight (6223.3 kg ha^{-1}) was same variety and the lowest (3702.3kg ha^{-1}) from PT-303 under high management conditions. The Stover yield, 6400kg ha^{-1} was obtained from the variety Rai-5 and the lowest stover yield, 4413.3kg ha^{-1} was obtained from Tori-7.

Ali *et al.* (1996) reported that stover yield ha^{-1} significantly differed with different population density. They found maximum stover yield with the population density of 400,000 plant ha^{-1}. The lowest stover yield was found from 100,000 plants ha^{-1}. The yield variation was due to lowest number of plants unit area and vice versa. It indicated that the improvement in yield attributes at lower plant density was not reflected by stover yield.

Chauhan *et al.* (1993) reported that stover yield of mustard was greatly affected by row spacing due to variation of the population unit area. Among three rows spacing (20, 30 and 40 cm) 30 cm row spacing gave highest yield of stover. The second highest yield was obtained with row spacing of 40 cm which was statistically different with 30 cm row spacing yield.

Singh and Singh (1984) observed that when population density of 33.3 plants m^{-2} was maintained, it gave higher HI, increased seed and straw yields of *B. campestries* var. Tori,

2.9 Biological yield

Singh *et al.* (1986).reported that Indian mustard gave the highest total biomass production at 45 cm row spacing over 30 and 60 cm row spacing. However, there was a scarcity of information regarding the biological yield due to spacing variation in rapeseed or mustard cultivation.

Plant density at different levels increased the harvest index of rapeseed (Ali *et al.* (1996). Population of 70 and 100 plants m^{-2} did not show significant difference in harvest index but 40 plants m^{-2} gave higher harvest index and higher seed yield.

Shrief *et al.* (1990).reported higher seed yield of rapeseed along with higher harvest index where density was maintained as 30 plants M^{-2}.

2.10 Harvest Index

Islam *et al.* (1994) showed that variety had significant effect on harvest index (%) of rapeseed and mustard. They found that the highest harvest index in the variety RS 72 which was identical to Dulat and the lowest in Sonali Sharisha(21.90%) followed by Sambal (26.7%).

Scarisbric *et al*. (1982) used variable seed rate for raising rapeseed and noticed d that harvest index did not increase when the seed rate was raised from 4.5 to 18.0 kg ha^{-1}. Population density at 54 plants m^{-2} gave the higher HI value.

From the above review of different experimental evidences related to this study it was noticed that different varieties and population density had influence on yield contributing characters of mustard.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

A field experiment with two rapeseed varieties and six population densities level was conducted in the rabi season (November 2006-March 2007) to evaluate the response of rapeseed cv. BARI sarisha-13 and SAU sarisha-1 in respect of growth and yield performances.

3.1Experimental Site

The research was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field is located at 90°335′E longitude and 23°774′ N latitude at a height of 9 meter above the sea level (BCA, 2004). The land was medium high and well drained.

3.2 Soil

The soil of the experimental site belongs to the agro-ecological region of "Madhupur Tract" (AEZ No.28). It was Deep Red Brown Terrace soil and belonged to "Nodda" cultivated series. The top soil is clay loam in texture. Organic matter content was very low (0.82%) and soil p^H varied from 5.55 to 6.00. The physical and chemical characteristics of the soil have been presented in Appendix I.

3.3 Climate

The experimental area experiences a sub-tropical climate where the kharif season starts with high temperature and it decreases when the season proceeds towards Rabi. The mean maximum temperature rises in the month of April, whereas in winter the mean maximum temperature downs in January, Usually scanty rainfalls in Rabi season (October to March) and heavy rainfall during Kharif season (April to September). The relative humidity increases from June to September (80% or above) and declined to a minimum in the winter.

The annual precipitation and potential evapotranspiration of the site were 2152 mm and 1297 mm, respectively. The average maximum and minimum temperature was 30.34°c and 21.21°c, respectively with mean temperature during the cropping period ranged between 12.2°c to31.2°c. The humidity varied from 73.52% to 81.2%, the day length ranged between 10.5-11.0 hours only. The weekly average rainfall, air temperature and relative humidity of the site during the experimental work have been shown in appendices II

3.4 Experimental materials

Two varieties of rapeseed namely BARI sharisha-13 and SAU sharisha-1 were used as planting materials. Seed of BARI sharisha-13 was collected from the Oil Seed Research Center, Bangladesh Agricultural Research Institute, Gazipur and SAU sarisha-1 from Department of Genetics and Plant Breeding, Sher-e- Bangla Agricultural University, Dhaka-1207.

The important characteristics of these varieties are mentioned below:

BARI sarisha-13: BARI sarisha-13 is a high yielding variety of rapeseed. It is a short duration variety. Siliqua of this variety are comparatively longer. Plant height of this variety is about 90-125 cm. Seeds are purple in color with 42- 43% oil. The crop matures within 90-95 days and its yield varies from 1500-1650 kg ha^{-1}.

SAU sarisha-1: SAU sarisha-1 is a high yielding variety of rapeseed. It is under yellow sarson group of *Brassica campestris*. Siliqua of this variety are comparatively longer. Erucic acid content is comparatively lower. Plant height of this variety is about 80-90 cm. Seeds are yellow in color with 41- 43% oil. The crop matures within 75-80 days and its yield varies from 1550-1750 kg ha^{-1}.

3.5 Experimental treatments

The treatments comprised of two varieties and six population densities. There were altogether 12 treatments combinations.

3.5.1 Experimental factors

Factor-1: Variety

V_1=BARI sarisha-13 V_2=SAU sarisha-1

Factor-2: Population density

P_1=30 plants m^{-2}	P_3=50 plants m^{-2}	P_5=70 plants m^{-2}
P_2=40 plants m^{-2}	P_4=60 plants m^{-2}	P_6=80 plants m^{-2}

3.5.2 Treatment combinations

The experiment consists of the following treatment combinations:

i. V_1P_1	iv. V_1P_4	vii. V_2P_1	x. V_2P_4
ii. V_1P_2	v. V_1P_5	viii. V_2P_2	xi. V_2P_5
iii. V_1P_3	vi. V_1P_6	ix. V_2P_3	xii. V_2P_6

3.6 Experimental design and layout

The experiment was laid out in a two factors randomized complete block design with three replications. Each replication was divided into these plots randomly. The size of each unit plot is 3m×3.5m (10.5m^2). The distance between two adjacent unit plots and that of blocks were 0.5m and 1.0m respectively.

3.7 Land preparation

The experimental field was opened by a tractor drawn disc plough. Later it was ploughed and cross ploughed three times with power tiller followed by laddering to obtain a desirable tilth. The corners of the land were spaded well. Weeds stubble and residues were eliminated from the soil and the land was made ready for laying out.

Finally, the plots were made and the decomposed organic manure were applied seven days before and the basal doses of inorganic fertilizer were applied one day before sowing and were spaded well and leveled. Then the plots were made ready for sowing.

3.8 Fertilizer application

Fertilizers were applied to the plots at the rate of 250, 170, 70, 150, 5 and 12 kg /ha of urea, triple super phosphate, muriate of potash, gypsum, zinc oxide and borax, respectively. Half of urea and the whole amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation and the rest half of urea were top dressed before flowering.

3.9 Sowing of seeds

Seeds were sown in line maintaining row spacing and seed to seed distance specification. Sowing was done manually by hand. Seeds were placed 2 cm depth and then rows were covered with loose soil properly.

3.10 Weeding and thinning

The experimental plots were weeded twice in time. First weeding was followed by thinning which was done at 12 days of emergence and second weeding was done at 30 days after emergence. Thinning was done once in all the unit plots with care to maintain a constant plant population density in each row.

3.11 Irrigation

Irrigation was done at 25 days and 45 days of sowing in order to maintain adequate moisture in the field.

3.12 Plant protection measure

There was negligible infestation of insect-pests during the crop growth period. The plants were slightly attacked by aphids at the time of flowering. So, four tea spoonfuls of Malathion mixed with 5gallons of water was sprayed in the plots on 11January 2007. The spraying was done at afternoon not to disturb honey bee visit for pollination.

3.13 General observations

The plots under experiment were frequently observed to notice any change in plant growth and other characters. The plant growth was very luxuriant.

3.14 Harvesting and post-harvest operations

The maturity of crop was determined when 85% to 90% of pods become grey in color. BARI Sharisha-13 and SAU Sharisha-1were harvested at maturity on 02 March 2007. The harvested crop of each plot were bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then seeds were cleaned. The seed and straw weights for each plot were recorded after proper drying in sun. Before harvesting, ten plants were selected randomly from each plot and were cut at the ground level for collecting data on yield contributing characters.

3.15 Sampling and data collection

Data collections were done on the following parameters from the experiment on growth and yield.

i. Plant height (cm) at 25 days, 50 days, 75 days after sowing and at final harvest.
ii. Number of branches plant^{-1}
iii. Number of siliquae plant^{-1}
iv. Length of siliqua (cm)
v. Number of seeds siliqua^{-1}
vi. Weight of 1000- seeds (g)
vii. Seed yield plant^{-1} (g)
viii. Seed yield (kg ha^{-1})
ix. Stover yield (kg ha^{-1})
x. Biological yield (kg ha^{-1})
xi. Harvest index (%)

Procedure for data collection before and after harvest

For assessing growth and yield parameter 10 plants were selected at random from individual plot from specific rows at 25 days, 50 days, 75 days for plant height (cm) but selected middle 4 rows were used at harvest for plant height (cm), number of branches plant^{-1}, number of siliquae plant^{-1}, length of siliqua(cm), number of seeds silliqua^{-1}, weight of 1000- seeds (g), seed yield plant^{-1}, seed yield (kg ha^{-1}), strover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) calculation.

3.15.1 Plant height

Plant height was measured from the soil level to the apex of the leaf or siliqua in randomly selected 10 plants from specific rows of each plot at 25 days, 50 days, 75 days, at harvest and mean plant height (cm) was recorded.

3.15.2 Total number of branches plant^{-1}

The total number of branches plant^{-1} was counted from selected samples and was recorded.

3.15.3 Number of siliquae plant^{-1}

The number of siliquae plant^{-1} was counted and the mean was found out.

3.15.4 Length of siliqua (cm)

Measurement was taken from the base of the pod to the apex of each siliqua.

3.15.5 Number of seeds siliqua^{-1}

The number of seeds siliqua^{-1} was counted and the mean was found out.

3.15.6 1000-seeds weight (g)

From the seed stock of each plot, 1000-seeeds were randomly collected and weight was taken by an electric balance. The 1000-seeds weight was recorded in gram.

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

Seeds obtained from each plant were sun dried, cleaned and weighed carefully. The dry weight of seeds of each plant was finally converted to gram.

3.15.8 Seed yield (kg ha^{-1})

Seeds obtained from each unit plot were sun dried, cleaned and weighed carefully. The dry weight of seeds of each unit plot was finally converted to kg ha^{-1}.

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

The weight of the plants containing seed were taken by subtracting the seed weight from the total weight, the straw weights were calculated and expressed in kg ha^{-1}.

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

The summation of seed yield and strover yield $plot^{-1}$ gave the biological yield.

3.15.11 Harvest index (%)

The harvest index was calculated the ratio of seed yield to biological yield (seed yield + stover yield) and expressed in terms of percentage. It was calculated by using the following formula (Donald, 1963).

$$\text{Harvest index} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.15.10 Statistical analysis

The collected data were analyzed statistically by using analysis of variance (ANOVA) technique with the help of computer package MSTAT. The mean differences among the treatments were tested with L S D method.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to study the performance of BARI Sarisha-13 and SAU Sarisha-1 as under varying population density. The results of the present investigation have been presented, discussed and compared with the results of other scientists.

4.1 Plant height

4.1.1 Effect of variety

There were significant variations for plant height between the varieties at different growing period (Table 4.1). The plant height at 25, 50, 75 and at harvest were found from BARI sarisha-13 as 6.09, 59.68, 116.65 and 117.32 cm respectively which were significantly different from SAU sarisha-1 showing corresponding plant height of 13.52, 53.83, 94.00 and 94.38 cm respectively. Varieties have different plant types and therefore, plant height in particular differs widely. Ali and Rahman (1986) observed significant variation in plant height in different varieties of mustard and rape. Jahan and Zakaria (1997) observed that BARI Sharisa-6 had the tallest plant (142.5 cm) which was at par with Sonali (139.5 cm) and Jatarai (138.6 cm).The shortest plant was observed in Tori-7 (80.97 cm). Mondal *et al.* (1992) observed the highest plant height (134.4 cm) in the variety J-5004, which was identical with SS-75 significantly taller than TS-72 and Tori-7. Ahmed *et al.* (1999) observed the tallest plant (120.56 cm) in the variety Daulat. The results indicated that the variety BARI sarisha-13 is of tall plant type and others are intermediate and of short stature in plant height. So, the significant difference in plant height may be associated with the varietal characteristics or genetic make up of the varieties of rape seed.

Table 4.1 Effect of variety on plant height (cm) at different growing period of BARI sarisha-13 and SAU sarisha-1

Variety	Days after sowing			
	25	50	75	At harvest
BARI sarisha-13	16.09	59.68	116.65	117.32
SAU sarisha-1	13.52	53.83	94.00	94.38
$LSD_{0.05}$	0.42	0.63	1.49	1.37
CV (%)	5.76	2.26	2.89	3.44

4.1.2 Effect of population density

Plant height was significantly influenced by different population density (Table 4.2). In the initial stage up to 25 DAS the growth of both the varieties were very slow and then the crops remained in rosette form. Stem elongation started with the initiation of reproductive phase of development. The rapid increase of plant height was observed from 25 to 75 DAS. After 75 DAS the growth of plant height became very slow. In the initial stage the plant canopy was very small and competition started for aerial apace. The closest population density of 80 plants m^{-2} ultimately produced significantly tallest plant than 70 plants m^{-2}, 60 plants m^{-2}, 50 plants m^{-2}, 40 plants m^{-2} and 30 plants m^{-2} in almost all the growing period. The increased plant population increased competition for nutrition, space and light and that might have resulted in the stunted growth. The competition for space might have elongated the densely populated plants (Mudholkar and Ahlawat, 1979). Increasing population density increased plant height in rapeseed was also reported by Singh and Dhillon (1991). Chauhan *et al.* (1993).The positive effect of increasing population density on plant height has been reported also in other crops like soybean (Rana *et al.*, 1991) seasame. The result revealed that the plant height decreased as the row spacing decreased. This was mainly due to over population pressure.

Table 4.2 Plant height (cm) at different growing period as affected by population density

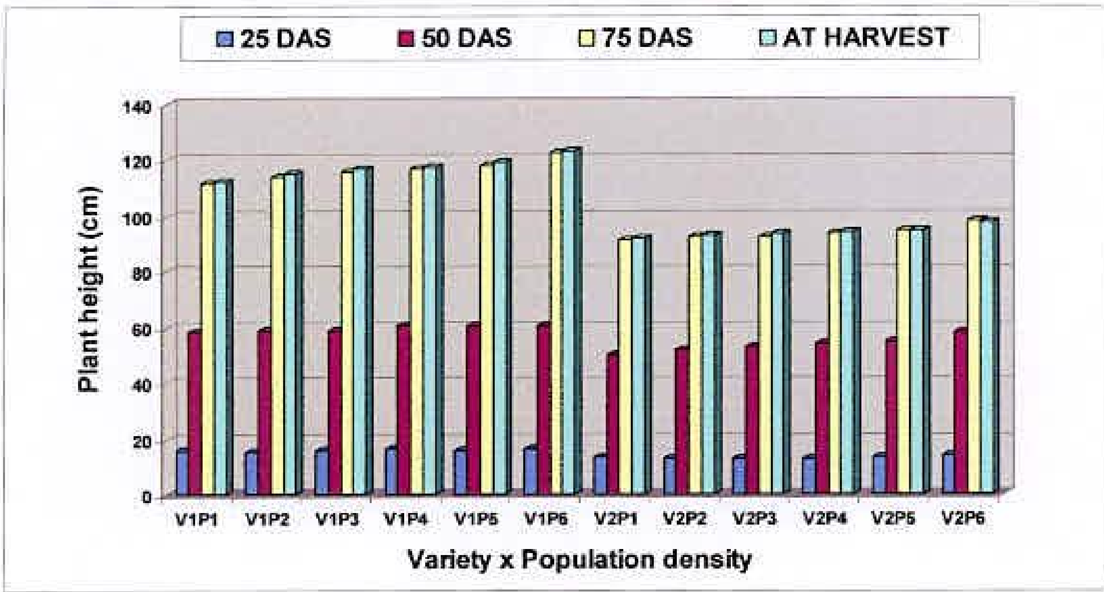
Population density	Days after sowing			
	25	50	75	At harvest
P_1	14.82	54.93	101.60	102.1
P_2	14.68	55.41	103.20	104.8
P_3	14.68	56.05	104.30	105.7
P_4	14.74	56.61	105.60	106.5
P_5	14.83	58.01	106.70	109.6
P_6	15.28a	59.51	110.50	111.2
$LSD_{0.05}$	NS	1.54	3.65	4.37
CV (%)	5.76	2.26	2.89	3.44

P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

4.1.3 Interaction effect of variety and population density

Interaction effect of variety and population density had a remarkable variation in plant height (Fig. 4.1). Significant differences of plant height were found in every periods of growing except at the early period (up to 25 DAS). This was due to the slow growth rate. It was found from the Fig. 4.1 that the interaction of 30 plants m^{-2}, 40 plants m^{-2}, 50 plants m^{-2}, 60 plants m^{-2}, 70 plants m^{-2}, 80 plants m^{-2} population density with BARI sarisha-13 gave the tallest plant height viz. 16.47 cm, 60.85 cm, 122.8 cm and 123.6 cm at 25, 50, 75 DAS and at harvest, respectively. Maximum plant height was observed in the treatment BARI sarisha-13 and 80 plants m^{-2} in all the periods of life cycle. The lowest plant height was found from the treatment SAU sarisha-1 x 30 plants m^{-2}. The plant response in terms of height to the combined treatment was found higher in the middle of growth period (from 50 DAS to 75 DAS) because of better growth. The maximum plant height (123.6 cm) at harvest was obtained from the treatment combination of

BARI sarisha-13 and 80 plants m^{-2} which were statistically similar with V_1P_5, V_1P_4 and V_1P_3 showing the plant height as 119.5cm, 117.9cm and 11.27 cm respectively.



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.1 Interaction effect of variety and population density on plant height at different days after sowing

4.2 Crop characters

4.2.1 Number of branches plant^{-1}

The yield contributing characters such as number of primary, secondary and tertiary branches are important determinant of the seed yield of rape seed and in this study indicated that the number of branches plant^{-1} varied significantly between the varieties and among the population density.

4.2.1.a Effect of variety

There was significant variation in number of branches plant^{-1} between the varieties (Table 4.3). The variety SAU sarisha-1 produced the higher number of branches plant^{-1} (7.34) and lower number of branches plant^{-1} (5.25) was given by BARI sarisha-13. The variety SAU sarisha-1 produced the number of branches plant^{-1} which was 39.80% higher than that of BARI sarsha-13. Jahan and Zakaria (1997) observed 4.07 primary branches plant^{-1} in the local Tori-7 and sampad which were at par with BLN-800. The minimum primary branches plant^{-1} (2.80) was produced by Jataria. Khaleque (1989) observed 3.9 and 3.1 branches plant^{-1} in TS-72 and Sonali sarisha, respectively.

Table 4.3 Varietal performance on crop characters of BARI sarisha-13 and SAU sarisha-1

Variety	Number of branches plant^{-1}	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000- seeds weight (g)
BARI sarisha-13	5.25	97.51	8.14	29.81	3.73
SAU sarisha-1	7.34	152.51	7.10	25.93	2.87
$LSD_{0.05}$	0.22	3.16	0.16	0.89	0.03
CV (%)	7.04	5.18	4.22	6.51	2.02

4.2.1.b Effect of population density

Population density significantly influenced the number of branches plant^{-1} (Table 4.4). Closer population density significantly showed decreased number of branches plant^{-1}. Significantly the highest number of branches plant^{-1} (7.77) was found in the widest population density of 30 plants m^{-2} and the lowest number of branches plant^{-1} (5.43) was produced by 80 plants m^{-2} which was statistically identical with 70 plants m^{-2} and 60 plants m^{-2} producing number of branches^{-1} as 5.67 and 5.77 respectively. The other intermediate population density 40 plants m^{-2} and 50 plants m^{-2} produced 6.70 and 6.45 branches plant^{-1}, respectively which was statistically identical to each other. Wider population density produced higher number of branches plant^{-1} which might be due to less interplant competition for light, space, nutrients and environmental resources. Chauhan *et al.* (1993) found similar results. Lower density increased the number of branches which might be due to less inter plant competition for light, nutrients, space and environmental resources (Alam, 2004). In rapeseed reduced number of branches plant^{-1} due to increasing population density has been reported by Giri and Gangasaran (1985). Gangwar and Kumar(1986) and Tomar and Namedo (1989) reported that when *B.campestris* var. Toria was grown maintaining 16.6 and 22.2 plants m-2, the number of primary and secondary branches plant^{-1} were increased and that promoted higher seed yield ha^{-1}. Shrief et al. (1980) maintained plant densities at 30, 60 and 80 plants m-2 and found that lower plant density increased the number of branches plant^{-1} but higher plant density increased, the seed yield by 7.27 percent.

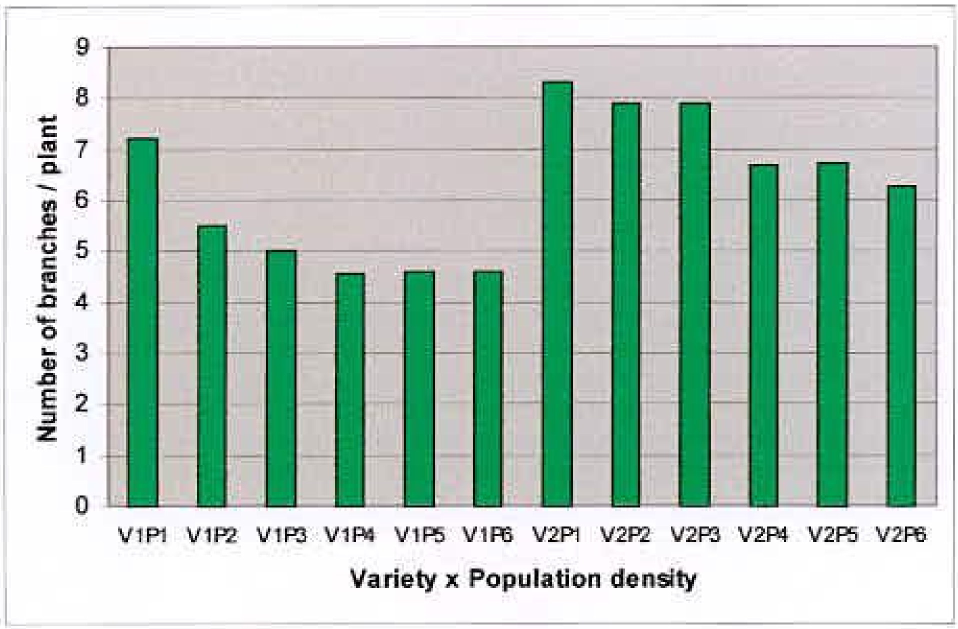
Table 4.4 Crop characters of BARI sarisha-13 and SAU sarisha-1 as affected by population density

Population density	Number of branches plant^{-1}	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000-seeds weight (g)
P_1	7.77	147.0	8.04	29.06	3.45
P_2	6.70	125.7	7.78	29.04	3.39
P_3	6.45	122.2	7.68	28.18	3.35
P_4	5.77	120.5	7.54	27.76	3.26
P_5	5.67	117.8	7.61	27.15	3.21
P_6	5.43	116.9	7.08	26.02	3.13
$LSD_{0.05}$	0.531	7.76	0.386	2.17	0.0757
CV (%)	7.04	5.18	4.22	6.51	2.02

P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

4.2.1.c Interaction effect of variety and population density

There was a significant interaction effect between two varieties and population density in number of branches plant^{-1} (Fig. 4.2).



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.2 Interaction effect of variety and population density on number of branches plant^{-1}of BARI sarisha-13 and SAU sarisha-1

The highest number of branches plant^{-1} (8.30) was produced from the treatment combination of SAU sarisha-1 and 30 plants m^{-2} which was statically similar with V_2P_2 and V_2P_3 showing the number of branches plant^{-1} as 7.90 and 7.90 respectively. The lowest number of branches plant^{-1} (4.60) was produced from the treatment combination of BARI sarisha-13 and 80 plants m^{-2} which was statistically identical with the treatment combination of V_1P_5, V_1P_4 and V_1P_3 showing the number of branches plant^{-1} as 4.60, 4.57, and 5.00 respectively.

4.2.2 Number of siliqua plant^{-1}

Number of seeds siliqua^{-1} is also an important yield contributing attribute of rapeseed and mustard. Different variety produced different number of seeds siliqua^{-1}. Population density is also a vital factor in producing number of seeds siliqua^{-1}.

4.2.2. a Effect of variety

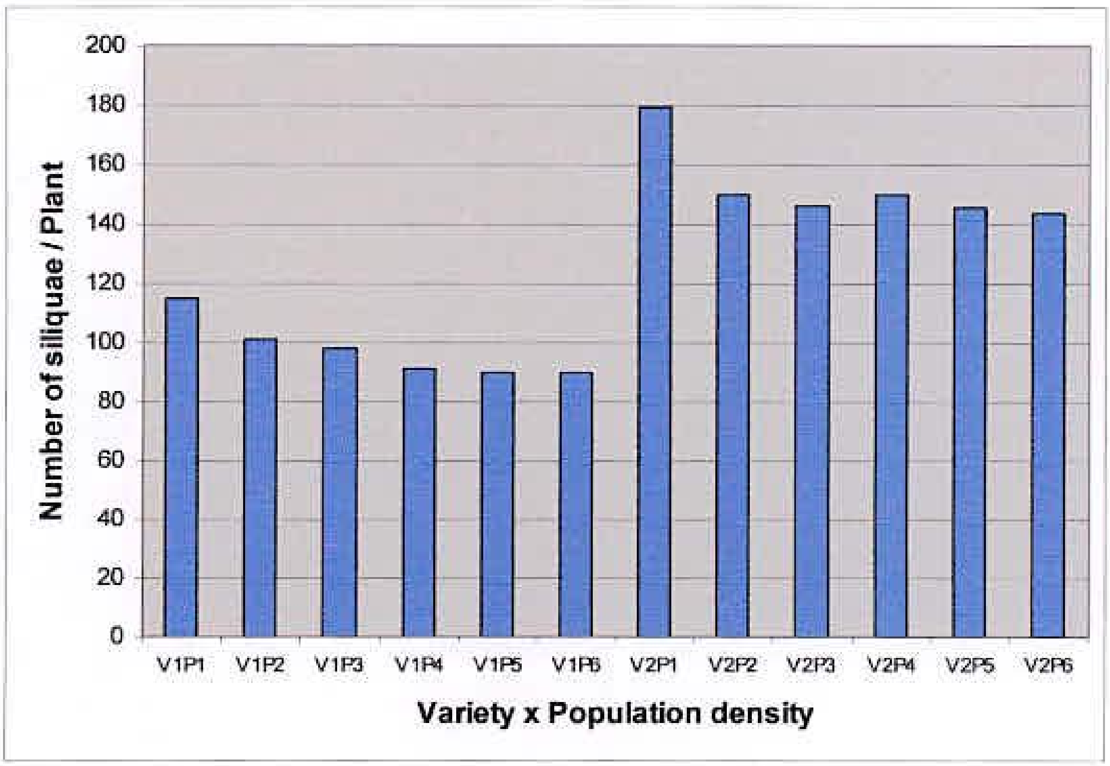
There was a significant difference in number of siliquae plant^{-1} between the varieties (Table 4.3) Higher number of siliquae plant-1 (152.51) was produced by the variety SAU sarisha-1 and the lower number of siliquae plant^{-1} was produced the variety BARI sarisha-13 (97.51). The variety SAU sarisha-1 produced the number of siliquae plant^{-1} which was 56.40% higher than that of BARI sarsha-13. Mondal *et al.* (1992) observed maximum number of siliquae plant^{-1} (136) in the variety J-5004 which was identical with the variety Tori-7 and the lowest number of siliquae plant^{-1} (45.9) was found in the variety SS-75.

4.2.2.b Effect of population density

The number of siliquae plant^{-1} differed significantly due to variation of population density (Table 4.4). The number of total siliquae plant^{-1} gradually declined with the increase in population density. The highest number of siliquae plant^{-1} (147.00) was found from the population density of 30 plants m^{-2} and the lowest number of siliquae plant^{-1} (116.80) was found in population density of 80 plants m^{-2} which was statistically similar to 70 plants m^{-2}, 60 plants m^{-2} and 50 plants m^{-2}. The other intermediate population density 40 plants m^{-2} gave (125.7) siliquae plant^{-1} which was statistically similar to 50 plants m^{-2}, 60 plants m^{-2} and 70 plants m^{-2}. Wider population density produced more number of siliquae plant^{-1} than closer population density mainly because of the fact that wider population density facilitated maximum utilization of solar energy as well as other environmental resources which helped more dry matter production. Number of siliquae plant^{-1} directly correlates with the dry matter production by the plants (Munier *et al.*, 1998). This result was corroborated with the result found by Alam (2004).

4.2.2.c Interaction effect of variety and population density

There was significant difference in number of siliquae plant^{-1} due to variety and population density (Fig.4.3). The highest number of siliquae plant^{-1} (179.10) was observed from the treatment combination of SAU sarisha-1 and 30 plants m^{-1} which was statistically different with the other treatment combination.



V_1=BARI sarisha-13	P_1=30 plants m^{-2}	P_3=50 plants m^{-2}	P_5=70 plants m^{-2}
V_2=SAU sarisha-1	P_2=40 plants m^{-2}	P_4=60 plants m^{-2}	P_6=80 plants m^{-2}

Fig.4.3 Interaction effect of variety and population density on number of siliquae plant^{-1} of BARI sarisha-13 and SAU sarisha-1

The lowest number of siliquae plant^{-1} (80.30) was found from the treatment combination of BARI sarisha-13 and 80 plants m^{-1} which were statistically identical with V_1P_2 (BARI sarisha-13X40 plants m^{-1}), V_1P_3 (BARI sarisha-13 X 60 plants m^{-1}), V_1P_4 (BARI sarisha-13 X 70 plants m^{-1}) and V_1P_5 (BARI sarisha-13 X 80 plants m^{-1}). Results showed that with increasing population density in both the varieties number of siliquae plant^{-1} decreased.

4.2.3. Length of siliqua

4.2.3.a Effect of variety

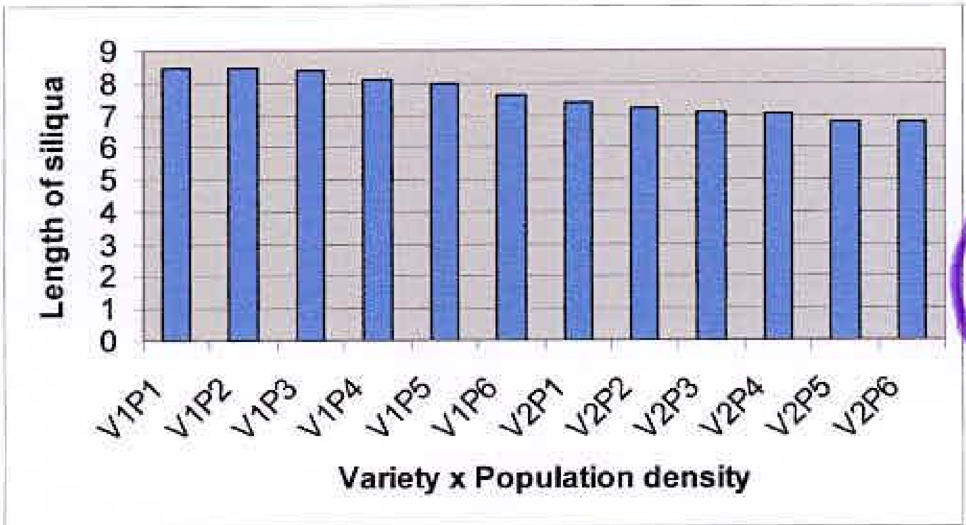
There was a significant difference between the varities in producing siliqua length (Table 4.3). The variety BARI sarisha-13 produced longer siliqua (8.14cm) and the variety SAU sarisha-1 produced shorter siliqua (7.10 cm). The above results indicated that there existed substantial variation for siliqua length between the varieties. So, the significant difference in siliqua length may be associated with the varietals characteristics or genetic make up of the varieties of rapeseed. Jahan and Zakaria (1997) observed the longest siliqua (8.07 cm) in BLN-800 and shortest siliqua length (4.43 cm) in Hyolya-401).

4.2.3.b. Effect of population density

There was a significant variation in respect to siliqua length due to population density. Results showed that lowest population density significantly increased the length of each siliqua (Table 4.4). The maximum length of siliqua (8.04 cm) was obtained from the population density of 30 plants m^{-1} which was statistically similar with 40 plants m^{-1} and 50 plants m^{-1} showing 7.78 cm and 7.68 cm respectively. The lowest siliqua length (7.08 cm) was observed from the closet population density of 80 plants m^{-1}. Wider population density, however, increased the siliqua length, which might be due to less competion for light, nutrients, space and environments. Singh and Singh (1984) and Shrief *et al.* (1990) reported that lower plant density increased the siliqua length.

4.2.3.c Interaction effect of variety and population density

There was significant variation in producing siliqua length by the interaction effect of variety and population density (Fig. 4.4). The highest length of siliqua (8.48 cm) was observed from the treatment combination of V_1P_1 (BARI sarisha-13 and 30 plants m^{-1}) which was statistically similar with the treatment combination of V_1P_2, V_1P_3, V_1P_4 and V_1P_5 showing the length of siliqua as 8.47 cm, 8.43 cm, 8.12 cm and 8.01 cm respectively.



V_1=BARI sarisha-13	P_1=30 plants m^{-2}	P_3=50 plants m^{-2}	P_5=70 plants m^{-2}
V_2=SAU sarisha-1	P_2=40 plants m^{-2}	P_4=60 plants m^{-2}	P_6=80 plants m^{-2}

Fig.4.4 Interaction effect of variety and population density on length of siliqua of BARI sarisha-13 and SAU sarisha-1

The lowest length of siliqua (6.78 cm) was found from the treatment combination of V_2P_6 (SAU sarisha-1 X 80 plants m^{-1}) which was statistically similar with the treatment combination of V_2P_1, V_2P_2, $V_2 P_3$, $V_2 P_4$ and V_2P_5 showing the length of siliqua as 7.37 cm, 7.24 cm, 7.06 cm, 6.79 cm and 6.78 cm respectively.

4.2.4 Number of seeds siliqua^{-1}

The number of seeds siliqua^{-1} contributes materially towards the grain yield in rapeseed. So, the number of seeds siliqua^{-1} is an important yield attributes of rapeseed and mustard and population density is a vital factor in producing optimum number of seeds siliqua^{-1}.

4.2.4.a Effect of variety

Number of seeds siliqua^{-1} was significantly influenced by variety (Table 4.3).The variety BARI-13 produced higher number of seeds siliqua^{-1} (29.81) and the variety SAU sarisha-1 produced lower number seeds siliqua^{-1} (25.93). Das *et al.* (1999) reported that MM 7 (Mutant) produced the highest number of seeds siliqua^{-1} (29.2) followed by MM 20 (Mutant 28.0) and BINA sarisha 4 (27.8) at Dinajpur.

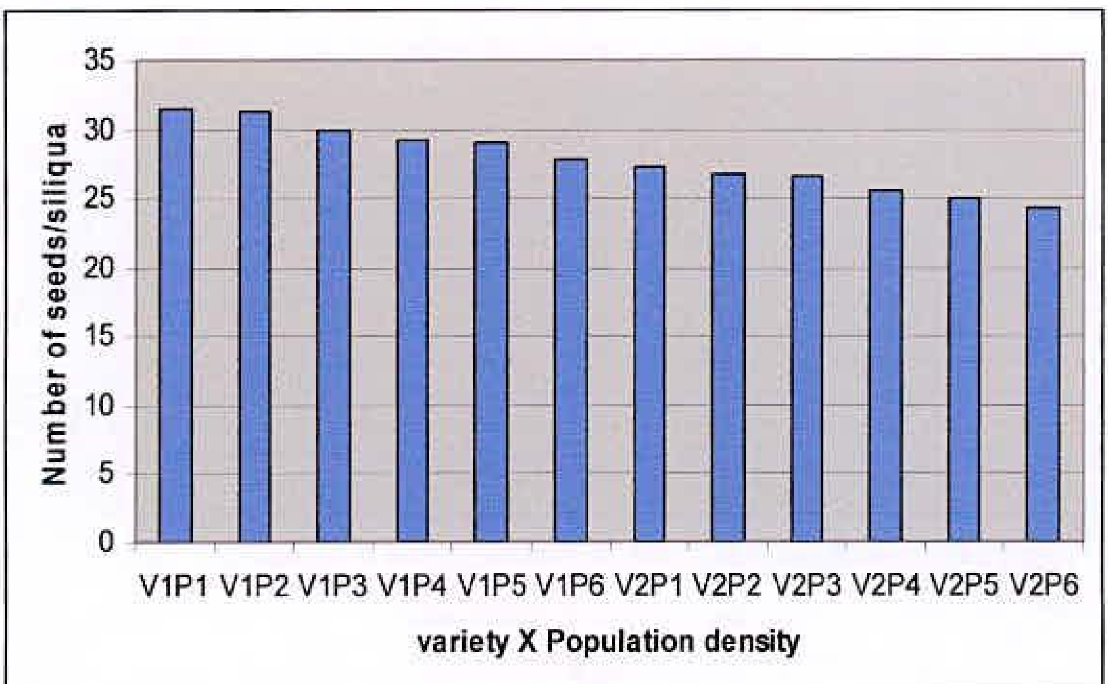
4.2.4.b Effect of Population density

Population density had a significant effect on number of seeds siliqua^{-1} (Table 4.4). The highest number of seeds siliqua^{-1} (29.06) was observed from the population density of 30 plants m^{-2} which was statistically identical with 40 plants m^{-2} producing number of seeds siliquae^{-1} as 29.04 and the lowest number of seeds siliqua $^{-1}$ (26.02) was found from the 80 plants m^{-2} which was statistically similar with 70 plants m^{-2}, 60 plants m^{-2}, and 50 plants m^{-2}. The results indicated that the number of seeds siliqua^{-1} decreased as the population density increased. Mondal *et al.* (1992) observed the highest seeds siliqua^{-1} (27.6) in SS-75 and the lowest number of seeds siliqua^{-1} in J-5004. Singh and Singh (1984) reported that the number of seeds siliqua^{-1} increased as the plant density decreased.

Tomar and Namedo (1989) obtained maximum number of seeds siliqua^{-1} at 22 plants siliqua^{-1} (26.13) in BARI sharisa-6 which was at par with Sonali (23.5) and Jatarai (22.8) and the lowest number of seeds siliqua^{-1} (18.0) was in Tori-7.

4.2.4.c Interaction effect of variety and population density

There was a significant interaction effect of the variety and population density in producing the number of seeds siliqua^{-1} (Fig.4.5). The highest number of seeds siliqua^{-1} (31.52) was produced by the treatment combination of V_1P_1 (BARI sarisha-13 X 30 plants m^{-1}) which was statistically identical with the treatment combination of V_1P_2 obtaining number of seeds siliqua^{-1} as 31.34.



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.5 Interaction effect of variety and population density on number of seeds siliqua^{-1} of BARI sarisha-13 and SAU sarisha-1

The lowest number of seeds siliqua^{-1} (24.31) was produced from the treatment combination of V_2P_6 (SAU sarisha-1 X 80 plants m^{-1}) which was statistically identical with V_2P_5 and V_2P_4 showing the number of seeds siliqua^{-1} as 25.05 and 25.53 respectively.

4.2.5 1000-seeds weight

It is also an important character which reflects the seed size. It varies from genotype to genotype and is influenced by some production factors. A good number research works have been conducted on this character.

4.2.5.a Effect of variety

1000-seeds weight was significantly influenced by variety (Table 4.3). The variety BARI sarisha-13 produced heavier 1000-seeds weight (3.73 g) and the variety SAU sarisha-1 produced lighter 1000-seeds weight (2.87 g). Kumar and Gangwar (1985) and Hussain *et al.* (1998) in a large number of strains of *B. campestris, B. napus* and *B.Juncea*. Mondal et al. (1992) observed that thousand seed weight ranged from 2.5 to 2.65 g in Improved Tori-7 (*B. campestris*) and 1.5-7.8 g in Rai-5 (*B. juncea*).

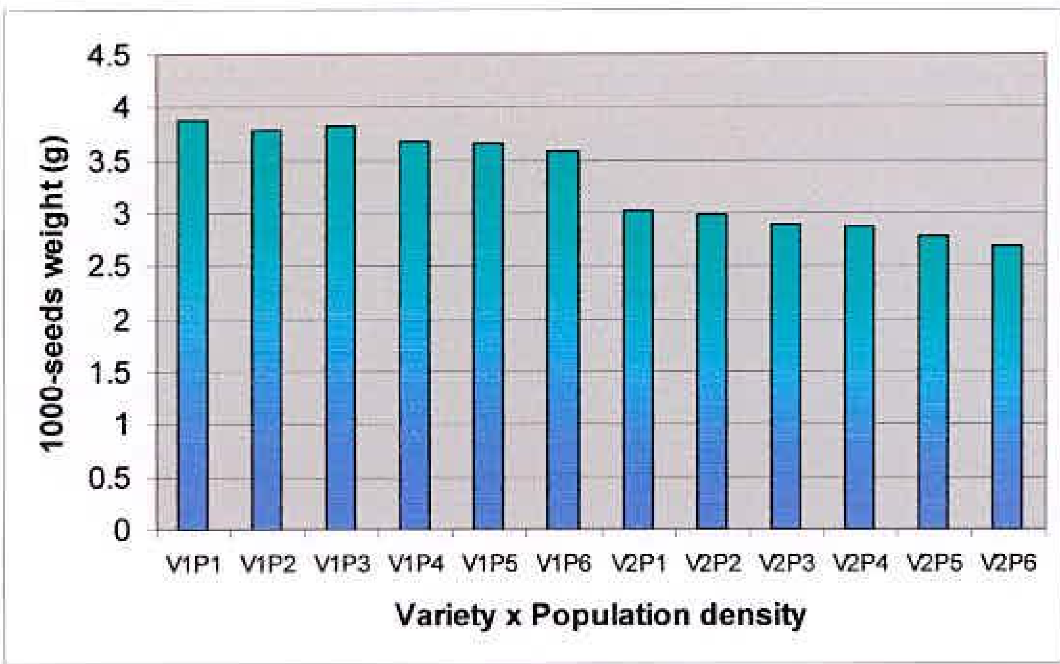
4.2.5.b Effect of population density

The weight of 1000-seeds significantly decreased with increasing population density (Table 4.4).The highest 1000-seeds weight (3.45 g) was found in 30 plants m^{-2} which was statistically similar with 40 plants m^{-2} recording 1000 seeds weight as 3.39 g. The lowest 1000-seeds weight (3.13 g) was obtained from the 80 plants m^{-2}. Thus it appeared that increasing population density, the 1000-seeds weight dcreased significantly. Singh and Singh (1984) and Gupta (1988) recorded higher weight of 1000-seeds at lower plant density, but higher seed yield of *B.campestris* and *B. juncea* was obtained with plant density of 33.3 and 44.4 plants m^{-2} due to optimum plant population.

Miah *et al.* (1987) and Tomar and namedo (1989) obtained higher 1000-seeds weight, when rapeseed was grown with 5 kg ha^{-1} seed rate and 22 plants m^{-2} respectively.

4.2.5.c Interaction effect of variety and population density

1000-seeds weight was significantly influenced by the interaction of variety and population density (Fig. 4.6).



V_1=BARI sarisha-13	P_1=30 plants m^{-2}	P_3=50 plants m^{-2}	P_5=70 plants m^{-2}
V_2=SAU sarisha-1	P_2=40 plants m^{-2}	P_4=60 plants m^{-2}	P_6=80 plants m^{-2}

Fig.4.6 Interaction effect of variety and population density on 1000-seeds weight of BARI sarisha-13 and SAU sarisha-1

The heavier 1000-seeds weight (3.88 g) was observed from the treatment combination of BARI sarisha-13 and 30 plants m^{-2} which were statistically identical with the treatment combination of (BARI sarisha-13 X 40 plants m^{-2}) and

(BARI sarisha-13 X 50 plants m^{-2}). The lighter 1000-seeds weight (2.68 g) was observed from the treatment combination of SAU sarisha-1 and 80 plants m^{-2} which were statistically similar with the treatment combination of SAU sarisha-1 and 70 plants m^{-2} showing the 1000-seeds weight as 2.78 g.

4.3 Yield

4.3.1 Seed yield plant^{-1}

4.3.1.a Effect of variety

Seed yield was significantly influenced by the variety (Table 4.5). The variety SAU sarisha-1 produced higher seed yield plant^{-1} (3.45 g) and the variety BARI sarisha-13 produced lower seed yield (3.21 g). The variety SAU sarisha-1 produced the seed yield plant^{-1} which was 7.48% higher than that of BARI sarsha-13.

Table 4.5 Varietal performance on yield and harvest index of BARI sarisha-13 and SAU sarisha-1

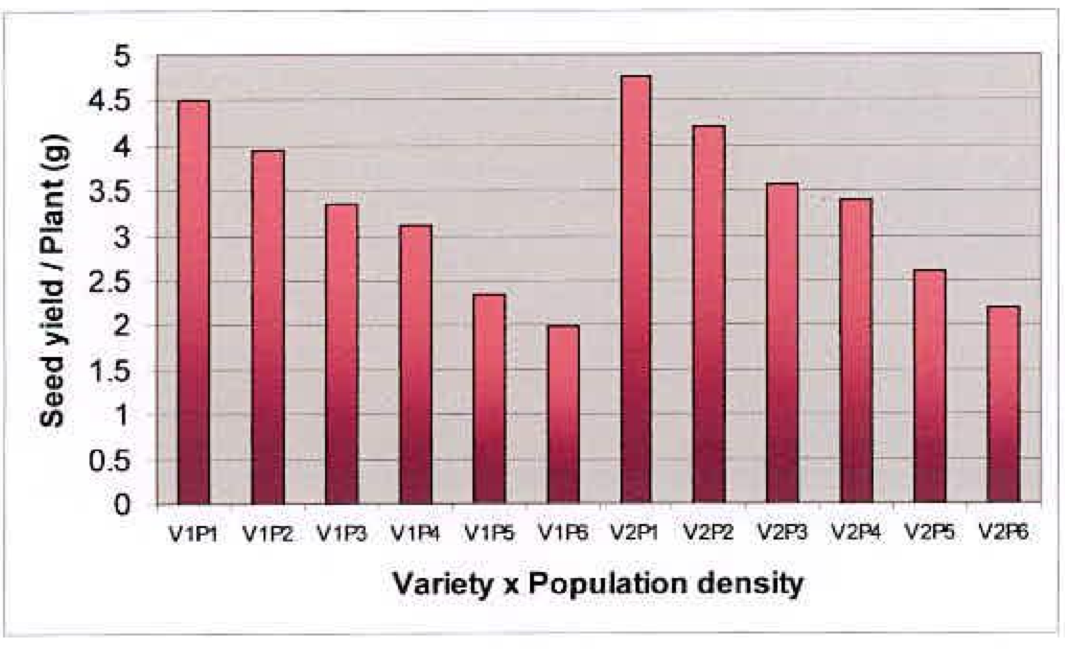
Variety	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
BARI sarisha-13	3.21	1663.81	3546.99	5204.12	31.88
SAU sarisha-1	3.45	1799.77	3153.27	4952.99	36.26
$LSD_{0.05}$	0.02	16.19	20.85	43.19	0.675
CV (%)	1.53	5.00	3.28	7.74	1.17

4.3.1.b Effect of population density

In the present study, significant variation was found in seed yield plant^{-1} at different population density (Table 4.6). Among the treatments, 30 plants m^{-2} produced the highest seed yield plant^{-1} (4.63 g) whereas, 80 plants m^{-2} produced the lowest seed yield plant^{-1} as 2.08 g. As the treatment 30 plants m^{-2} provided the maximum space, the rate of higher photosynthesis and the partitioning of photosynthate were effectively translocated to the reproductive part. The reduction in seed yield plant^{-1} might be due to cumulative effect of less number of siliqua, smaller seed size, less number of seed siliqua^{-1} for closer population density 80 plants m^{-2}. The results corroborated with the result of Siddique (1999). Seed yield plant^{-1} with 30 plants m^{-2} was 13.76%, 33.82%, 43.87%, 87.45% and 122.6% higher than that of 40 plants m^{-2}, 50 plants m^{-2}, 60 plants m^{-2}, 70 plants m^{-2} and 80 plants m^{-2} respectively.

4.3.1.c Interaction effect of variety and population density

Seed yield plant^{-1} was significantly influenced by the interaction of variety and population density (Fig.4.7).



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.7 Interaction effect of variety and population density on the seed yield plant^{-1} (g)

The highest seed yield plant^{-1} (4.76 g) was observed from the treatment combination of SAU sarisha-1 and 30 plants m^{-2} and the lowest seed yield plant^{-1} (1.98 g) was obtained from the treatment combination of BARI sarisha-13 and 80 plants m^{-2}.

4.3.2 Seed yield hectare^{-1}

4.3.2.a Effect of variety

Seed yield was significantly influenced by the variety (Table 4.5). The variety SAU sarisha-1 produced higher seed yield (1799.77 kg ha^{-1}) and the variety BARI sarisha-13 produced lower seed yield (1663.81 kg ha^{-1}). The variety SAU sarisha-1 produced the seed yield ha^{-1} which was 8.17% higher than that of BARI sarsha-13. Rahman (2002) observed higher seed yield in BARI harisha-7, BARI Sharisha-8 and BARI sharisha-11 (2.00-2.50 ton ha^{-1}) and the lowest yield in variety Tori-7(0.95-1.10 ton ha^{-1}). Higher seed yield in SAU Sarisha-1 might be due to the contribution of cumulative favorable effects of the crop characteristics viz. number of branches plant^{-1}, siliquae plant^{-1}, and seeds siliqua^{-1}. It has been reported that the higher seed yield was positively correlated with branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1}, plants m^{-2} and 1000-seed weight. Rahman (2002) observed higher seed yield in BARI sharisha-7, BARI sharisha-8 and BARI sharisa-11 (2.00-2.50 t/ha) and the lowest yield in variety Tori-7 (0.95-1.10 t/ha).

4.3.2.b Effect of population density

Population density had a significant effect on seed yield on rapeseed (Table 4.6). Increasing population density up to 60 plants m^{-2} significantly increased the seed yield per hectare and there after, it sharply declined (Table 4.6). The treatment of 60 plants m^{-2} produced significantly the highest seed yield 1957.00 kg ha^{-1} which was followed by 70 plants m^{-2} and 80 plants m^{-2} showing the seed yield 1838.07 kg ha^{-1} and 1775.10 kg ha^{-1} respectively. The lowest seed yield (1528.02 kg ha^{-1})

was observed from the widest population density 30 plants m^{-2}. The intermediate population density treatment 40 plants m^{-2} and 50 plants m^{-2} produced 1631.21 kg ha^{-1} and 1662.13 kg ha^{-1} yield respectively which were statistically identical to each other. It may be concluded that intermediate population density 60 plants m^{-2} assisted to produce substantially highest seed yield. This was mainly due to the fact that an optimum plant density facilitated maximum utilization of solar radiation and nutrients which enhanced TDM production and development of other yield components. Seed yield $hectare^{-1}$ with 60 plants m^{-2} was 28.07%, 19.97%, 17.74%, 10.25% and 6.47% higher than that of 30 plants m^{-2}, 40 plants m^{-2}, 50 plants m^{-2}, 70 plants m^{-2} and 80 plants m^{-2} respectively. Khader and Bhargava (1985) and Gupta (1988) recorded maximum seed yield of *B. juncea* and *B. campestris* with plant density at 44 plants m-2. Singh and Singh (1984) obtained higher seed yield of *B. campestris* var. toria, with plant density level at 33.3 plants m-2. Shastry and Kumar (1981), Giri and Gangasaran (1985), Tomar and namedo (1989) obtained maximum seed yield of *Brassica spp.* with plant density at 22 plants m-2. On the other hand Kumar and Gangwar (1985) and Gangwar and Kumar (1986) reported higher seed yield of *B. campestris,* when plant density was maintained at 16.6 plants m-2. Similarly .Chavan *et al.*(1989) obtained maximum seed yield of mustard when crop was grown maintaining 15 plants m-2. However, Suraj *et al.* (1975) and Scaribrick *et al.* (1982) obtained maximum seed yield of *Brassica spp.* when plant densities were maintained at 50 and 54 plants m-2, respectively. In closer population densities in both the varieties inter and intra plant competition reduced the seed yield. On the contrary, the lower number of plant per unit area reduced the seed yield due to insufficient plant population.

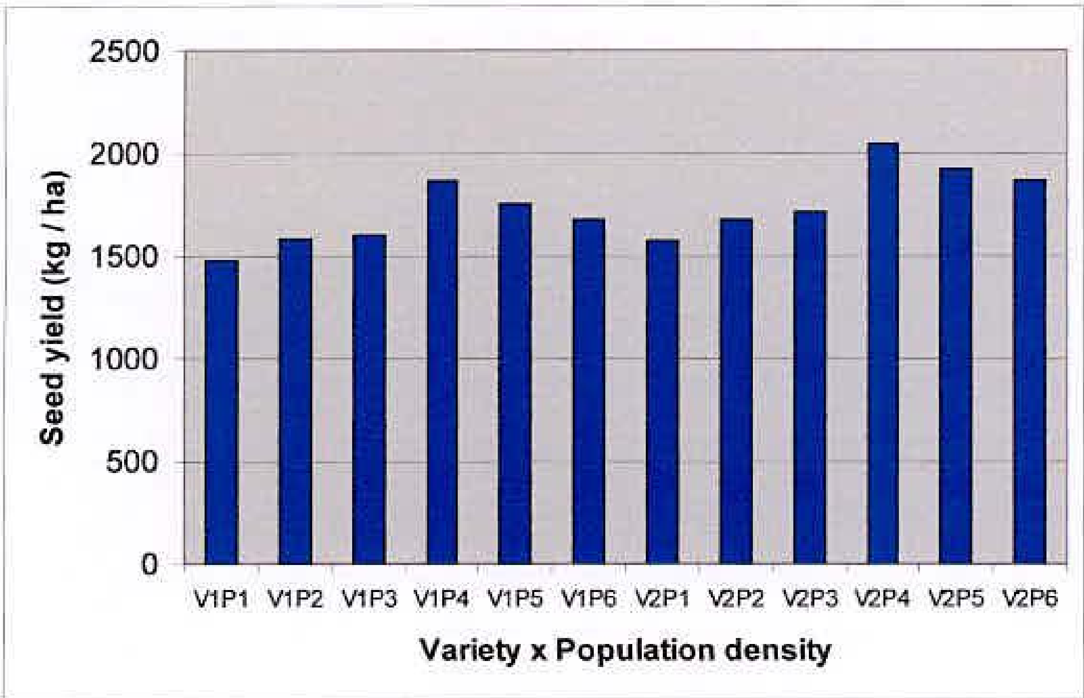
Table 4.6 Yield and harvest index of BARI sarisha-13 and SAU sarisha-1 as affected by population density

Population density	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
P_1	4.63	1528.02	3264.11	4792.20	31.94
P_2	4.07	1631.21	3319.09	4950.31	33.00
P_3	3.46	1662.13	3375.01	5037.27	33.03
P_4	3.26	1957.00	3478.04	5415.18	36.05
P_5	2.47	1838.07	3363.13	5201.13	35.41
P_6	2.08	1775.10	3302.15	5077.22	35.01
$LSD_{0.05}$	0.0656	41.48	51.16	106.00	0.477
CV (%)	1.53	5.13	3.28	5.74	1.17

P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

4.3.2.c Interaction effect of variety and population density

Seed yield was significantly influenced by the interaction of variety and population density (Fig. 4.8). The highest seed yield (2044.21 kg ha^{-1}) was observed from the treatment combination of SAU sarisha-1 and 60 plants m^{-2} which was followed by the treatment V_2P_5, V_2P_6 and V_1P_4 showing the seed yield as 1922.01 kg ha^{-1}, 1867.17kg ha^{-1} and 1870 kg ha^{-1} respectively. The lowest seed yield (1485.09 kg ha^{-1}) was found from the treatment combination of BARI sarisha-13 and 30 plants m^{-2}.



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.8 Interaction effect of variety and population density on the seed yield (kg ha^{-1})

4. 3. 3 Stover yield

4.3.3.a Effect of variety

The variety had significant influence on stover yield (Table 4.5). Higher stover yield (3546.99 kg ha^{-1}) was produced by the variety BARI sarisha-13 and lower stover yield (3153.27 kg ha^{-1}) was produced by the variety SAU sarisha -1.

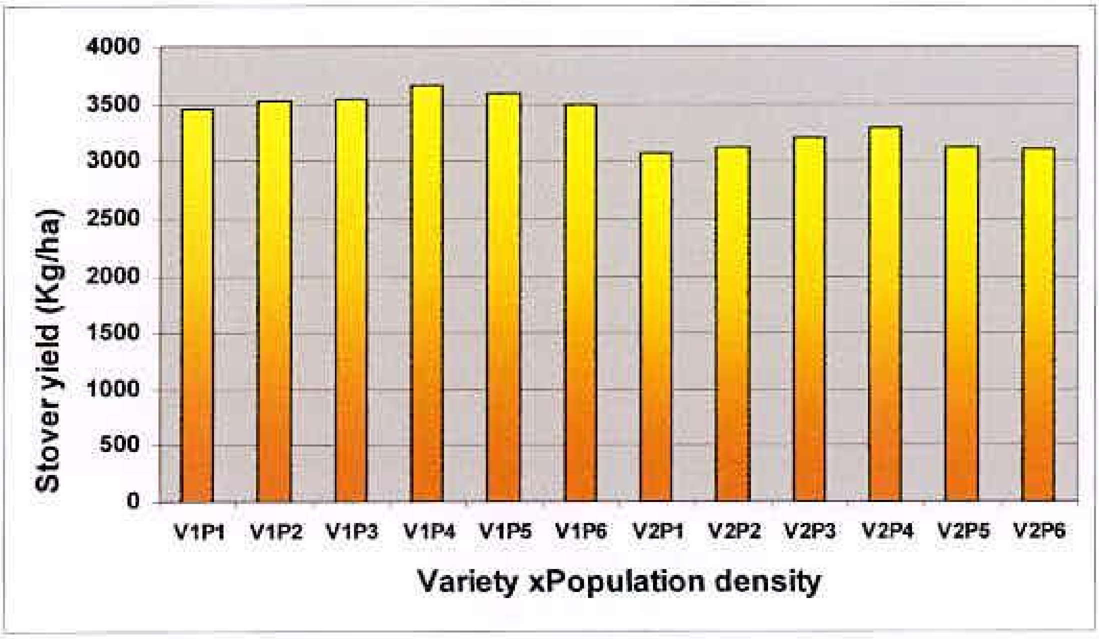
4.3.3.b Effect of population density

Table 4.6 showed significant variation in stover yield among the population density. The highest stover yield (3478.04 kg ha^{-1}) was produced from the treatment 60 plants m^{-2} which was followed by the treatment 50 plants m^{-2}

showing the stover yield as 3375.01 kg ha^{-1} and the lowest stover yield (3264.11 kg ha^{-1}) was produced by the treatment 30 plants m^{-2}.

4.3.3.c Interaction effect of variety and population density

There was significant interaction effect (Fig.4.9) due to variation in varietal characteristics and population density in stover yield. The highest stover yield (3662.21 kg ha^{-1}) was observed from the treatment combination of BARI sarisha-13 and 60 plants m^{-2} which was statistically similar with the treatment BARI sarisha-13 and 70 plants m^{-2}. The lowest stover yield (3106.09 kg ha^{-1}) was found from the treatment combination of SAU sarisha-1 and 90 plants m^{-2} which was statistically identical with the treatment combination of SAU sarisha-1 and 70 plants m^{-2} showing the stover yield 3126 kg ha^{-1}.



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.9 Interaction effect of variety and population density on the stover yield (kg ha^{-1})

4.3.4 Biological yield

4.3.4.a Effect of variety

Biological yield was significantly influenced by the variety (Table 4.5).The variety BARI sarisha-13 produced higher biological yield (5204.12 kg ha^{-1}) and the variety SAU sarisha -1 produced lower biological yield (4952.99 kg ha^{-1}).

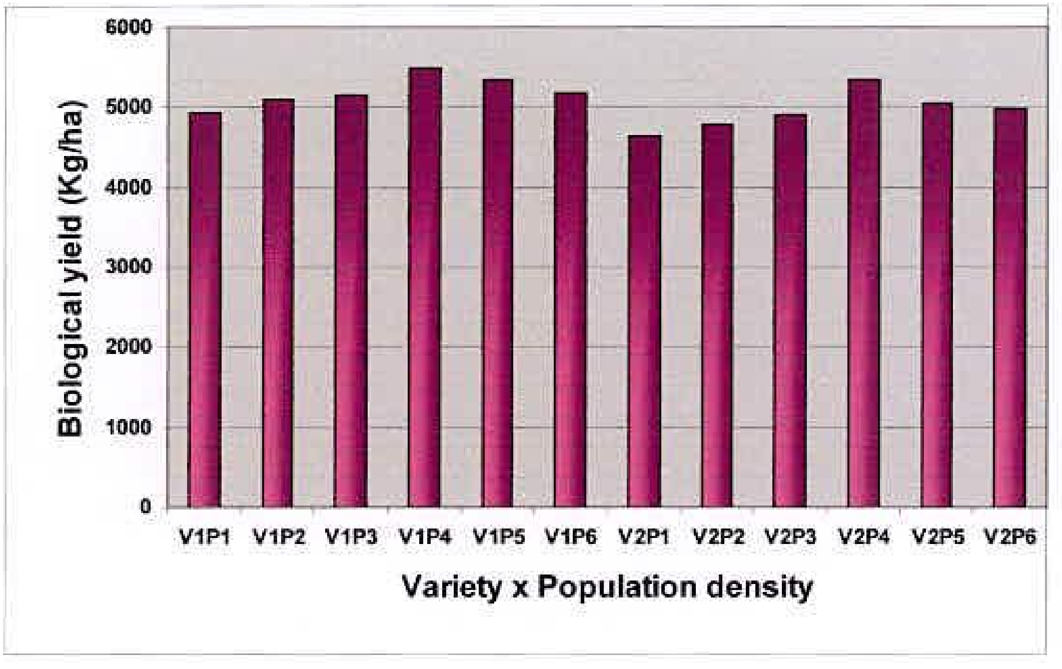
4.3.4.b Effect of population density

There was significant influence in producing biological yield by population density (Table 4.6). The highest biological yield (5414.18 kg ha^{-1}) was observed from the treatment 60 plants m^{-2} and the lowest biological yield (4792.20 kg ha^{-1}) was found from the treatment 30 plants m^{-2}.

4.3.4.c Interaction effect of variety and population density

Biological yield was significantly influenced by the interaction of variety and population density (Fig.4.10). The treatment combination of BARI sarisha-13 and 60 plants m^{-2} produced the highest biological yield (5493.00 kg ha^{-1}) which was statistically identical with the treatment combination of BARI sarisha-13 and 70 plants m^{-2} and SAU sarisha-1 and 60 plants m^{-2} showing the biological yield 5355.00 kg ha^{-1} and 5337 kg ha^{-1} respectively.

The treatment combination of SAU sarisha-1 and 30 plants m^{-2} produced the lowest biological yield (4646.00 kg ha^{-1}) which was statistically identical with the treatment combination of SAU sarisha-1 and 40 plants m^{-2} showing the biological yield as 4795.00 kg ha^{-1}.



V_1=BARI sarisha-13 P_1=30 plants m^{-2} P_3=50 plants m^{-2} P_5=70 plants m^{-2}
V_2=SAU sarisha-1 P_2=40 plants m^{-2} P_4=60 plants m^{-2} P_6=80 plants m^{-2}

Fig.4.10 Interaction effect of variety and population density on the biological yield (kg ha^{-1})

4.3.5 Harvest index

4.3.5.a Effect of variety

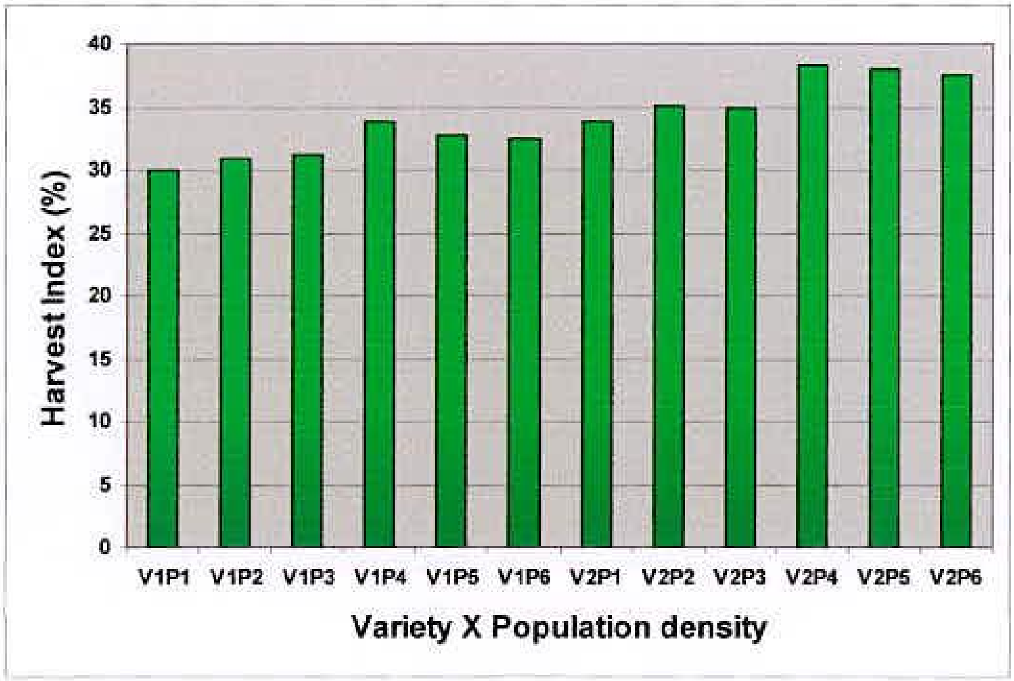
Harvest index was significantly influenced by variety (Table 4.5). The variety SAU sarisha-1 produced higher harvest index (36.26%) and the variety BARI sarisha-13 produced lower harvest index (31.88%).

4.3.5.b Effect of population density

Population density significantly affected the harvest index (Table 4.6). The highest harvest index value of (36.05%) was obtained from the treatment 60 plants m^{-2}. The lowest harvest index value of (31.94%) was obtained from the treatment 30 plants m^{-2} and harvest index from the treatment 70 plants m^{-2} and 80 plants m^{-2} were obtained as 35.41% and 35.01% respectively which were statistically identical.The treatment 50 plants m^{-2} and 40 plants m^{-2} showed the harvest index value as 33.03% and 33.00% respectively which were statistically identical. Scarisbrick *et al.* (1982) reported that plant density at 54 plants m^{-2} performed higher harvest index, consequently, which executed higher seed yield of *Brassica napus*. Singh and Singh (1984) reported that plant density level at 16.6 plants m^{-2} increased all yield attributes, but at higher plant density level of 33.3 plants m^{-2} resulted higher harvest index, consequently higher grain yield of *Brassica compestris*. Shrief *et al.* (1990) also reported higher seed yield and higher HI of rapeseed with30 plants m^{-2}.

4.3.5.c Interaction effect of variety and population density

The harvest index (%) was significantly influenced by the variety and population density (Fig.4.11) The treatment V_2P_4 produced the highest harvest index value (38.30%) which was statistically similar with the treatment V_2P_5 (38.06%). The treatment V_1P_1 produced the lowest harvest index value (30.07 %).



V_1=BARI sarisha-13	P_1=30 plants m^{-2}	P_3=50 plants m^{-2}	P_5=70 plants m^{-2}
V_2=SAU sarisha-1	P_2=40 plants m^{-2}	P_4=60 plants m^{-2}	P_6=80 plants m^{-2}

Fig.4.11 Interaction effect of variety and population density on the harvest index value (%))

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the field laboratory of the Sher-e-Bangla Agricultural University farm, Dhaka in Rabi season during October 2006 to March 2007 to find out the effect of population density on the yield and yield components of two 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 treatments were two rapeseed varieties viz. BARI sarisha-13 and SAU sarisha-1 and six population density viz. 30 plants m^{-2}, 40 plants m^{-2}, 50 plants m^{-2}, 60 plants m^{-2}, 70 plants m^{-2} and 80 plants m^{-2}. 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 sowing date was on November 15, 2006. The unit plot size was 3 m × 3.5 m (10.5 m^2). The land preparation, fertilization, irrigation, drainage, pest management and other intercultural operation, harvesting, post harvest operation and data collections were done carefully.

Observations were made in randomly selected 10 plants on plant height (cm) at 25 days, 50 days, 75 days, at final harvest but number of branches $plant^{-1}$, number of siliquae $plant^{-1}$, length of siliqua (cm), number of seeds $siliqua^{-1}$, weight of 1000-seeds (g), seed yield $plant^{-1}$(g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index(%) only at final harvest.

The results of the experiment showed that two varieties had a significant effect on plant height, number of branches $plant^{-1}$, number of siliquae $plant^{-1}$, length of siliqua, number of seeds $siliqua^{-1}$, 1000-seed weight, seed yield $plant^{-1}$, seed yield ha^{-1}, stover yield ha^{-1} and harvest index. Higher plant height (117.32 cm), length of siliqua (8.14 cm), number of seeds $siliqua^{-1}$ (29.81), 1000-seed weight (3.73 g), stover yield (kg ha^{-1}) and biological yield (52040.12 kg ha^{-1}) were obtained by the variety BARI sarisha-13. On the other hand higher number of branch $plant^{-1}$ (7.34), number of siliquae $plant^{-1}$ (152.51), seed yield $plant^{-1}$ (3.45g), seed yield (1799 kg ha^{-1}) and harvest index (36.26 %) were found by the variety SAU sarisha-1.

The interaction of variety and population density had significant effect on plant height, number of branches $plant^{-1}$, number of siliquae $plant^{-1}$, length of siliqua, number of seeds $siliqua^{-1}$, 1000-seeds weight, seed yield per plant, seed yield ha^{-1}, stover yield kg ha^{-1} and harvest index (%).

The highest plant height (123.6 cm) was produced by the treatment combination of variety BARI sarisha-13 and population density 80 plants m^{-2}. The highest number of branches $plant^{-1}$ (8.30) and number of siliquae $plant^{-1}$ were found from the treatment combination of variety SAU sarisha-1 and population density 30 plants m^{-2}.The highest length of siliqua (8.48cm), number of seeds $siliqua^{-1}$, 1000-seed weight were observed from the treatment combination of variety BARI sarisha-13 and population density 30 plants m^{-2}. The highest seed yield $plant^{-1}$ (4.76 g) was produced by the treatment combination of variety SAU sarisha-1 and population density 30 plants m^{-2}. The highest seed yield (2044.21 kg ha^{-1}) was obtained from the treatment combination of variety SAU sarisha-1 and population density 60 plants m^{-2}. The highest stover yield (3662.21 kg ha^{-1}) and biological yield (5493.00 kg ha^{-1}) were observed from the treatment combination of variety BARI sarisha-13 and population density 60 plants m^{-2}.The highest harvest index (38.30%) was calculated from the treatment combination of variety SAU sarisha-1 and population density 60 plants m^{-2}.

From the above summary, it could be concluded that higher seed yield of rapeseed could be obtained by using SAU sarisha-1 with 60 plants m^{-2} under the agro climatic conditions of Madhupur Soil Tract (AEZ-28).

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APPENDICES

Appendix I: Morphological, physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site (Islam, 2005)

A. Physical composition of the soil

Soil separates	(%)
Sand	36.90
Silt	26.40
Clay	36.66
Texture class	Clay loam

B. Chemical composition of the soil

Sl.	Soil characteristics	Analytical data
1	Organic carbon (%)	0.82
2	Total N (kg/ha)	1790.00
3	Total S (ppm)	225.00
4	Total P (ppm)	840.00
5	Available N (kg/ha)	54.00
6	Available P (kg/ha)	69.00
7	Exchangeable K (kg/ha)	89.50
8	Available S (ppm)	16.00
9	P^H (1:2.5 soil to water)	5.5
10	CEC	11.23

Appendix II: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November 2006 to March 2007

Month	Air temperature (°C)		Relative humidity (%)	Total Rainfall(mm)
	Minimum	Maximum		
November 06	20.15	22	87	00
December 06	18.10	20	64	00
January 07	13.2	24.90	67.5	3.0
February 07	17.8	28.1	61.5	4.0
March 07	22.6	32.5	66.5	155

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka- 1207